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Impacts of Technology Adoption: Comparing Returns to the Farming Sector in Maine under Alternative Technology Regimes

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IMPACTS OF TECHNOLOGY ADOPTION: COMPARING RETURNS TO THE FARMING SECTOR IN MAINE UNDER ALTERNATIVE TECHNOLOGY REGIMES

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An Abstract of the Thesis Presented
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This thesis tests if certain technology choices are associated with a reduction in the proportion of farming activities in the agro-food system in Maine. Goodman, Sorj, and Wilkinson define appropriationism as the replacement of farming sector activities by industrial inputs. Based on the concept of appropriationism, industrial farming systems using large amounts of synthetic inputs contribute less to farming than more agrarian systems, like organic farming. Thus, returns to the farming sector should be greater for organic compared with conventional potato farming in Maine since organic farming uses fewer industrial inputs. Goodman et. al. define substitutionism as the displacement of farming sector commodities and activities by industrial processes in the marketing sector. Based on the concept of substitutionism, returns to the farming sector should be greater for Lay's Classic®™ potato chips made from natural potatoes compared with Baked Lay's®™ potato crisps manufactured from processed dehydrated potatoes. Returns to the farming sector are defined as returns to the farmer or farm family from farming activities,

returns to farm labor, and returns to farmers and farm labor producing inputs used on the farm.

Results show absolute returns to the farming sector are less for organic compared to conventional tablestock potato farms in Maine. However as a proportion of farm revenues, large organic farms that market at least 25% of their produce to retail stores or directly to consumers do as well as conventional farms. When comparing returns as a proportion of consumer expenditures, these organic farms do better than conventional farms. Returns to the farming sector are less for organic because of yield penalties, cost of marketing services, and diseconomies of size for organic tablestock potato farms. Expanding acreage and reintegrating livestock with cropping systems may increase returns to the farming sector. Organic farming demonstrates difficulties in providing marketing services at the farm level. Providing marketing services limits the ability to expand production to capture economies of size. Maine organic potato farmers emphasize non-monetary values such as supporting sustainable agriculture, self-sufficiency, the intrinsic value of work, and close community and family connections.

Returns to the farming sector as a proportion of consumer expenditures are about three times greater for Lay's Classic®™ potato chips than for Baked Lay's®™ potato crisps, since the value that farmers receive for potatoes used to produce dehydrated potato flakes in one pound of crisps is about half of the value that farmers receive for potatoes used to make one pound of chips. However, this assumes farmers assign a cost to producing low-grade potatoes for dehydration proportionate to their value. Premium potatoes are used to produce potato chips. Low-grade potatoes are used to produce the dehydrated potato flakes used to make potato crisps. Returns to the farming sector are slightly greater for potato crisps if no costs are allocated to producing low-grade potatoes for dehydration. A shift in consumer preferences from potato chips to crisps may result in a geographical shift of potato production from Maine to the Pacific Northwest assuming no food-grade dehydration facilities are built in Maine.

DEDICATION

for Tokiko and Henry,
my Mom and Dad

I wish you were here with me.
I love you very much.

and

for Kristie L. Miner
for giving me much support

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Chapter 1

INTRODUCTION AND BACKGROUND

Over time, there has been a decline in the number of farms in the United States. Larger farms through consolidation absorb smaller farms. This results in an increase in the average size of farms and a decline in the number of farms. From 1959 to 1997, the number of U.S. farms decreased about 48% while average farm size increased about 61% (USDA, NASS-CA). Potato farms show similar consolidation (Smith et. al., 2000).

Causes of Decline in Farms and Farming

A number of hypotheses explain the decline in farm numbers and the increase in average farm size demonstrated at the national and regional level. One hypothesis is based on farms seeking to increase profits by adopting new technologies. For example, technology adoption by farmers increases output and farm income, but eventually decreases output price assuming demand is constant. Some farms are forced out of the industry while the remaining farms seek to adopt newer technologies to remain competitive. The number of farms continually declines. Farmers that are left increase acreage and output to compensate for declining output price and to reduce costs.

An alternative hypothesis offers a different explanation. Here a decline in farming activity drives reduction in farm numbers. Non-farm firms that produce inputs to agricultural production and that offer marketing services seek to increase their share of value-added activities from farms. The need for farm-based fertility, pest management and marketing diminishes, reducing per unit returns to farming activities. This results in a decline in the number of farms as many activities that were once conducted by farms are taken over by non-farm firms. Average farm size increases since many of the production technologies and marketing services used by farmers result in a specialization of farming activities. This specialization results in a decrease of management resources needed per unit of production. Thus farm managers are able to plant more of a given commodity, which requires additional acreage. Consequently average farm size increases. This thesis tests the proposition that technology choices are associated with different levels of farming activities in the Maine potato industry.

The Concept of Appropriationism and Substitutionism

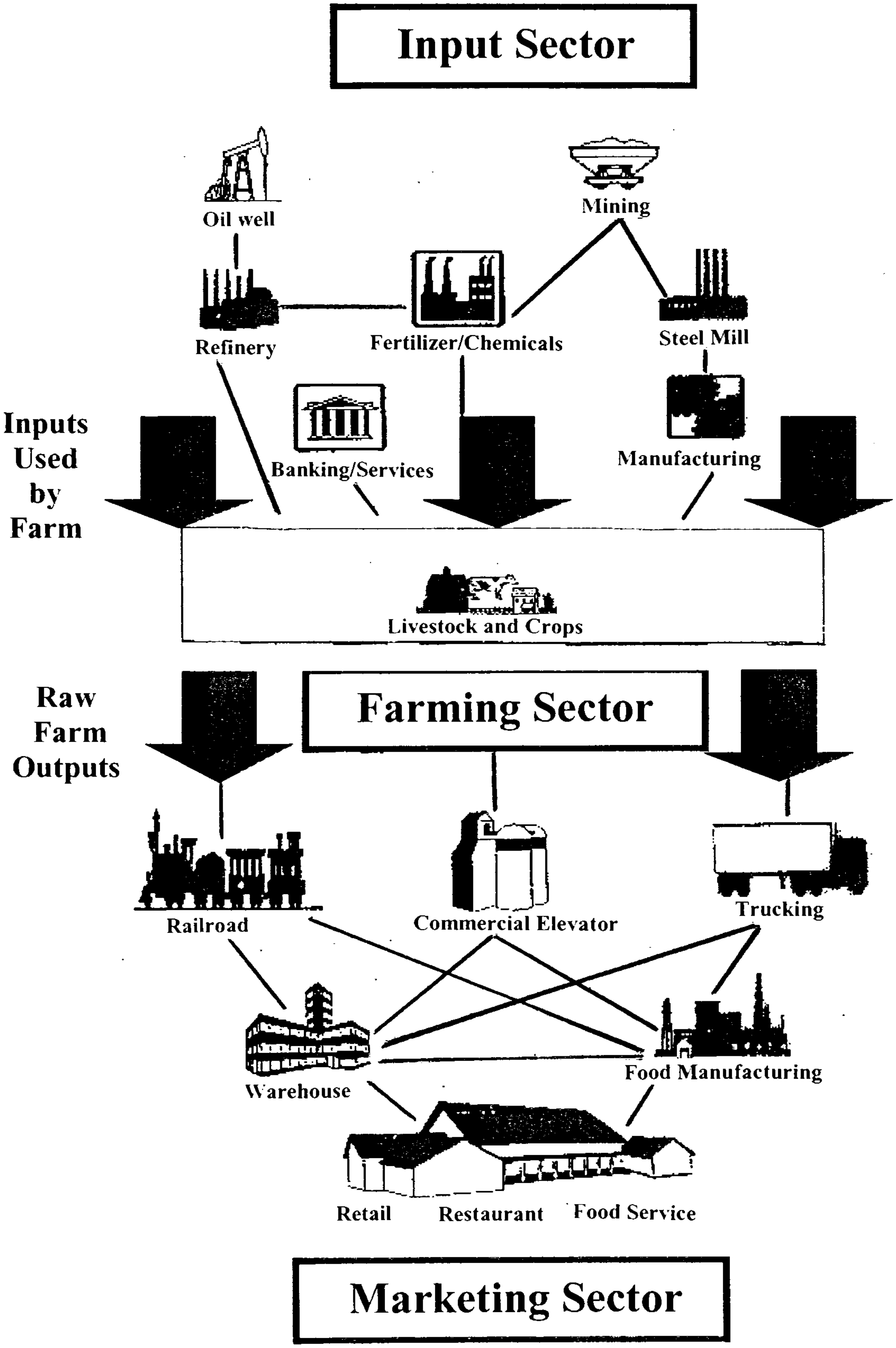
The objective of this thesis is to estimate the returns to farming as a measure of farming activities under alternative technology regimes in the production and processing of Maine potatoes. Potato production and processing occur under different sets of alternative technology regimes within the agro-food system. Technology regimes are differentiated practices and/or processes that are used for the production and/or marketing of agricultural commodities. This study compares the impacts on returns to farming between conventional and organic potato production and between the processing of potato chips and potato crisps.[1]

Returns to the components of the agro-food system are measured as income to the factors of production in each of the components and are used as a proxy for the amount of economic activity retained. The agro-food system is composed of farming, input and marketing sectors (Figure 1.1[2]). The farming sector includes all on-farm activities that

[1] Potato crisps are potato chip products baked from dough containing dehydrated potato flakes and other ingredients. Dehydrated potato flakes have been used to make fabricated potato chips since Proctor and Gamble introduced Pringles on October 19, 1968 (Proctor and Gamble).

[2] This figure of the Agro-food System is representative and not specific to the potato industry. Additional input sector firms in the potato industry breed plants while marketing sector firms that provide cold storage replace those that provide commercial elevators.

Figure 1.1: The Agro-food System, including the Input, Farming and Marketing Sectors (Smith, 1997).



generate farm production. Non-farm firms that produce farm inputs such as fertilizers, pesticides and machinery and those that provide banking and other services to farmers make up the input sector. The marketing sector is comprised of all non-farm firms that take commodities or products from the farming sector and transform them into consumer purchases that are distributed in the marketplace. Firms in the marketing sector transport agricultural commodities, produce value-added products and promote and distribute these products (Smith, 1992).

Goodman, Sorj, and Wilkinson believe that firms in the input sector seek to gain market share through appropriationism. Appropriationism involves the development of inputs to production such as pesticides, fertilizers, financing, and machinery that replace farming sector activities. Input sector firms in the agro-food system produce these inputs (Goodman et. al., 1987). Goodman et. al. suggest that industrial farming systems using large amounts of synthetic fertilizers and chemicals contribute less to farming than more agrarian systems, like those of organic farming.

Based on the concept of appropriationism, this thesis compares returns to the farming sector for conventional and organic potato production systems in Maine. Returns to the farming sector are measured as returns to factors of production, including the farm family and farm workers. These returns to the farming sector are defined as farming value added. Farming value added is calculated as farm revenues minus purchased inputs, plus paid farm labor and property taxes, plus income to indirectly impacted factors of production[3].

[3] The observed farm's paid farm labor and property taxes are directly impacted factors of production. Indirectly impacted factors of production are on other farms producing inputs used on the observed farm.

It is expected that returns to the farming sector should be lower for conventional compared to organic potato production. However, previous research indicates returns to farm firms may be smaller for organic potato production, especially if prices are the same for organic and conventional commodities (Marra, 1996b). This is due to lower total revenues from reduced potato yields per acre for organic compared to conventional.

Goodman et. al. believe that firms in the marketing sector seek to gain market share through substitutionism. Substitutionism involves processes or the production of products by marketing sector firms that replace farming sector activities by utilizing lower valued farm products. These products and processes of substitutionism displace demand for higher quality produce and value-added goods produced by the farming sector. Goodman et. al. suggest that processing technologies that use processed ingredients contribute less to farming than those that use raw agricultural ingredients.

Based on the concept of substitutionism, this thesis compares estimates of returns to the farming sector in Maine for potato chips and crisps, which represent types of manufactured food products noted by Goodman et. al. Returns to the farming sector are measured as the farming sector's share of the consumer expenditures spent on these two snack foods, and are referred to as farming share. Potato crisps are manufactured from dehydrated potato flakes and other processed products while potato chips are made from sliced whole potatoes and oil. Consistent with the notion of substitutionism, potatoes used to make dehydrated potato flakes have significantly lower farm prices than chipping potatoes. Thus returns to the farming sector should be lower for potato crisps than for potato chips.

Chapter 2

LITERATURE REVIEW

The relevant literature provides a background on technology adoption and potato production and processing. The technology adoption literature summarizes 1) explanations for why technology is adopted in the agricultural sector and 2) the various measures used to quantify the magnitude and direction of technology adoption impacts on society, the farming sector and other firms in the agro-food system as well as the effects of these impacts. A discussion on potato production and processing reviews 1) the production of conventional and organic potatoes and 2) the manufacture of potato chips and potato crisps.

Technology Adoption

Technology adoption and its impacts on farmers have been extensively studied. The relevant literature on technology adoption includes explanations about why farmers and firms in the input and marketing sectors adopt technologies. Measures of technology adoption and the impacts of technology adoption on firms in the agro-food system are also discussed.

Technology Adoption Explanations

The literature offers many explanations for technology adoption. This review focuses on profitability, relative factor prices, and firms seeking to gain market share. However, other factors may influence a firm's decision to adopt technology. These include 1) the percentage of competitors that have already adopted the technology, 2) the firm's acceptance of risk, 3) the degree of market competitiveness, 4) attitudes of labor toward adoption, 5) durability of machinery, 6) the firm's expansion rate and 7) public attitudes toward the technology being adopted. Although the focus is on farmers, it should be noted that the profitability of products produced for and from farmers by input and marketing sector firms might also drive technology adoption by farmers (Mansfield, 1961). The profitability of these products produced for and from farmers may drive input and marketing sector firms to increase their market share (Goodman et. al., 1987).

Additionally, "institutions" may influence technology adoption and technical change may be the main source of changes in "institutions." "Institutions" are conventions, rules or entitlements that define how individuals and organizations of individuals coordinate themselves and relate to each other and their environment. A more complete relationship between "institutions" and technical change is explained as follows.

> "Institutions, because of what they are, define the social and economic environment within which new techniques can be introduced, controlled and used. Because institutions define and protect income streams (property rights) it is impossible to have new technology introduced without congenial and appropriate institutional arrangements" (Bromley, 1989).

Simple examples of "institutions" that constrain technology adoption include patents and regulations against adoption of genetically modified crops for organic certification.

Profitability Models. The earliest models attribute technology adoption in the agro-food system to profitability for farmers, producers of agricultural inputs, and marketers of agricultural products. If the expected profits for using a particular technology are high then adoption will be rapid. However, if the expected profits are low then adoption will be slower (Griliches, 1957). For example, technology adoption by farmers increases farm profitability; however this results in a treadmill effect. A farmer adopts technology to increase output and profits. Other farmers note the increased returns and utilize the same technology. In the long run as enough farmers adopt, aggregate supply increases and the price of the commodity decreases, ceretis paribus. In order to achieve further increases in output and profits and to remain competitive, the adopting farmers continue to utilize new technologies, boarding a "technology treadmill" (Cochrane, 1979). Unless they can find a niche market, farmers that do not board the technology treadmill are at a competitive disadvantage to farmers that adopt and are subsequently forced out of farming. This has been characterized as "farm cannibalism" (Ibid.). Technology adoption under this model is a discrete process[4] resulting in an increase in efficiency of farming firms and a rise in consumer surplus from the outward shift in aggregate supply (Ibid.).

The percentage of firms adopting a particular technology over time illustrates an adoption cycle. This adoption cycle has been characterized as an S-shaped logistical function. Lower rates of adoption occur when a technology is first introduced. If the firms that adopt this technology early are successful, other firms begin to adopt the technology. Adoption is more rapid in the middle of an adoption cycle as more firms decide to adopt. When almost all firms have adopted the technology, the rate of adoption diminishes. The rate of adoption "tended to be faster for innovations that were more profitable and that required relatively small investments" (Mansfield, 1961). Technology adoption may also depend on the average skill level of firms in the industry since

[4] Technology adoption has also been viewed as a continuous process where the intensity of adoption can be variable. Technology adoption can be interdependent with the adoption of other technologies. Therefore a technology may have a greater chance of being adopted by a farmer if it is used in conjunction with complementary technologies (Rauniyar and Goode, 1992).

innovations are "first adopted by skilled and experimenting entrepreneurs" (Kislev and Shchori-Bachrach, 1973).

Not all farms can equally adopt certain technologies. In addition to expected profitability, technology adoption is also limited by the cost of investing in technologies and the capacity for the farm to raise financial capital. Researchers have focused on the fixed costs of technology adoption such as machinery, labor training, education, and market development. These fixed costs may limit the adoption of certain technologies. Farms that have open access to financial capital are in a better position to adopt technologies than farms that have limited access to such capital. Therefore, farms in developed nations are better able to adopt technologies with high fixed costs than farms in developing nations (Rahman et. al., 1998). Similarly, large farms are better able to adopt technologies with high fixed costs than small farms (Just and Zilberman, 1982). While certain technologies might increase profits for all farms, many farms are unable to adopt because of initial costs and the inability to raise financial capital, resulting in an unequal distribution of benefits from certain technologies.

Induced Innovation. A subsequent model generalizes from the earlier models by focusing on relative input factor prices rather than profits. Under the induced innovation model, "technical change is treated as endogenous to the development process" (Ruttan and Hayami, 1990). According to this theory, technology is adopted "to facilitate the substitution of relatively abundant (hence cheap) factors for relatively scarce (hence expensive) factors in the economy" (Ibid.). Countries that are faced with highly inelastic supply curves for labor, for example, are more likely to adopt technologies that substitute capital for labor. Here capital takes the form of machinery, chemical pesticides, and fertilizers. In countries where the supply of land is inelastic, there is adoption of biological technologies like high yielding crop varieties to substitute for constrained acreage. Where labor is substantially less expensive than capital-intensive factors of production, labor will be used in favor of capital. Thus the adoption of technologies is closely related to the prices of capital, land and labor. The theory of induced innovation proposes that there are multiple paths to technological changes in agriculture (Ibid.).

Appropriationism and Substitutionism. An alternative explanation of technology adoption in agriculture is based on firms in the input and marketing sectors seeking market share. Appropriationism and substitutionism are not necessarily contradictory to the previous two explanations. However, these concepts explain the bias for the type of technologies that are developed by input and marketing sector firms, which are subsequently adopted by farms. Input sector firms gain market share from the farming sector through the process of appropriationism while marketing sector firms similarly gain market share through the process of substitutionism[5].

Appropriationism is defined as the "discontinuous but persistent undermining of discrete elements of the agricultural production process, their transformation into industrial activities, and their re-incorporation into agriculture as inputs" (Goodman et. al., 1987). Here firms in the input sector increase their market share relative to other firms in the agro-food system by manufacturing production inputs purchased by farmers. These manufactured inputs serve as proxies for more sustainable farm technologies[6] such

[5] Appropriationism and substitutionism "constitute a combined, interactive movement of capital successively replacing rural with industrial activities" that operates in a "series of discrete, discontinuous transformations" (Goodman et. al., 1987).

[6] Sustainable farm technologies refer to farming processes and methods that substitute for conventional agricultural technologies such as chemically produced fertilizers, biotechnology, and synthetic pesticides, herbicides and fungicides. The technologies of conventional agriculture fit the definition: "The application(s) of science, esp. to *industrial* or commercial objectives" (Italics are the author's). The technologies of organic agriculture fit the anthropological definition better: "The bod(ies) of knowledge available to a civilization that is of use in fashioning implements, practicing manual arts and skills, and extracting or collecting materials" (American Heritage Dictionary, 1985).

as crop rotation, composting, crop and livestock integration, and cover cropping to maintain soil fertility.

Examples of appropriationism can be found in the development of high yielding seed varieties by non-farm firms, industrial animal production, recombinant DNA (rDNA) technology used to enhance agronomic traits[7] and the industrial production of chemical fertilizers, pesticides and herbicides. Hybridized seed varieties developed by non-farm firms displace the tradition of farmers selecting and saving their own seed. Animals produced in factory farms reduce the need for a rural land base for raising animals. Genetically modified crops and the use of chemical fertilizers, pesticides and herbicides can reduce the need for farm-based activities. These activities include composting, green and livestock manuring to enhance soil fertility, crop rotation to mitigate the incidence of disease and insect infestations, as well as farm based weed management technologies such as stale seed bedding and manual and mechanical cultivation.

Substitutionism is described as "the industrial production of food" where manufactured ingredients and commodities replace raw agricultural products produced by farms (Goodman et. al., 1987). Firms in the marketing sector increase market share relative to other firms in the agro-food system by engaging in such substitutionism. Here raw agricultural products are replaced with industrially produced substitutes during food processing. Similarly, farm based technologies are replaced with industrial processing activities. Substitutionism is characterized by value-added activities conducted by marketing sector firms and not by value-added activities used by farms.

[7] Agronomic traits include crop characteristics such as yield, drought tolerance, and resistance to disease, insects, and herbicides. Quality traits include characteristics such as altered starch content and composition, enhanced flavor, and enhanced processing attributes (Roller and Harlander, 1998).

Examples of substitutionism include vegetable canning, the manufacture of frozen vegetables and margarine, the use of rDNA technology to produce chymosin[8] for the processing of cheese, and the production of potato crisps. Industrially produced canned and frozen vegetables serve as convenient, non-perishable substitutes for their seasonally available raw farm gate counterparts. Hydrogenating vegetable oils produces margarine. Margarine serves as a substitute for butter, an agricultural product produced by farmers. The use of rDNA technology to produce chymosin in greater quantities and at lower cost by biotechnology firms replaces the traditional method of using calf rennet to coagulate milk during farm-based cheese production. Potato crisps are produced from dehydrated potato flakes and serve as a substitute for potato chips, which are made from whole potatoes.

According to Goodman et. al. (1987), input sector firms appropriate activities away from the farming sector while marketing sector firms use substitutionism to gain market share from the farming sector. Firms in the input and marketing sectors conduct activities once handled by farmers (Smith, 1992; Smith, 1997). This alternative explanation of technology adoption has been developed into a simultaneous equations model of the agro-food system. This model of input, farming, and marketing sector profits shows that research and development to reduce input costs and government payments to farmers have ambiguous effects on farm sector profits per se while having a positive effect on total profits of the agro-food system (Levins, 2000).

[8] Chymosin is an enzyme used to clot milk during cheese production. It is traditionally obtained from the fourth stomach of young calves. Researchers have developed ways to produce vast quantities of chymosin at reduced cost. Yeast or bacteria are genetically modified to express for the production of chymosin. Chymosin is then separated from the yeast or bacteria that produced it (Roller and Goodenough, 1998).

Technology Adoption Measures and Impacts

The criteria and techniques used to quantify technology adoption impacts can be categorized according to their scope of measurement. This scope ranges from impacts on public welfare to impacts at the individual producer level. Lying between these two extremes are impacts of technology adoption on a particular component of the agro-food system, the farming sector. Technology adoption during the production or marketing of agricultural products may have positive or negative impacts on firms in the agro-food system.

Technology Adoption Measures. The criteria and techniques used to measure the impacts of technology adoption can be categorized as measures of 1) market-level impacts using economic surplus models, 2) market and farm-level impacts using quantitative market and linear programming models, 3) attributes of firms that adopt similar technologies using cluster analysis, 4) farm-level impacts using farm financial indicators, and 5) returns to the input and farming sectors from farm budget analysis.

Economic surplus models measure technology adoption impacts on public welfare by estimating consumer and producer surplus. Consumer and producer surplus are quantitative measures of welfare gains or losses that consumers and producers experience from price changes in agricultural products (Nicholson, 1998). Technology use can shift aggregate supply outward, which decreases price, ceretis paribus. This shift may increase or decrease producer surplus. The magnitude and direction of the change in producer surplus depends on the elasticity of the demand for the agricultural product. Agricultural commodities with more inelastic demands have greater price changes and less increases in producer surplus than commodities with more elastic demands (Caswell and Shoemaker, 1993).

Quantitative market models improve upon the static analysis of economic surplus models by offering improved reliability and the ability to look at dynamic market-level responses to technology adoption. Examples of quantitative market models include structural econometric models and equilibrium displacement models. Farm-level impacts can be measured using linear programming models, which can jointly consider costs, revenues, and profitability of multiple farms (Griffith et. al., 1995).

Attributes of forestry product processing firms that adopt similar technologies have been categorized using cluster analysis. Cluster analysis uses algorithms to develop "meaningful clusters of respondents based on similarities across specified characteristics" such as technological innovations in wood product processing. Clustering provides a continuum of categorization from a completely homogenous cluster where all firms are in one cluster to an entirely heterogeneous cluster where each firm is in its own cluster. Cluster analysis has also been used in "consumer and industrial research for market segmentation" (Cohen and Sinclair, 1990).

Individual farm-level financial indicators such as returns over variable costs (ROVC), return to capital, and return to equity are derived using farm budgets. ROVC measures farm profitability. ROVC is total farm revenues minus the sum of all variable costs used in production. Annualized costs of owning the farm are incurred regardless of whether or not a crop is produced and they are not subtracted from total farm revenues when calculating ROVC (Marra, 1996b). Return to capital and equity also measure farm profitability. Farm profitability defines the size of farm profits "*relative to* the size of the business or the value of the resources used to produce the profit" (Kay, 1986). Return to capital measures profitability by dividing the farm's return to total capital by total farm assets while return to equity is calculated by dividing the farm's return to equity by net worth or the owner's equity[9].

By analyzing farm budgets, returns to individual farmers and the input and farming sectors can be measured. Net farm income (NFI) measures returns to individual farmers. Net value added of agriculture (VAA) measures returns to farms, farm labor, and to input sector firms such as farm lenders and landlords. Farming value added (FVA) measures returns solely to the farming sector.

NFI measures farm profits by subtracting cash operating and interest expenses, expense adjustments, and depreciation from the total value of production (Castle et. al., 1987). VAA differs from NFI by not subtracting wages, interest, and rent. VAA is a measure of the "net output that remains in the farm sector to reward all persons who have committed land, labor, capital, or management skills to these businesses." VAA is "more appropriate to making relevant comparisons across different types of farming" (Stanton et. al., 1992). VAA includes returns to firms that may be in the input sector such as lenders and landlords (USDA, ERS, 2001a). Thus VAA is not an accurate measure of returns to the farming sector when defining the farming sector as the activity taking place on or around the farm (Smith, 1997). The U.S. Department of Agriculture (USDA, ERS) has used VAA in addition to NFI in national agricultural income accounts since 1993 (USDA, ERS, 2001b). USDA started using VAA to account for all providers of factors of production, to make it easier to observe what is causing changes and trends in farm

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[9] Return to total capital is calculated by first adjusting net farm income by adding interest paid and subtracting the value to unpaid family labor. The opportunity costs of labor and management are then subtracted from this adjusted net farm income to derive return

income and to be more consistent with internationally accepted measures (USDA, ERS, 2001a).

While VAA measures returns to production agriculture, which includes both input and farming sector firms, it does not measure returns solely to the farming sector. Farm budget analysis can measure returns to the farming sector with various farming value added measures. Farming value added (FVA) is a measure of the value contributed by farm families and farm labor. FVA is equal to farm revenues minus inputs purchased from non-farm firms. In addition to being measured as an absolute value, FVA can be measured as a proportion of producers' share (Files, 1999) and as a proportion of consumer expenditures (Smith, 1992; Smith, 1997).

Technology Adoption Impacts. Technology adoption can provide considerable benefits to farmers and processors of agricultural commodities. Agricultural commodities with more elastic demands have greater increases in producer surplus than commodities with more inelastic demands (Caswell and Shoemaker, 1993). A dynamic, general equilibrium simulation model for rice demonstrates that adoption of high yielding rice varieties increases profits per producer (Ito et. al., 1992). Input-output models show mechanization increases rice farmers' incomes (Ahammed and Herdt, 1983). Gross margin budgets and linear programming models indicate technology adoption can benefit individual producers by reducing costs of lamb production (Griffith et. al., 1995). Cluster analysis shows that softwood lumber and plywood companies that adopt new manufacturing technologies appear to have greater profitability and market share than those that do not (Cohen and Sinclair, 1990).

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to total capital. Return to equity is net farm income minus the opportunity costs of labor and management, minus the value of unpaid family labor (Kay, 1986).

Technology adoption can have negative social impacts. Farm mechanization can result in undesirable social costs such as the "technological displacement" of laborers that were necessary prior to the adoption of tomato harvesters. Even though net social returns are positive for tomato harvester adoption after compensating displaced labor, the benefits and costs of using tomato harvesters needs to be distributed more equitably (Schmitz and Seckler, 1970). The benefits to consumers from adopting recombinant trout growth hormone (rTGH) in aquaculture can be measured by consumer's surplus. Consumer's surplus may be negative if consumer acceptance of rTGH in trout aquaculture is unfavorable (Bonnieux et. al., 1993).

Technology adoption can have negative impacts on agricultural producers. Analysis of incremental revenues and costs shows that the use of recombinant bovine somatotropin (rBST) may be less profitable for small Wisconsin dairy farms (Marion and Wills, 1990). The use of high yield varieties of rice by U.S. farms increases profits per farmer but at the expense of a decrease in the total number of farms (Ito et. al., 1992). Producing larger and leaner Australian lamb may not benefit producers since production costs are higher than with traditional lamb and since a local price premium is not available (Griffith et. al., 1995). Models using social accounting matrices show that modern irrigation technologies may be better at increasing productivity than mechanization. Thus mechanization may not be the best choice to increase farm production (Ahammed and Herdt, 1983).

Impacts on Returns to Farmers and the Farming Sector. Organic farms tend to use different production technologies than conventional farms. Organic farming "avoids or largely excludes the use of synthetically compounded fertilizers, pesticides, growth regulators, and livestock feed additives. To the maximum extent feasible, organic farming systems rely upon crop rotations, crop residues, animal manures, legumes, green manures, off-farm organic wastes, mechanical cultivation, mineral-bearing rocks, and aspects of biological pest control to maintain soil productivity and tilth, to supply plant nutrients, and to control insects, weeds and other pests" (Stanhill, 1990; Bateman and Lampkin, 1986). These alternative production technologies may result in variable returns to farmers. Prior research comparing returns to conventional and organic farms have shown mixed results.

Klepper et. al. (1977) and Lockeretz et. al. (1978) have shown comparable average net incomes between fourteen commercial organic and fourteen conventional farms in the Midwest raising field crops such as "corn, soybeans, hay, wheat and oats" from 1974 to 1976. Organic farms were matched with similar conventional farms in the area for comparison. Organic commodity prices were assumed to be the same as conventional prices even if organic farmers received a price premium. Another study on Midwest farms growing similar crops from 1977 to 1978 showed comparable returns between organic and conventional farms. In 1977, a year with poor growing conditions, net returns for all crops were not significantly different between organic and conventional (Shearer et. al., 1981).

Some studies have shown that returns may be greater for organic than conventional farming. A 1986 study of grain farms in the Palouse region in Washington showed higher returns for organic compared to conventional farmers assuming 1986 average market prices. Organic farms had 31% higher net returns for high yields and 448% higher net returns for low yields (Goldstein and Young, 1987). An economic analysis of experimental data of 1978 to 1985 Nebraska corn and soybean production showed mean net returns for organic systems to be an average of 1% greater than conventional systems. This assumed organic farmers only paid for manure application and not for the manure itself (Helmers et. al., 1986). Hypothetical farm budgets for field crop farms in Ohio indicate that net returns for organic farms are 11% greater than conventional farms. Positive differentials for organic farms were an organic price premium, reduced expenditures on chemical inputs, and high returning crop mixes such as soybeans and hay. Negative differentials for organic farms were reduced yields, smaller farm size, and lower government program payments (Batte et. al., 1993).

Numerous studies have shown lower profitability for organic compared to conventional agricultural production. In a study conducted on New York and Pennsylvania wheat farms during 1974 to 1975, profitability for organic farms was on average about 76% lower than conventional farms due to lower yields and higher opportunity costs for organic farms[10] (Berardi, 1978). Goldstein and Young found that if 1986 government target prices and equal wheat yields were assumed, organic grain farms had 21% lower net returns for high yields and 7% lower net returns for low yields compared to conventional grain farms. A 1985 to 1986 study of Australian wheat farmers showed that net incomes for chemical-free farms were 19% lower than for conventional farms (Wynen and Edwards, 1988). Shearer et. al. (1981) showed in 1978, a year with above-average growing conditions, field crop net returns for organic farms were 13% lower than for conventional farms. A 1978 to 1982 simulation model comparing the transition from conventional to organic corn, soybean, and grain

[10] Profitability in this study was defined as revenues minus total economic production costs. Although opportunity costs were higher for organic wheat farms, cash operating costs for organic farms were lower (Berardi, 1978).

production in Pennsylvania showed similar results. Returns over cash operating costs were 7% lower for organic compared to conventional production after a five-year transition period (Dabbert and Madden, 1986). Helmers et. al. (1986) showed mean net returns for organic field crop systems to be 17 % lower than comparable conventional systems assuming farms had to pay for manure at the price of conventional fertilizer. In a Florida study, net revenues are substantially less for labor intensive, biodynamic vegetable production compared to capital intensive, conventional production (Canler and Colette, 1980).

The Maine Potato Ecosystem Project contrasted returns over variable costs (ROVC) for conventional, reduced input and biological potato production[11]. Results show conventional potato production has lower ROVC than reduced input production. This is due to comparable yields between reduced input and conventional plots and to lower variable costs for reduced input production. However, ROVC is greater for conventional than biological potato plots assuming conventional and biological potatoes have the same farm price (Marra, 1996b; Gallandt et. al., 1998). This is due to lower yields for biological compared to conventional potato production during field experiments (Porter and McBurnie, 1996; Lampkin, 1994b; Stanhill, 1990).

Prior research has contrasted hypothetical livestock and potato operations using varying degrees of sustainable farming technologies. These technologies include compost and manure applications, spatial integration of livestock and potato operations, and rotational grazing. Both large and small operations are contrasted for all scenarios.

[11] The Maine Potato Ecosystem Project is a long-term study of potato cropping systems started in 1991, at the University of Maine's Aroostook Farm Research Center in Presque Isle. Conventional, reduced input, and biological production systems are studied. Biological plots approximate organic potato production using manure and compost instead of chemical fertilizers. Biological agents and cultural practices are used to control pests instead of chemical pesticides (Marra, 1996a).

Net farm income (NFI) and farming value added as a proportion of producers' share (FVA_p) are used to contrast returns to farmers and the farming sector respectively. NFI is higher for large operations than small ones. NFI for large conventional, spatially integrated, confined feeding dairy operations was 19% higher than for similar dairy operations that used rotational grazing instead of confined feeding. However, FVA_p is 7% greater for spatially integrated dairy and potato operations using rotational grazing than for those using confined feeding. Large spatially integrated dairy and potato operations using rotational grazing have 18% higher FVA_p than large spatially separated dairy and potato farms using confined feeding (Files, 1999).

Potato Production and Processing

A detailed background of the methods used to cultivate potatoes and to process potatoes into potato chip products is provided. Differences between conventional and organic potato production are outlined. The different processing technologies for converting raw potatoes into potato chips and potato crisps are also discussed.

Conventional and Organic Potato Production

There are significant differences between conventional and organic potato farms in Aroostook County, Maine. Conventional and organic farms differ in the technologies and inputs used during production. Conventional and organic producers are also distinguished by the way their products are marketed. Organic potato producers in Aroostook County tend to grow a wider variety of agricultural commodities than their conventional counterparts.

Conventional Potato Production. Conventional potato production in Aroostook County, Maine has declined over the past few decades. From 1969 to 1997, the number of potato farms in Aroostook County decreased from approximately 2000 to 400 (USDA, NASS-CA; MPB, 2001). Total harvested acreage dropped from approximately 126,000 acres to 65,000 acres from 1964 to 1997. During this same period, potato production declined from about 34,524,000 to 17,172,000 cwt. In 1992, roughly 565 potato farms harvested about 21,870,000 cwt on 73,000 acres (USDA, NASS-PS; MPB, 2001). These conventional potato farms along with others in Maine use capital-intensive production technologies.

The decline in potato production in Aroostook County, Maine, over the past few decades has been affected by production shifting to Canada and the Pacific Northwest (MPB, 2002). For instance, total regional potato production in Maine, New Brunswick and Prince Edward Island increased from about 218,000 to 240,000 acres from 1980 to 1997. During this time, total potato acreage in Aroostook County decreased from approximately 97,000 to 65,000 acres while acreage increased in Prince Edward Island from about 58,000 to 112,000 acres. Acreage in New Brunswick increased slightly from about 52,000 to 56,000 acres from 1980 to 1997 (MPB, Online).

Much of the decline in Maine production has been in tablestock. Seed production has remained relatively constant while processing acreage has increased. The Maine Potato Board (MPB) estimates processing acreage in Aroostook County increased from about 20,000 to 45,000 acres from 1980 to 1997. Consumers have been consuming less tablestock and more processed potato products such as frozen french fries and potato chips (MPB, 2002). This is reflected in national changes in potato production and utilization. From 1964 to 1997, total U.S. tablestock potato production decreased from about 68 to 49 pounds per person while per capita potato production for frozen french fries increased substantially from approximately 12 to 62 pounds. Potato production for chips increased slightly from about 15 to 18 pounds per person during this time (NPPB, Online).

In recent years, conventional producers primarily marketed their potatoes using contracts with frozen french fry and potato chip processors. The MPB estimated 60% of potatoes grown in Aroostook County are processed. About 45% of potatoes are contracted to McCain's or other frozen french fry processors with 15% contracted to chippers like Frito Lay. Roughly 20% of potatoes are marketed as tablestock. The remaining 20% are sold as seed for sale both inside and outside the area. Aroostook County accounts for approximately 90% of the potato farms in Maine. Potato farms outside of Aroostook County market about 70% of their potatoes for chipping, 25% for tablestock and 5% for seed (MPB, 2001).

Organic Potato Production. Although it remains a small fraction of total potato production, organic potato acreage in Aroostook County, Maine has increased in recent years. From 1992 to 1999, the number of organic potato farms in Aroostook County certified by the Maine Organic Farmers and Gardeners Association (MOFGA) increased from three to ten. Certified acreage increased from 15 to about 56 acres from 1992 to 1999. Assuming an average organic yield of 150 cwt/acre, output increased from about 2,250 to 8,400 cwt during this time period (MOFGA, 2001). Founded in 1971, MOFGA is an affiliation of farmers and gardeners that undergo a certification process to market their products as MOFGA-certified organic.

Organic potato farms may differ from their conventional counterparts by production technologies and marketing. Organic potato farmers in Aroostook County use many production technologies that are consistent with organic farming objectives and other organic producers in northern New England (Mitchell, 1994). Organic farming uses production systems dependent on "farm-derived renewable resources and the management of ecological and biological processes and interactions" to produce crops, prevent pests and disease, and to provide adequate financial returns (Lampkin, 1994a). These production technologies are used to achieve soil fertility and/or prevent pest infestations. Most organic potato farms in Aroostook County sell a portion of their produce to wholesale markets. These organic potato farms also use marketing techniques in addition to wholesale distributors and contracts, including selling more directly to consumers. These alternatives may include farm stands, farmers' markets, mail and Internet order, and community supported agriculture (CSA) arrangements[12].

Manufacture of Potato Chips and Potato Crisps

Frito Lay, a subsidiary of PepsiCo, Inc., uses different production processes for Lay's Classic®™ potato chips and Baked Lay's®™ potato crisps. Lay's Classic®™ potato chips are made from whole potatoes using processes consistent with the industry. Baked Lay's®™ potato crisps are baked using dough made primarily from dehydrated potato flakes.

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[12] CSA arrangements are organizations between members of a community and a local farmer. Members buy shares of produce, generally making initial payments to the farmer in the spring before planting. This insures that the farmer can pay expenses incurred at the start of the growing season. CSA members take on some of the risk involved in production since their share price is the same regardless of whether there are crop surpluses or shortages. Highly successful CSA arrangements are ones that are organized and run by members rather than by farmers. CSA organizations "have emerged from the organic and biodynamic farming communities" and are not commonly used among conventional farmers (Mitchell, 1994).

Potato Chips. The annual use of potatoes by the potato chip industry has remained fairly constant between the mid-1960's and the mid-1980's. Annual industry-wide potato use during this period fluctuated around 3.5 billion pounds per year. Industry potato use has increased since the mid-1980's (Smith, Ora, 1987). Frito Lay currently uses about 5 billion pounds of potatoes a year with roughly four pounds of potatoes needed to make one pound of potato chips. Chipping plants and suppliers for each plant are regional (Frito Lay, 2001).

Most potato chips are processed in fewer than a hundred nationwide processing facilities. Potato chip processing varies slightly between the larger potato chip companies. However, the basic process is similar throughout the industry. Production starts with either a hand or mechanical grading process to remove stones and defective potatoes. These graded potatoes are loaded into a washer. After washing, potatoes are usually peeled using a "continuous-type" abrasion peeler. The rotten portions of the peeled potatoes are removed by hand cutting. The potatoes are then sliced in a "potato-slicing unit." The most widely used slicer is a centrifugal slicer that can process up to 7000 pounds of potatoes an hour. Potato slices are washed to separate thin slices and to remove excess surface starch, which prevents chips from sticking together during frying. Slices are dried before frying.

Potato chips are either batch fried or continuously fried. Chips like Cape Cod®™ are batch fried while Lay's Classic®™ chips are continuously fried. Continuous fryers have a higher production capacity than batch fryers. Potato chip plants can have multiple continuous fryers with each fryer handling 4000 to 8000 pounds of potatoes an hour. During the frying process, water in the slices is displaced with oil releasing water vapor.

Since moisture levels in potatoes vary, it is important to be able to control the rate that the potato chips move through the fryer. All elements in the frying machine are either manually adjustable or automatically controlled. Selection of oils used in frying is dependent on market prices of these oils as well as regional consumer preferences. After frying, the potato chips are loaded onto a hopper that runs through a salting machine. The chips are cooled and mechanically inspected for defective chips, which are removed. Finally, potato chips are mechanically weighed and packaged into a "flexible-film packaging" that minimizes rancidity and staleness from exposure to heat and light (Smith, Ora, 1987; Frito Lay, 2000).

Potato Crisps. Baked Lay's®™ potato crisps are produced using dehydrated potato flakes. About five pounds of potatoes are used to make one pound of Baked Lay's®™ potato crisps. Dehydrated potato flakes have been used to make fabricated potato chips since the late 1960's, but Frito Lay was the first company to market potato crisps with only 1.5 grams of fat per serving. Baked Lay's®™ was introduced into general markets in January of 1996 (Demetrakakes, 1997). The immediate popularity of Baked Lay's®™ is obvious from first year sales, which were approximately $275 million from over 2.5 million bags of crisps sold (Toops, 1997). Baked Lay's®™ have about three-quarters the calories per serving compared to Lay's Classic®™ (Frito Lay, 2001). Producing such a potato crisp required a substantial commitment to research and development (McGraw, 1996).

Baked Lay's®™ are produced by gently mixing dehydrated potato flakes, water, modified food starch, sugar, corn oil, partially hydrogenated soybean oil, salt, soy lecithin, leavening, and dextrose into dough. There are many potential problems that must be avoided in order to produce a successful potato crisp. The dough can become excessively sticky if the potato starch is overexposed to heat, making it difficult to roll into sheets. Once the dough is rolled out, it may break apart easily. Cut dough is prone to shrinking and accurate control of the dough's water content is a challenge.

The key to successful baking of the crisp is for the dough to have the proper starch to fat ratio. Once the proper starch to fat ratio is reached, the dough is run through a series of rollers to get it to the desired thickness. A series of automated cutters punch out a wide variety of shapes to simulate the irregularity of traditional potato chips. It is speculated that the dough pieces are then fed through either a convection or a gas oven with anywhere from two to five temperature zones. Temperatures start at 600 to 700°F and drop to 300 to 400 °F. During the baking process, the moisture content drops from about 45% to 2%. Most traditional potato chips have moisture contents of around 2%. After baking, the potato crisps are seasoned depending on the variety. They are packaged for sale similar to potato chips (Demetrakakes, 1997).

Details for some Baked Lay's®™ ingredients deserve attention. Drying cooked, mashed potatoes in drum driers with applicator rolls to a specific moisture level produces dehydrated potato flakes (Willard et. al., 1987). About 60% of dehydration plants are in Idaho while the remaining 40% are in Washington, Nevada, Wisconsin, and North Dakota (FSMNS, 2000b). Corn oil is pressed from the germ of the corn kernel during either wet or dry milling[13]. Cornstarch is separated from wet milled corn gluten (USDA, ERS, 2000). Modified food starch can be derived from cornstarch (Orthoefer, 1994).

[13] During dry milling, corn is degermed and dehulled. The corn is then processed into corn meal or brewers' grits. The germ is pressed for oil. The hulls are sold as hominy feed. During wet milling, the corn is soaked, the corn hull and germ are both removed and the germ is pressed to extract oil. The byproducts of wet milling are corn gluten feed and corn gluten. After cornstarch is separated from corn gluten, corn gluten feed remains. Cornstarch is used to produce three sweeteners: regular corn syrup, high-fructose corn syrup, and dextrose. The byproduct of either oil extraction process is corn germ meal (USDA, ERS, 2000).

About 75% of the cornstarch produced is used for the production of corn sweeteners including dextrose (Hebeda, 1994). Sugar production in the U.S. is evenly split between the refining of sugar beets and sugarcane[14]. Refined sugar recovery rates are about 15% and 12% for sugar beets and sugarcane respectively (FSA, 2001). After soybean oil is pressed from soybeans, residual fibers and gums are removed from the oil by degumming. Soy lecithin is produced during degumming. Refined soybean oil is hydrogenated to produce partially hydrogenated soybean oil (O'Shea, 2001).

[14] During sugar beet refining, the sugar beets are sliced and processed. White sugar can be directly obtained from sugar beets. Byproducts are beet pulp and molasses. During sugarcane refining, the cane is crushed to extract cane juice. Raw sugar is refined from cane juice. Byproducts of refining are solid waste, bagasse, and molasses. Raw sugar must be sent to another processor for further refinement into white sugar (FSA).

Chapter 3

TECHNOLOGY ADOPTION AND IMPACTS IN POTATO PRODUCTION

Conventional farmers have adopted technologies encouraging technology treadmills and farm cannibalism. Conventional agriculture encourages appropriationism from the input sector and substitutionism from the marketing sector. In contrast, organic agriculture uses technologies that may recapture activities and revenues from the input and marketing sectors. Production technologies used by organic farmers reduce reliance on purchased chemical inputs. However, many organic farmers are reliant on purchased organic fertilizers such as fish waste and manure. In some cases this may provide fewer returns to the farming sector since the cost of procuring and applying off-farm organic fertilizers can be greater than chemical fertilizers.

Some organic farmers produce value-added products and market directly to consumers. Such marketing increases returns to the farming sector but also incurs extra costs. Thus, organic farming may or may not provide greater returns to the farming sector than conventional farming. Previous research indicates that returns over variable costs for farmers may be greater for conventional compared to organic production due to the lower yields of organic production. However, this prior analysis assumes that both types of potatoes sell for the same farm price. Conventional and organic potatoes do not sell for the same price at the farm or retail level. Farm profitability for organic operations may be greater if an organic price premium is used for potatoes. This assumes that this premium is large enough to cover the higher costs per unit of output for organic farms.

Appropriationism in potato production would be demonstrated if returns to the farming sector are smaller relative to returns to the input sector for conventional compared to organic farming. To demonstrate Goodman, Sorj and Wilkinson's concept of appropriationism, farming value added measures are estimated for conventional and organic potato farms in Aroostook County, Maine. Derivation of these measures is outlined in the methods section. The results section shows the comparative values of these various farming value added measures for conventional and organic potato sectors in Aroostook County.

Methods

Farm budgets are constructed for conventional and organic potato operations (Tables 3.3 to 3.6). Budgets include gross income from growing potatoes and complementary crops as well as itemized production and marketing expenses. These budgets are used to estimate average values for net farm income (NFI) and farming value added measures for conventional and organic operations. Farming value added measures are 1) farming value added (FVA), 2) farming value added as a proportion of producers' share (FVA_p), and 3) farming value added as a proportion of consumer expenditures (FVA_c).

Data

Aroostook County conventional potato farm data were obtained from Farm Credit of Maine while organic farms were surveyed. Farm Credit data were used as a proxy for a representative survey of conventional potato farmers in Aroostook County. Budget data from Farm Credit of Maine may not be representative of conventional potato farmers since it may be biased toward more financially successful farmers. A survey of

Aroostook County Organic Potato Farmers conducted from 2000 to 2001 provided data for organic potato farmers for the 1999 crop year.

Conventional Farms. For conventional potato farms, averaged budgets were collected from Farm Credit for the 1998 crop year. Budget data from 1999 were not available. These budgets list gross income, net income, and itemized per acre or per farm expenses for each category of conventional potato farm (Tables 3.3 to 3.6). Potato farms are categorized by size and by market channels. Average potato acreage for small, medium and large conventional potato farms are 112, 197, and 372 acres respectively. Average conventional farm size is calculated by assuming a two-year rotation of potatoes and grain, the dominant rotation in Aroostook County. Thus, small, medium and large conventional potato farms have an average farm size of 224, 394, and 744 acres

Table 3.1: Average farm size and sample size for size classifications and marketing channels of conventional and organic potato farms in Aroostook County, Maine[a].

Farm Sample Attribute	Small	Medium	Large	Tablestock	Seed	Processing
Conventional						
Farm Sample Size	13	14	14	5	11	25
Average Potato Acreage	112	197	372	253	194	241
Average Farm Size (Calculated acres)	224	394	744	506	388	482
Organic						
Farm Sample Size	3	3	5	10	1	0
Average Potato Acreage	1	4	13	8	6	N/A
Average Farm Size (Acres)	24	11	38	28	12	N/A

[a] Conventional and organic data from 1998 and 1999 crop year respectively

respectively (Table 3.1). Average potato acreage for conventional tablestock, processing and seed potato farms is 253, 241, and 194 acres respectively. Average farm size for conventional tablestock, processing and seed potato farms is 506, 482, and 388 acres respectively, assuming a two-year rotation (Table 3.1).

Conventional potato farms in Maine use chemical fertilizers, pesticides, herbicides and fungicides. A 15-15-15 nitrogen, phosphorus, and potassium fertilizer is an example of a commonly used conventional fertilizer. A chemical pesticide commonly used to control the Colorado potato beetle (CPB) is Admire®™. Weeds are primarily controlled by applications of herbicides such as Sencore®™. Late blight is managed with non-organic fungicides such as Bravo®™. Crop rotations are generally shorter than organic rotations, involving a two-year rotation of potato and rotation crop such as barley, oats, or soybeans.

Organic Farms. Twelve organic potato farms certified by the Maine Organic Farmers and Gardeners Association (MOFGA) were surveyed in Aroostook County, Maine. All twelve organic potato farms participated in a background survey. However only eleven of these twelve farms participated in the FVA survey. Only one of the twelve surveyed farms was MOFGA certified organic in 1992. From 1992 to 1999, harvested potato acreage for surveyed farms increased from approximately 10 to 83 acres. Assuming an average organic yield of 150 cwt/acre, output increased from approximately 1,500 to 12,400 cwt during this time period. Organic farms that specialize in potato production grow an average of ten acres of potatoes. Organic farms that grow potatoes as part of a diversified portfolio of crops grow an average of only one acre of potatoes.

In 1999, the average organic tablestock potato farm grew about 8 acres of potatoes on approximately 28 acres. The only organic seed potato farm grew 6 acres of potatoes on 12 acres. Small organic potato farms have larger average farm size compared to medium sized potato farms since they grow a wider range of crops. Small, medium and large organic potato farms had average farm sizes of about 24, 11, and 38 acres respectively in 1999. Small, medium, and large organic potato farms grew an average of approximately 1, 4, and 13 acres of potatoes respectively (Table 3.1).

Seven of the twelve organic potato farmers in Aroostook County produce a diverse mix of crops. Examples include carrots, onions, squash, rutabaga, dry beans and other mixed vegetables as well as fruit such as apples and raspberries. The other five grow more limited numbers of crops for sale. These crops are potatoes, grain and/or hay. Four of the twelve farmers raise commercial livestock, which are integrated with their crops. Three raise non-commercial livestock for home consumption.

The majority of organic potato farmers in Aroostook County use long crop rotations of three to four years, involving a sequence of potato, grain, and clover. Most use cover crops and green manuring. Half use compost in production. However, all the farmers use some off-farm fertilizer ranging from fish waste to soybean meal to animal manure. Biologically benign pesticides and fungicides are used. These include foliar applications of Novador®™ Bacillus thuringiensis (Bt) to control for the CPB and Kocide®™ or Champ®™ copper fungicides to prevent late blight. Weeds are controlled by mechanical and hand cultivation.

Organic potato farmers in Aroostook County also use a wider variety of marketing practices than conventional, some of which are similar to conventional agriculture of the past. Most organic farmers pack and grade their potatoes and sell to wholesale distributors. Over half sell to or with other farmers, sell to retail stores, or direct market their potatoes to consumers. Methods of direct marketing include farm stands, farmers' markets, mail and Internet order, and community supported agriculture. Only one organic farmer uses mail and Internet order. Less than half of the organic potato farmers have contracts with other farmers. Only one organic farmer has a french fry contract since this farmer has both conventional and organic operations. One quarter of the organic farmers add value to their products by further processing. Examples of value-added commodities include frozen raspberries and bread mixes. Eleven of the twelve organic potato farms surveyed marketed to tablestock markets while the remaining farm grew for a seed potato market.

Gross income, net income, and itemized production and marketing expenses were collected from organic farmers in Aroostook County with written and oral surveys and compiled into budgets (Tables 3.3 to 3.6). Each farmer estimated what percent of each itemized expense was purchased from other farmers. Only three of the twelve organic farms surveyed were able to sustain their family's needs on net farm income. One of these three farms has both a conventional and organic operation. Nine of the twelve organic farmers surveyed considered farming a significant part of their livelihood.

Budgets for organic farms represent the actual farm crop mix. Six of the twelve organic potato farms relied on potatoes as their major cash crop. The other six farms grew other cash crops in addition to potatoes. In addition to cash crops, all twelve farms grew rotation crops of grains and clover. Production and marketing expenses for all farms are not adjusted by the percentage of each expense used exclusively for potatoes, due to difficulty in estimating such a percentage for each expense.

Net Farm Income Estimation

Net farm income (NFI) is calculated for all categories of conventional and organic potato farms in Aroostook County. Net farm income for a particular farm is gross farm income minus all itemized expenses incurred by the operation. Itemized expenses include 1) seed, 2) fertilizer, 3) chemicals, 4) labor, 5) gas, fuel and oil, 6) repairs, 7) supplies, 8) insurance, 9) miscellaneous expenses, 10) interest, 11) property taxes, and 12) depreciation.

Farming Value Added Estimations

As noted in the literature review, FVA_p is the proportion of total farm revenue that is retained in the farming sector. Budget line items that return to both farming and non-farming sectors must be adjusted by appropriate FVA factors to calculate FVA, FVA_p, and FVA_c. FVA only subtracts non-farming sector expenses from gross farm revenue.

Farming Value Added Factors. FVA_p is the proportion of a farmer's total revenue that is retained in the farming sector. Total costs are categorized as "a" costs and "b" costs. Farm production costs representing goods and services provided by non-farming sectors are denoted as "a" costs while "b" costs represent goods and services provided by the farming sector. FVA_p is total farm revenue minus "a" costs divided by total farm revenue. Thus a FVA_p value of zero indicates that no farm revenue is retained in the farming sector while a FVA_p of one means that all farm revenue is retained in the farming sector.

Any of the twelve production expenses listed above may consist of both "a" and "b" costs. Therefore, each itemized expense is adjusted by the appropriate FVA factor to determine the percentage of each expense that is a "b" cost. For example, labor and property tax expenses directly paid by the farmer return all of their cost to the farming sector by definition. Thus labor and property taxes are direct impacts of FVA and have FVA factors of 100%. A proportion of items purchased from other farmers contribute to farming value added. In that contribution to FVA are the input providing farm's returns to farm profits, labor, and property taxes from the sale of that input. These are the indirect impacts of FVA. An expense that has a FVA factor of 20% returns 20% of its cost to the farming sector and 80% of its cost to non-farm sectors. FVA factors for conventional and organic potato farm expenses are given in Table 3.2.

Budget line item expenses for both conventional and organic farms are adjusted as follows. Labor and taxes are adjusted by FVA factors of 100%. Total seed costs appear as a budget line item. It is assumed that total seed expenses are split between potato seed and common rotation crop sequences such as oat/clover and barley/lentil rye. Based on current seed prices and application rates from Agway and Maine Potato Growers, the cost per acre proportion of potato (0.90) to rotation crops (0.10) is derived. Thus 90% of total seed cost is adjusted by a FVA factor of 43% for potato seed while 10% of total seed cost is adjusted by a FVA factor of 22%. This FVA factor of 22% is used for barley seed and as a proxy for oat, clover, and lentil rye seed.

Farm Credit of Maine did not itemize miscellaneous budget line item expenses for conventional farms. These line items are assumed to be all "a" costs since conventional farms use few miscellaneous items from other farms. This assumption is supported by the conventional budget of one of the surveyed organic farmers whose main income is from producing conventional potatoes for the processing market. Miscellaneous expenses are adjusted with FVA factors for organic farms based on the percentage of

Table 3.2: FVA factors for conventional and organic potato operations with source of information.

Budget Line Items	FVA Factors (%)	Source
Direct impacts paid by farmer		
1) Labor	100	From definition of FVA
2) Property Taxes	100	From definition of FVA
Indirect impacts from purchases from other farmers		
3) Potato Seed	43	Based on the average FVA ratio for the conventional treatment of the MPE Study (Files, 1999)
4) Grain and Cover Crop Seed	22	Barley and alfalfa seed used as proxy for oat, clover and lentil rye (Files, 1999)
5) Miscellaneous (Organic):		
a) Produce Bought	43	Potato seed used as proxy (Files, 1999)
b) Rent or Lease:		
Vehicle/Mach./ Equip.	20	Barley custom combine rental used as proxy (Files, 1999)
Land	100	Rented from other farmers
Animals	42	Replacement heifers used as proxy (Files, 1999)
c) Custom Hire	20	Barley custom combine rental used as proxy (Files, 1999)
d) Feed Purchased	43	Potato seed used as proxy (Files, 1999)
e) Poultry and Bees	42	Replacement heifers used as proxy (Files, 1999)

each miscellaneous cost purchased from other farmers as reported in the survey. This percentage of the line item cost is adjusted by the appropriate FVA factor for 1) produce bought, 2) rent or lease of a) vehicles, machinery, and equipment and b) land, animals, etc., 3) custom hire, 4) feed purchased, and 5) poultry and bees. Table 3.2 lists FVA factors for these itemized miscellaneous expenses. For example, if 50% of a farmer's produce bought is purchased from other farmers, then half of this expense is adjusted by a FVA factor of 43%.

Farming Value Added Equations. After all farm expenses are adjusted by the appropriate FVA factors, three farming value added measures are estimated. These are 1) farming value added (FVA), 2) farming value added as a proportion of producers' share (FVA_p), and 3) farming value added as a proportion of consumer expenditures (FVA_c).

Farming Value Added. FVA is calculated for conventional and organic potato farms in Aroostook County. FVA is calculated by the following equation:

$$FVA = (TR - TC) + TC_b \tag{1}$$

$$= [TR - (TC_a + TC_b)] + TC_b \tag{2}$$

$$= TR - TC_a \tag{3}$$

Where: TR = Total revenues ($)
TC_a = Total cost of inputs from the non-farming sector ($)
TC = Total cost of inputs from both the farming and non-farming sectors ($)
TC_b = Total cost of inputs from the farming sector ($)

In other words, FVA is total farm revenues (TR) minus "a" costs, or TC_a. TC_a includes fertilizers, pesticides, and equipment. Total cost of inputs from the farming sector (TC_b) are not subtracted from TR. TC_b includes paid labor, real estate taxes, and the proportion of purchases from other farmers that remain in the farming sector.

Farming Value Added as a Proportion of Producers' Share. FVA_p is also calculated for conventional and organic potato farms. A FVA_p value of zero indicates that no farm revenue is retained in the farming sector while a FVA_p of one means that all farm revenue is retained in the farming sector. Average values for FVA_p for both the conventional and organic potato sectors in Aroostook County are calculated and contrasted. The following equation is used to calculate FVA_p for each individual farm:

$$FVA_p = \frac{FVA}{TR} \tag{4}$$

From Equation (3), Equation (4) can be written as:

$$FVA_p = \frac{TR - TC_a}{TR} \tag{5}$$

$$= 1 - \frac{TC_a}{TR} \tag{6}$$

Farming Value Added as a Proportion of Consumer Expenditures. FVA_c is defined as farming value added as a proportion of consumer expenditures for the final consumer products (E) produced from a farm:

$$FVA_c = \frac{FVA}{E} \tag{7}$$

Where: E = Consumer expenditures for the final consumer products produced from farm commodities ($)

Since such consumer expenditures are difficult to observe from the data collected, FVA_c is estimated using the following equation where FVA_c is equal to farming value added as a proportion of producers' share (FVA_p) multiplied by producers' share as a proportion of consumer expenditure for the farm:

$$FVA_c = FVA_p\{P_{pc}\} \tag{8}$$

Where: P_{pc} = Producers' share as a proportion of consumer expenditure for the farm

This proportion (P_{pc}) can be expressed for i crops and j markets:

$$FVA_c = FVA_p\left\{\sum_i\left[\sum_j \frac{p_{ij}^p q_{ij}^p}{p_{ij}^c(q_{ij}^c t_i)} w_j\right] w_i\right\} \tag{9}$$

Where: p_{ij}^p = Price that a farm receives for crop i in market j ($/lb)

q_{ij}^p = Quantity of crop i in market j sold (lb)

p_{ij}^c = Price that consumers pay for value-added product produced from crop i in market j ($/lb)

q_{ij}^c = Quantity of value-added product produced from crop i in market j purchased by consumers (lb)

t_i = Conversion for raw product to consumer purchase

w_i = Share weight of crop i by value of production

w_j = Share weight of marketing channel j for crop i by volume of production

For conventional potato farmers, it is assumed that 100% of the value of production is from potatoes and a rotation crop such as barley. For organic farmers, there is usually more value of production attributed to other crops. Conventional marketing channels include wholesale tablestock distributors, processing markets such as chipping and french fries, and wholesale seed distributors. Tablestock and seed are the only marketing channels used by the surveyed organic farmers. Tablestock markets include wholesale distributors, a cooperative, retail stores, and direct marketing to consumers. Organic seed markets are Fedco Seeds, a commercial seed distributor, and direct marketing to consumers.

Results

Conventional and organic potato farms are categorized by size and by marketing channel. Size classifications and marketing channels vary substantially between conventional and organic farms. Average small conventional potato farms grew about 110 acres of potatoes on 220 acres while large conventional farms grew approximately 370 acres of potatoes on 740 acres. Average organic potato production and farm sizes are substantially smaller, ranging from one acre of potatoes grown on about 24 acres for small organic potato farms to approximately 13 acres of potatoes grown on about 38 acres for large organic farms (Table 3.1). While conventional potato farms are classified as producing for a tablestock, seed or processing marketing channel, organic potato farms primarily produce for a tablestock market. Farm budgets are compared for conventional and organic potato farms by farm size. Budget items are listed in dollars per farm (Table 3.3) and in dollars per acre (Table 3.4). Farm budgets are also compared for conventional and organic potato farms by marketing channel with budget items also listed in dollars per farm (Table 3.5) and in dollars per acre (Table 3.6).

Conventional Farms

Estimates for NFI and farming value added measures for conventional potato farms in Aroostook County are provided in Table 3.7. Average NFI and NFI per acre are highest for conventional potato farms producing seed potatoes, followed by farms marketing tablestock and potatoes used for processing. However, FVA is highest for conventional potato farms producing potatoes for processing, followed by farms producing potatoes for seed and tablestock when averaged across farms in each marketing category. FVA per

Table 3.3: Itemized farm budgets for average conventional tablestock, seed and processing farms and for average organic tablestock farms by size ($/farm).

Gross Income, Item. Expenses and Costs	Conventional:			Organic:		
	Small	Medium	Large	Small	Medium	Large (Partial wholesale)
Gross Income	188,115	355,918	711,674	10,857	5,443	121,289
Expenses:						
Seed	19,991	24,410	74,443	2,963	1,006	6,059
Fertilizer	16,172	43,112	69,976	1,284	1,635	4,310
Chemicals	22,125	31,694	98,637	70	-	1,682
Labor	24,595	36,025	86,354	5,894	800	21,101
Gas/Fuel/Oil	6,963	10,237	18,611	1,552	363	3,363
Repairs	13,252	21,457	43,177	2,311	1,323	3,148
Supplies	5,391	8,071	23,450	1,342	480	12,033
Insurance	8,198	10,630	16,005	547	74	1,197
Miscellaneous	24,820	68,309	102,359	7,733	1,866	48,417
Interest	12,578	20,473	16,005	98	-	3,179
Taxes	6,514	11,221	26,799	911	1,550	2,270
Depreciation	14,712	21,064	36,849	901	1,149	5,397
Total Expenses	175,312	306,703	612,665	25,606	10,246	112,155
Variable Costs	133,309	243,315	517,006	23,149	7,473	100,112
Fixed Costs	42,003	63,388	95,659	2,457	2,773	12,043
"a" Costs	136,027	249,474	469,064	16,450	7,484	85,651
"b" Costs	39,285	57,230	143,600	9,156	2,761	26,504

Note: Values may not sum due to rounding.

Table 3.4: Itemized farm budgets for average conventional tablestock, seed and processing farms and for average organic tablestock farms by size ($/acre).

Gross Income, Item. Expenses and Costs	Conventional:			Organic:		
	Small	Medium	Large	Small	Medium	Large (Partial wholesale)
Gross Income	837.50	904.00	956.00	459.44	518.33	3119.97
Expenses:						
Seed	89.00	62.00	100.00	125.41	95.81	155.86
Fertilizer	72.00	109.50	94.00	54.34	155.71	110.87
Chemicals	98.50	80.50	132.50	2.96	-	43.26
Labor	109.50	91.50	116.00	249.41	76.19	542.78
Gas/Fuel/Oil	31.00	26.00	25.00	65.68	34.53	86.50
Repairs	59.00	54.50	58.00	97.79	125.99	80.98
Supplies	24.00	20.50	31.50	56.81	45.73	309.52
Insurance	36.50	27.00	21.50	23.13	7.05	30.79
Miscellaneous	110.50	173.50	137.50	327.25	177.70	1245.46
Interest	56.00	52.00	21.50	4.16	-	81.78
Taxes	29.00	28.50	36.00	38.57	147.62	58.40
Depreciation	65.50	53.50	49.50	38.13	109.43	138.83
Total Expenses	780.50	779.00	823.00	1083.64	975.76	2885.02
Variable Costs	593.50	618.00	694.50	979.64	711.67	2575.22
Fixed Costs	187.00	161.00	128.50	103.99	264.09	309.80
"a" Costs	605.60	633.64	630.10	696.15	712.77	2203.25
"b" Costs	174.90	145.36	192.90	387.49	263.00	681.77

Note: Values may not sum due to rounding.

Table 3.5: Itemized farm budgets for average conventional and organic farms by marketing channel ($/farm).

Gross Income, Item. Expenses and Costs	Conventional:			Organic:
	Tablestock	Seed	Processing	Tablestock
Gross Income	373,681	363,314	460,868	56,188
Expenses:				
Seed	11,638	41,749	45,074	3,665
Fertilizer	48,576	34,953	46,762	2,897
Chemicals	57,178	34,564	57,850	778
Labor	46,299	45,633	52,065	10,743
Gas/Fuel/Oil	9,614	8,350	13,980	2,039
Repairs	20,999	20,195	29,889	2,603
Supplies	3,036	12,816	14,221	6,199
Insurance	7,843	11,068	12,534	705
Miscellaneous	63,503	55,730	71,107	22,857
Interest	18,469	21,166	29,407	1,301
Taxes	15,180	13,981	15,427	1,518
Depreciation	23,276	12,428	29,889	2,659
Total Expenses	325,611	312,633	418,204	57,965
Variable Costs	260,843	253,990	330,948	51,782
Fixed Costs	64,768	58,643	87,256	6,183
a Costs	259,372	235,944	332,278	43,601
b Costs	66,239	76,689	85,927	14,364

Note: Values may not sum due to rounding.

Table 3.6: Itemized farm budgets for average conventional and organic farms by marketing channel ($/acre).

Gross Income, Item. Expenses and Costs	Conventional:			Organic:
	Tablestock	Seed	Processing	Tablestock
Gross Income	738.50	935.50	956.00	1982.73
Expenses:				
Seed	23.00	107.50	93.50	129.33
Fertilizer	96.00	90.00	97.00	102.24
Chemicals	113.00	89.00	120.00	27.44
Labor	91.50	117.50	108.00	379.10
Gas/Fuel/Oil	19.00	21.50	29.00	71.96
Repairs	41.50	52.00	62.00	91.84
Supplies	6.00	33.00	29.50	218.75
Insurance	15.50	28.50	26.00	24.88
Miscellaneous	125.50	143.50	147.50	806.56
Interest	36.50	54.50	61.00	45.92
Taxes	30.00	36.00	32.00	53.56
Depreciation	46.00	32.00	62.00	93.82
Total Expenses	643.50	805.00	867.50	2045.41
Variable Costs	515.50	654.00	686.50	1827.23
Fixed Costs	128.00	151.00	181.00	218.19
a Costs	512.59	607.53	689.26	1538.55
b Costs	130.91	197.47	178.24	506.86

Note: Values may not sum due to rounding.

Table 3.7: NFI and FVA estimates for conventional potato farms in Maine, categorized by size and marketing channel.

Returns to Farmers and Farming Sector	Conventional Potato Farm Averages					
	Small	Medium	Large	Table-stock	Seed	Process-ing
NFI ($/farm)	12,803	49,214	99,009	48,070	50,681	42,664
NFI ($/acre)	57	125	133	95	131	89
FVA ($/farm)	52,089	106,444	242,609	114,309	127,371	128,591
FVA ($/acre)	232	270	326	226	328	267
FVA_p	0.277	0.299	0.341	0.306	0.351	0.279
FVA_c	(N/A)	(N/A)	(N/A)	0.068	(N/A)	0.006

Note: (N/A) refers to farm data that cannot be estimated.

acre is highest for seed followed by processing and tablestock. The price that farmers receive for seed, tablestock and processing potatoes used in this analysis are from 1999 and may be not be representative of the average price received over the past few years. For example, the average 1999 Free on Board (FOB) price of about $0.09/lb for bagged potatoes in Maine is high compared to prices from previous years.

Average NFI and FVA per farm and per acre are larger with increasing farm size, implying economies of size. FVA_p also increases as the size of conventional potato farms increase, implying economies of size. FVA_p is highest for conventional potato seed farms (0.351) followed by conventional farms with tablestock (0.306) and processing (0.279) marketing channels. FVA_c is not estimated by farm size since budgets are not itemized by farm size within each marketing channel. FVA_c is not estimated for seed growers since it is assumed that conventional seed farmers sell their seed to farmers and not to consumers. FVA_c is higher for tablestock (0.068) than for processing (0.006).

Organic Farms

Estimates for NFI and farming value added measures for organic tablestock potato farms in Aroostook County are listed in Table 3.8. Large organic farms are divided into two categories: 1) wholesale, where farms sell 100% of their potatoes to a wholesale market and 2) partial-wholesale, where farms sell 75% or less of their potatoes to a wholesale market. Only one large organic farm falls into the wholesale category and only one organic farm exclusively produces seed potato. Thus, estimates for NFI and FVA are not disclosed for these two farm categories.

Table 3.8: NFI and FVA estimates for organic tablestock and seed potato farms in Aroostook County, Maine, categorized by size and/or marketing channel.

Returns to Farmers and Farming Sector	Organic Potato Farm Averages				
	Tablestock				
	Small	Medium	Large (Wholesale)	Large (Partial wholesale)	Seed
NFI ($/farm)	(14,750)	(4803)	(D)	9134	(D)
NFI ($/acre)	(624)	(457)	(D)	235	(D)
FVA ($/farm)	(5593)	(2042)	(D)	35,637	(D)
FVA ($/acre)	(237)	(194)	(D)	917	(D)
FVA_p	(0.862)	(0.393)	0.126	0.295	0.622
FVA_c	(0.861)	(0.284)	0.044	0.155	(N/A)

Note: (D) refers to farm data that cannot be disclosed. Negative proportionate FVA values indicate that farm "a" costs exceed total revenue.

Organic farms surveyed grow more of a diverse mix of crops than the standard potatoes and grain common on conventional farms. Small organic tablestock farms grow about one acre of potatoes as part of a diversified operation. Medium sized tablestock farms specialize in potatoes growing three to four acres. Large organic tablestock farms also specialize in potatoes growing 10 to 20 acres. Like conventional potato farms, average NFI and FVA per farm and per acre increase with farm size for organic tablestock farms. This implies economies of size for organic potato production. NFI and FVA measures are negative for small and medium sized organic farms.

FVA_p and FVA_c are higher with increasing organic farm size. Since FVA_p and FVA_c are proportions that are not necessarily dependent on farm size, it appears that organic potato farms in Aroostook County exhibit economies of size like conventional potato farms in Maine. It appears that large organic farms growing less than 75% of their potatoes for a wholesale market have FVA_p's that are comparable to those of conventional tablestock farms. FVA_p for large organic, partial-wholesale is 0.295, compared to a FVA_p of 0.306 for large conventional tablestock. These FVA_p's were not statistically different from one another using a two-tailed t-test. The only large organic tablestock potato farm that sold 100% of its potatoes wholesale has a FVA_p that is about 59% lower than the FVA_p for conventional tablestock. This lower FVA_p is probably due to a lower price received for potatoes compared to other large organic potato farms. This lower price may not be high enough to cover higher costs and lower marketable yields.

The only organic seed potato farm has a FVA_p of 0.622, which is about 77% greater than the average FVA_p for conventional seed potato farms of 0.351. The organic FVA_p is about twice that of conventional seed since the price received for organic seed potato is about eight times greater than the conventional price (Table 5.2). Additionally, the organic seed farm has proportionally lower total costs than conventional (Table 5.1).

Small, medium, and large wholesale organic tablestock farms have FVA_c's that are less than conventional tablestock farms. The conventional tablestock FVA_c of 0.068 is about 56% less than large organic partial-wholesale farms that have a FVA_c of 0.155

(Tables 3.7 and 3.8). FVA_c is not estimated for seed growers since it is assumed that organic seed sold to consumers is small compared to seed sold to farmers.

Chapter 4

TECHNOLOGY ADOPTION AND IMPACTS IN THE MANUFACTURE OF POTATO CHIPS AND CRISPS

Comparing producers' share (PS), marketing share (MS), farming share (FS), and input share (IS) demonstrates the concept of substitutionism for Lay's Classic®™ potato chips and Baked Lay's®™ potato crisps. PS measures returns to the input and farming sectors for potato chips and crisps. In other words, PS is the percentage of the consumer dollar spent on a product that is returned to both the input and farming sectors. MS, FS, and IS measure returns to the marketing, farming, and input sectors respectively. Estimates of FS, IS, and MS are derived from estimating PS. The methods section outlines calculation of these estimates and lists data sources. FS is the percentage of the consumer dollar spent on a product that is returned solely to the farming sector. Therefore, FS is equal to farming value added as a proportion of consumer expenditure (FVA_c). FS is estimated from PS for potato chips and crisps rather than estimating FVA_c directly.

A cross sectional comparison of potato chips and potato crisps is used as a proxy for a time series comparison of Lay's Classic®™ potato chips and Baked Lay's®™ potato crisps over time. Substitutionism is demonstrated if farming share is smaller relative to returns to the marketing sector for potato crisps than for potato chips. Potato chips and crisps use different processing technologies and may provide varying returns to the farming sector. Returns to the farming sector may be less for potato crisps than for potato chips since low-grade potatoes are used to make dehydrated potato flakes used in Baked Lay's®™. Farmers receive less money for potatoes sent to dehydration plants than they do for chipping potatoes. The results section illustrates the comparative values of these four shares for potato chips and crisps.

Methods

IS, FS, and MS are derived by estimating PS for Lay's Classic®™ potato chips and Baked Lay's®™ potato crisps. PS is estimated by the sum of the values of all agricultural ingredients in each snack product divided by the value of the snack product. Prices and quantities used are estimated when observed data are unavailable.

Estimating Input, Farming and Marketing Shares

All consumer expenditures for Lay's Classic®™ potato chips and Baked Lay's®™ potato crisps are allocated into three shares:

$$MS_a + FS_a + IS_a = 1 \tag{10}$$

Where: MS_a = Marketing share for product a
FS_a = Farming share for product a
IS_a = Input share for product a

All three shares are the proportion of the consumer dollar that is retained in the three agro-food system sectors. PS is defined as:

$$PS_a = FS_a + IS_a \tag{11}$$

By substituting equation (12) into (11), equations for MS, FS, and IS are derived:

$$MS_a = 1 - PS_a \tag{12}$$

$$FS_a = PS_a - IS_a \tag{13}$$

$$IS_a = PS_a - FS_a \tag{14}$$

PS, MS, FS, and IS can be contrasted between Lay's Classic®™ potato chips and Baked Lay's®™ potato crisps using equations (11) through (14). FS is estimated from PS by multiplying by a mean FVA_p value of 0.279 for conventional Maine potato farms producing potatoes for processing (Table 3.7). This FVA_p value is used as a proxy for Maine potato farms producing potatoes for chipping and hypothetical dehydration. A proxy is used since potato processing includes only chips and french fries in Maine.

Estimating Producers' Share

Returns to the farming sector for Lay's Classic®™ potato chips and Baked Lay's®™ potato crisps are determined by comparing PS for each product. PS for each Frito Lay snack (PS_a) is calculated by the general equation:

$$PS_a = \frac{\sum v_i}{V_a} \tag{15}$$

Where: PS_a = Producers' share for product a
v_i = Value of ingredient i in product a to agricultural producers ($)
V_a = Value of consumer product a ($)

The value to agricultural producer of ingredient i in each snack product (v_i) is defined as:

$$v_i = p_{fi}(t)(q_i) \qquad \text{Where: } t = \frac{m_{ai}}{M_{ai}} \tag{16}$$

Where: p_{fi} = Price farmers receive for ingredient i ($/lb)
t = Conversion for raw product to product ingredient
q_i = Quantity of ingredient i in product a (lb)
m_{ai} = Weight of ingredient i before production of product a (lb)
M_{ai} = Weight of ingredient i after production of product a (lb)

In some cases, the price that farmers receive for ingredient i (p_{fi}) may be directly observed. If observed values are not available then p_{fi} is estimated by multiplying the price farmers receive for the raw agricultural product used to make the ingredient by the proportion of the value of the ingredient in the raw agricultural product:

$$p_{fi} = p_f \left\{ \frac{p_n(q_n)}{\sum_n p_n(q_n)} \right\} \tag{17}$$

Where: p_f = Price received by farmers for the raw agricultural crop used to make ingredient i (\$/lb)
p_n = Price received by processors for processed product n produced from raw agricultural crop used to make ingredient i (\$/lb)
q_n = Quantity of processed product n produced from raw agricultural crop used to make ingredient i (lb)

For example, the price that farmers receive for cottonseed oil is estimated by multiplying the price that farmers receive for cottonseed by the value of cottonseed oil divided by the sum of the values of cottonseed oil and cottonseed meal, the two products produced from cottonseed.

PS for Lay's Classic®™ potato chips and Baked Lay's®™ potato crisps are also calculated using prices for potato chips and crisps that are share-weighted by bag size. Share weighting by bag size requires annual quantities of potato chips and crisps sold by different bag sizes. This information was not available from Frito Lay. The 1999 channel sales data for the potato chip industry are used as a proxy for both Lay's Classic®™ and Baked Lay's®™ (SFA, 2001).

Potato Chips. PS for Lay's Classic®™ potato chips (PS_{LC}) is specified from equation (15):

$$PS_{LC} = \frac{v_p + v_o}{V_{LC}} \tag{18}$$

Where: v_p = Value of potatoes to agricultural producers (\$)
v_o = Value of oil to agricultural producers (\$)

V_{LC} = Value of Lay's Classic®™ potato chips ($)

The numerator in equation (18) is the sum of the value to producers for potatoes and oil. By substituting product specific versions of equation (16) into equation (18):

$$PS_{LC} = \frac{\left[p_{fp}\left(\frac{m_{LCp}}{M_{LCp}}\right)q_p\right] + \left[p_{fo}\left(\frac{m_{LCo}}{M_{LCo}}\right)q_o\right]}{V_{LC}} \qquad (19)$$

Where: p_{fp} = Price farmers receive for potatoes used for chip production ($/lb)
m_{LCp} = Weight of potatoes before chip production (lb)
M_{LCp} = Weight of potatoes after chip production (lb)
q_p = Quantity of potatoes in Lay's Classic®™ potato chips (lb)
p_{fo} = Price farmers receive for oil used for chip production ($/lb)
m_{LCo} = Weight of oil before chip production (lb)
M_{LCo} = Weight of oil after chip production (lb)
q_o = Quantity of oil in Lay's Classic®™ potato chips (lb)
V_{LC} = Value of Lay's Classic®™ potato chips ($)

Value of Potato Chip Ingredients to Producers. The value of potatoes and oil to producers for Lay's Classic®™ potato chips is estimated using equation (16). The value to producers is estimated for corn, cottonseed, and sunflower seed oil. According to Frito Lay, the selection of oil used during production is based on market prices. It is assumed that in any given batch of chips, only one of the three oils is used for frying.

Prices Farmers Receive for Potato Chip Ingredients. The price received by farmers for potatoes was obtained from a local Maine farmer with a Frito Lay contract. This contract is typical of farmer contracts used by Frito Lay in Maine. This price is averaged over the September to April contract period and is share weighted by the different volume of Maine potatoes shipped for chipping each month during the contract period. Monthly shipments for chipping were provided by USDA Market News Service.

The prices received by farmers for cottonseed and sunflower seed oil is adjusted by the proportion of oil to meal in the raw agricultural product. The price received by farmers for corn oil is adjusted by the proportion of oil to gluten meal to cornstarch in the raw agricultural product. Proportions and conversions of crude to refined oil for corn, cottonseed, and sunflower seed are from Agricultural Handbook #697. The price farmers received for salt is assumed to be zero since salt is not an agricultural commodity.

Prices Farmers Receive for Agricultural Crops Used to Make Potato Chip Ingredients. The prices that farmers received for corn, cottonseed, and sunflower seed are averaged from 1995 to 1998 to avoid extreme prices in any given year. Averaged prices are not normalized to a base year. Oil price data are from the United States Department of Agriculture's (USDA's) National Agricultural Statistics Service, Crop Data Sets (NASS-CDS) web page.

Conversion Factor for Raw Product to Product Ingredients. The values received by farmers for potatoes and oil are adjusted by a conversion factor for the raw product to the product ingredient. This conversion factor (t) is the ratio of the weight of each ingredient before chip production to the weight after production. For example, it takes on average about four pounds of potatoes to produce one pound of potato chips due to tuber water displacement by oil during frying. The conversion factor for potatoes ranges from about 3.6 to 4.8. This conversion factor is the pounds of potatoes required to make one pound of potato chips. It is based on chip recovery rate estimates provided by Edwin S. Plissey, Potato Specialist Emeritus at the University of Maine at Orono (2000) and by Frito Lay (2001). Chip recovery rates range from 21% to 28%. It is assumed that no oil is lost during frying. Therefore an oil conversion factor of 1.0 is used.

Value of Potato Chips. The consumer value of potato chips (V_{LC}) is calculated by multiplying the price of Lay's Classic®™ potato chips times the quantity of Lay's Classic®™ for each bag size. Prices of Lay's Classic®™ potato chips were observed at Shop and Save, one of two major supermarket chains in Maine, from the fall of 1999 to the spring of 2000. The quantity of potato chips in each bag is calculated from nutritional facts labeling.

Potato Crisps. Similarly, PS for Baked Lay's®™ potato crisps (PS_{BL}) can be estimated using a product specific version of equation (15):

$$PS_{BL} = \frac{v_f + v_{fs} + v_s + v_{co} + v_{so} + v_l + v_d}{V_{BL}} \tag{20}$$

Where: v_f = Value of dehydrated potato flakes to agricultural producers ($)
v_{fs} = Value of modified food starch to agricultural producers ($)
v_s = Value of sugar to agricultural producers ($)
v_{co} = Value of corn oil to agricultural producers ($)
v_{so} = Value of partially hydrogenated soybean oil to agricultural producers ($)
v_l = Value of soy lecithin to agricultural producers ($)
v_d = Value of dextrose to agricultural producers ($)
V_{BL} = Value of Baked Lay's®™ potato crisps ($)

The numerator in equation (20) is the sum of value to producers for dehydrated potato flakes (v_f), modified food starch (v_{fs}), sugar (v_s), corn oil (v_{co}), partially hydrogenated soybean oil (v_{so}), soy lecithin (v_l), and dextrose (v_d). By substituting product specific versions of equation (16) into equation (20):

$$PS_{BL} = \frac{\sum_i \left[p_{fi} \left(\frac{m_{BLi}}{M_{BLi}} \right) q_i \right]}{V_{BL}} \tag{21}$$

Where: p_{fi} = Price farmers receive for ingredient i used for crisp production ($/lb)

m_{BLi} = Weight of ingredient i before crisp production (lb)
M_{BLi} = Weight of ingredient i after crisp production (lb)
q_i = Quantity of ingredient i in Baked Lay's®™ potato crisps (lb)
V_{BL} = Value of Baked Lay's®™ potato crisps ($)

Value of Potato Crisp Ingredients to Producers. The value of all agricultural ingredients to producers for Baked Lay's®™ potato crisps is estimated using equation (16). The value to producers is estimated for all ingredients in Baked Lay's®™.

Prices Farmers Receive for Potato Crisp Ingredients. The price Maine farmers received for potatoes used to produce dehydrated potato flakes is not available from USDA. This price is estimated for Maine since there are no food-grade potato dehydration plants operating in Maine. The price that farmers received for potatoes going to dehydration plants in Idaho is used as a proxy. This price received by farmers in Idaho for dehydration potatoes is adjusted to reflect a hypothetical dehydration price in Maine. This is done by adjusting Idaho dehydration potato prices by the proportionate price difference between the price farmers received for french fry potatoes in Idaho than in Maine. Tom Cooper and Debbie Southwick at the Federal-State Market News Service provided prices farmers received for dehydration and french fry potatoes in Idaho (FSMNS, 2000a). Maine french fry contract prices are taken from the 1999 to 2000 McCain contract with growers.

The prices received by farmers for modified food starch, sugar, corn oil, partially hydrogenated soybean oil, and soy lecithin are estimated using equation (17). The price received by farmers for these ingredients is estimated by multiplying the price farmers received for the raw agricultural crop used to make the ingredient by the proportion of the value of the ingredient in the raw agricultural crop. Farm prices for raw agricultural crops were obtained from USDA's National Agricultural Statistics Service. Corn oil, cornstarch, and dextrose are made from corn. It is assumed that modified food starch and dextrose are made from cornstarch. Corn oil, cornstarch, and dextrose prices are estimated using proportions of corn oil to gluten meal to cornstarch and conversions of crude to refined oil from Agricultural Handbook #697. The price farmers received for soybean oil is derived similarly. A share-weighted price that farmers received for sugar is estimated from prices farmers received for sugarcane and sugar beets and recovery rates of sugar from sugarcane and sugar beets. Sugar recovery rates were provided by the Farm Service Agency.

Prices Farmers Receive for Agricultural Crops Used to Make Potato Crisp Ingredients. The prices farmers received for corn, soybeans, sugar beets, and sugarcane are from USDA's NASS-CDS price data. Prices are averaged from 1995 to 1998 to account for any significant price fluctuations. Averaged prices are not normalized to a base year. The price farmers received for salt and leavening is assumed to be zero since salt and leavening are not agricultural commodities.

Conversion Factor for Raw Product to Product Ingredients. The prices received by farmers for all Baked Lay's®™ ingredients are adjusted by a conversion factor for the raw product to the product ingredient. This conversion factor (t) is the ratio of the weight of each ingredient before crisp production to the weight after production. According to Tom Cooper from the Federal-State Market News Service, it takes about 6.5 pounds of raw potatoes to make one pound of dehydrated potato flakes. All ingredients including dehydrated potato flakes are assumed to have no loss during baking. This assumption is substantiated by Professor Mary Camire of the Food Science and Human Nutrition (FSHN) department at the University of Maine at Orono (2001).

The quantity of each ingredient in Baked Lay's®™ potato crisps after production is estimated from the nutritional facts labeling and analysis by the University of Maine's FSHN department (2000). Nutritional facts labeling did not specify quantities of 1) dehydrated potatoes versus modified food starch, 2) corn oil versus partially hydrogenated soybean oil, and 3) sugar versus dextrose. Unfortunately, Frito Lay would not disclose these proprietary ingredient ratios. Phenolic testing showed no significant difference between Baked Lay's®™ potato crisps and a pure sample of McCain dehydrated potato flakes. Professor Camire estimated dehydrated potato flakes to be 90% and modified food starch to be 10% of total carbohydrate content. This was based on her knowledge of the industry. Reliable tests for more sensitive starch analysis and for oil and sugar analysis were not available.

The following assumptions are made about ingredient quantities for Baked Lay's®™ potato crisps using nutritional facts labeling and Professor Camire's estimates. All protein is assumed to be attributed to dehydrated potato flakes and not to modified food starch. Dehydrated potato flakes and modified food starch make up about 79% and 8% of the weight of Baked Lay's®™ potato crisps respectively. Salt weight is given as about 0.0057% of the total product weight. Soy lecithin, leavening, and dextrose are listed in descending order of weight from salt. It is assumed that these last three ingredients comprise 0.0054%, 0.0050% and 0.0047% of product weight respectively. Sugar and dextrose make up about 7% of total product weight. There is more sugar than dextrose in Baked Lay's based on nutritional facts labeling. The quantities of these sugars are derived by assuming that sugar and dextrose make up about 6% and 0.0047% of the product weight. It is assumed that corn oil, partially hydrogenated soybean oil, and soy lecithin comprise about 5% of the weight of the product. There is more corn oil than partially hydrogenated soybean oil based on nutritional facts labeling. Changing the ratio of these two oils while still keeping the quantity of corn oil greater than soybean oil does not significantly change PS or FS.

Value of Potato Crisps. The value of potato crisps is calculated by multiplying the price of Baked Lay's®™ potato crisps times the quantity of Baked Lay's®™ for each bag size. Prices of Baked Lay's®™ potato crisps were observed at Shop and Save from the fall of 1999 to the spring of 2000. The quantity of potato crisps in each bag is calculated from nutritional facts labeling.

Results

Producers' share (PS) is estimated for Lay's Classic®™ potato chips and Baked Lay's®™ potato crisps. PS estimates are used to estimate the three agro-food system shares for potato chips and crisps. These shares are input share, farming share, and marketing share.

Producers' Share Estimates

PS for both Lay's Classic®™ and Baked Lay's®™ are estimated using prices for these snack products 1) varying by individual bag size and 2) share weighted by bag size. Variables used to estimate PS for potato chips and crisps are listed in Tables 4.1 and 4.2. For both snack products, Table 4.1 shows the price farmers receive for each product ingredient, the conversion factors for each raw ingredient during the manufacturing process and the quantity of each ingredient in the finished snack product. Table 4.2 lists

Table 4.1: Variables used to calculate value of ingredients for one pound of Lay's Classic®™ potato chips and Baked Lay's®™ potato crisps.

Ingredients for Lay's Classic®™ Potato Chips and Baked Lay's®™ Potato Crisps	Variables Used to Calculate Value of Ingredients:		
	Price farmers receive for ingredient ($/lb)	Conversion of raw ingredients to final product ingredients	Quant. of ingred. in one pound of potato chips or crisps (lb)
Potato Chips			
Potatoes			
21% Recovery Rate	0.072	4.8	0.626
25% Recovery Rate	0.072	4.0	0.626
28% Recovery Rate	0.072	3.6	0.626
Oil			
Corn	0.003	1	0.367
Cottonseed	0.033	1	0.367
Sunflower seed	0.092	1	0.367
Salt	0	1	0.007
Potato Crisps[a]			
Dehydrated Potatoes	0.017	6.5	0.791
Modified Food Starch	0.030	1	0.080
Sugar	0.002	1	0.062
Corn Oil	0.003	1	0.024
Partially Hydrogenated Soybean Oil	0.037	1	0.022
Salt	0	1	0.006
Soy Lecithin	0.037	1	0.005
Leavening	0	1	0.005
Dextrose	0.030	1	0.005

[a] Assumes corn oil and partially hydrogenated soybean oil weigh 0.0015 and 0.0014 lb respectively in one pound of Baked Lay's®™ potato crisps.

prices for Lay's Classic®™ and Baked Lay's®™ by individual bag size and share weighted by channel sales data for the potato chip industry provided by the Snack Food Association.

Table 4.2: Price of Lay's Classic®™ potato chips and Baked Lay's®™ potato crisps by varying bag size and weighted by channel sales data for potato chips.

Bag Size (ounces) or Share weighted by Channel Sales	Price of Lay's Classic®™ Potato Chips and Baked Lay's®™ Potato Crisps ($/lb)
Potato Chips	
1.75	4.57
5.50	4.33
13.25	3.61
21.50	2.97
Average	3.87
Share-weighted	3.91
Potato Crisps	
1.125	7.11
5.50	5.79
10.00	5.42
14.00	5.13
Average	5.86
Share-weighted	5.73

<u>**Potato Chips.**</u> PS for Lay's Classic®™ potato chips fried in corn, cottonseed, or sunflower seed oil are listed in Table 4.3 by varying chip recovery rates and bag sizes. Chip recovery rates are 21%, 25%, and 28% while conversion factors are 3.6, 4.0, and 4.8. PS for each bag size is averaged across all three oils that are used. Bag sizes range from 1.75 to 21.5 ounces. Not surprisingly, PS decreases with higher recovery rates or lower conversion factors, ceretis paribus. PS estimates are highest for potato chips fried in sunflower seed oil, followed by cottonseed and corn oils, but these differences are small.

Table 4.3: Producers' shares for Lay's Classic®™ potato chips using corn, cottonseed and sunflower seed oils with chip recovery rates of 21%, 25%, and 28% and bag sizes of 1.75, 5.5, 13.25, and 21.5 ounces.

Chip Recovery Rates (Conversion Factors)	Bag Size (ounces)	Producers' Share for Potato Chips			
		With Corn Oil	With Cotton-seed Oil	With Sunflower seed Oil	Average
21% (4.8)	1.75	0.047	0.050	0.055	0.051
	5.5	0.050	0.053	0.058	0.053
	13.25	0.060	0.063	0.069	0.064
	21.5	0.073	0.077	0.084	0.078
25% (4.0)	1.75	0.040	0.042	0.047	0.043
	5.5	0.042	0.045	0.050	0.045
	13.25	0.051	0.054	0.060	0.055
	21.5	0.061	0.065	0.072	0.066
28% (3.6)	1.75	0.036	0.038	0.043	0.039
	5.5	0.038	0.040	0.045	0.041
	13.25	0.045	0.048	0.054	0.049
	21.5	0.055	0.059	0.066	0.060

PS estimates using a price for Lay's Classic®™ potato chips share weighted by bag size are shown in Table 4.4. Share-weighted estimates of PS are consistent with individual bag size estimates in Table 4.3. PS is averaged across all three oils that are used. Share-weighted estimates of PS are lower for higher recovery rates and decrease going from sunflower seed to cottonseed to corn oils consistent with the disaggregated data in Table 4.3.

__Potato Crisps.__ PS estimates of Baked Lay's®™ by varying bag size are shown in Table 4.5. There are no meaningful differences in PS when the proportion of corn oil to partially hydrogenated soybean oil is varied to all possible values. Table 4.5 also shows

Table 4.4: Producers' share estimates for Lay's Classic®™ potato chips using corn, cottonseed or sunflower seed oils with recovery rates of 21%, 25%, and 28% using a weighted average price.

Chip Recovery Rates (Conversion Factors)	Producers' Share for Potato Chips (Share-weighted)			
	With Corn Oil	With Cotton-seed Oil	With Sunflower seed Oil	Average
21% (4.8)	0.055	0.058	0.064	0.059
25% (4.0)	0.047	0.050	0.055	0.050
28% (3.6)	0.042	0.045	0.050	0.045

an estimate of PS using a price for Baked Lay's®™ share-weighted by bag size. The PS estimated using a share-weighted price for potato crisps is comparable to the PS for the 5.5 ounce bag size.

Table 4.5: Producers' share estimates for Baked Lay's®™ potato crisps by bag size and using a weighted average price.

Bag Size (ounces)	Producers' Share for Potato Crisps
	Average
1.125	0.013
5.5	0.016
10	0.017
14	0.018
Share-weighted	0.016

Agro-food System Shares' Estimates for Potato Chips and Crisps

Maximum and minimum values for Lay's Classic®™ and Baked Lay's®™ PS are used to estimate ranges of values for MS, FS, and IS. As explained in the methods section, MS is simply one minus PS. FS is estimated by multiplying PS by the proportion of PS returned to the farming sector (FVA_p) for conventional processing potatoes. A proportion of 0.279 is used (Table 3.7). IS values are estimated by subtracting FS from PS.

PS values vary depending on the bag sizes of both snack products. These ranges of agro-food system shares are provided in Table 4.6. Baked Lay's®™ potato crisps have lower PS, composed of input and farming shares and a higher marketing share than Lay's Classic®™ potato chips over the entire range of bag sizes for both products.

Table 4.6: Estimates for agro-food system shares for Lay's Classic®™ potato chips and Baked Lay's®™ potato crisps [based on minimum and maximum estimates for producers' share (PS) varying by bag size].

Agro-food System Shares	**Agro-food System Shares for Potato Snack Product (Maximum and Minimum by Bag Size)**			
	Potato Chips		**Potato Crisps**	
	Minimum PS	**Maximum PS**	**Minimum PS**	**Maximum PS**
Producers' Share	0.036	0.084	0.013	0.018
1) Input Share	0.026	0.061	0.009	0.013
2) Farming Share	0.010	0.023	0.004	0.005
Marketing Share	0.964	0.916	0.987	0.982

Agro-food system shares are also share-weighted according to bag size. Estimates are provided in Table 4.7. For Lay's Classic®™ potato chips, estimates are for a potato recovery rate of 25% or a conversion factor of 4.0. Potato chip estimates are averaged across all three oils used. For Baked Lay's®™ potato crisps, agricultural shares are the same regardless of the proportion of corn oil to partially hydrogenated soybean oil.

Table 4.7: Estimates for agro-food system shares for Lay's Classic®™ potato chips and Baked Lay's®™ potato crisps, share weighted by bag size.

Agro-food System Shares	Agro-food System Shares for Potato Snack Product (Share-weighted by Bag Size)	
	Potato Chips (25% Recovery Rate)	Potato Crisps
Producers' Share	0.050	0.016
1) Input Share	0.036	0.012
2) Farming Share	0.014	0.004
Marketing Share	0.950	0.984

There is a substantial difference between agricultural sector shares for Lay's Classic®™ potato chips and Baked Lay's®™ potato crisps. PS, IS, and FS for Baked Lay's®™ is about 68% less than for Lay's Classic®™. MS is about 4% greater for Baked Lay's®™ than for Lay's Classic®™.

Chapter 5

DISCUSSION

Appropriationism is not consistently supported by the results from comparing returns to the farming sector for conventional and organic potato farming in Maine. The concept of substitutionism is not clearly supported by the results of comparing the manufacture of potato chips and crisps. Possible explanations of these results are discussed.

Potato Production

Results of comparing returns to the farming sector in Maine for conventional and organic potato farms do not clearly support the concept of appropriationism suggested by Goodman et. al. (1987). The returns to the farming sector should be greater for organic compared to conventional potato farms since it is expected that organic potato farms use less purchased inputs per unit of production than their conventional counterparts, relying instead on technologies such as long crop rotations, composting, and nitrogen-fixing green manures. However, the concept of appropriationism only appeared to hold for conventional tablestock and large organic farms selling at least 25% of their commodities more directly to consumers. Average FVA per acre were higher for this type of organic farm compared to conventional tablestock (Tables 3.7 and 3.8).

Organic partial-wholesale tablestock farms have higher NFI and FVA per acre than conventional tablestock farms. NFI of $235 per acre for these organic farms is about 147% greater than $95 per acre for conventional tablestock. FVA for these organic farms of $917 per acre is approximately 306% greater than $226 per acre for conventional

(Tables 3.7 and 3.8). These larger organic tablestock farms have higher NFI per acre even though their total costs as a percent of total revenues are higher than conventional tablestock (Table 5.1). These organic farms have 322% greater average total revenue per acre of $3120, compared to $739 per acre for conventional tablestock (Tables 3.4 and

Table 5.1: Total costs as a percent of total revenues and variable and fixed costs and "a" and "b" costs as a percent of total costs for conventional potato farms in Maine and organic potato farms in Aroostook County, Maine.

Classifications of Farms	Percent of Total Revenues (%)	Percent of Total Costs (%)			
	Total Costs	Variable Costs	Fixed Costs	"a" Costs	"b" Costs
Conventional					
1) Tablestock	87	80	20	80	20
2) Seed	86	81	19	75	25
3) Processing	91	79	21	79	21
a) French	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)
b) Chips	(N/A)	(N/A)	(N/A)	(N/A)	(N/A)
Conventional					
1) Small	93	76	24	78	22
2) Medium	86	79	21	81	19
3) Large	86	84	16	77	23
Organic Type					
1) Tablestock	103	89	11	75	25
2) Seed	47	90	10	81	19
Organic Table-stock Size					
1) Small	236	90	10	64	36
2) Medium	188	73	27	73	27
3) Large (Wholesale)	101	98	2	86	14
4) Large (Partial Wholesale)	92	89	11	76	24

Note: (N/A) refers to unavailable farm data.

3.6). FVA per acre is greater for these organic farms because "a" costs comprise a lower percentage of total costs than conventional tablestock (Table 5.1).

Large, organic tablestock farms that do not sell exclusively to wholesale distributors have average NFI and FVA per farm that are lower than their conventional counterparts. Conventional tablestock farms have NFI and FVA of $48,070 and $114,309 respectively (Table 3.7). Large, organic partial-wholesale tablestock farms have lower NFI and FVA of $9134 and $35,637 respectively (Table 3.8). This is due to higher total revenues from larger acreage for conventional tablestock farms (Table 3.5) compared to these organic farms (Table 3.3) while total costs for these types of farms are proportionally similar (Table 5.1). When considering returns to farming as a proportion of farm revenues (FVA_p), large partial-wholesale organic farms (0.295) perform similarly to conventional tablestock farms (0.306) since the larger volume of potatoes produced by conventional farms does not affect this proportionate measure (Tables 3.7 and 3.8).

Reasons Appropriationism Not Supported

Other studies mentioned in the literature review indicate that some organic systems may be more profitable for farmers. Results from this study indicate that even though large partial-wholesale organic tablestock potato systems return more to the farming sector per acre, they return similar proportional amounts to the farming sector compared to their conventional counterparts. Organic potato farming may not necessarily shift more activity to the farming sector for a variety of reasons. These reasons are 1) organic potato systems have substantial yield penalties, increasing "a" costs per unit of output, 2) "a" costs per acre for organic systems may be higher due to added marketing services, 3) organic tablestock farms are substantially smaller than conventional, resulting in diseconomies of size.

Even though the tablestock farm price of $0.60/lb for these organic partial-wholesale tablestock farms is substantially higher than a conventional tablestock farm

Table 5.2: Potato and potato product prices and average potato yield per acre for conventional potato farms in Maine and organic potato farms in Aroostook County, Maine.

Classifications of Farms	Price ($/lb)		Average Potato Yield per Acre (cwt)	
	Rec. by Farm	Paid by Consumer	Total	Marketable
Conventional Type				
1) Tablestock	0.07[a]	0.40[b]	280[f]	200[f]
2) Seed	0.07[c]	(N/A)	270[f]	260[f]
3) Processing	0.06[de]	1.34[b]	320[f]	290[f]
a) French Fries	0.06[d]	1.21[b]	320[f]	290[f]
b) Chips	0.07[e]	3.13[b]	290[f]	260[f]
Conventional Size				
1) Small	(N/A)	(N/A)	(N/A)	(N/A)
2) Medium	(N/A)	(N/A)	(N/A)	(N/A)
3) Large	(N/A)	(N/A)	(N/A)	(N/A)
Organic Type[g]				
1) Tablestock	0.53	0.96	153	114
2) Seed	0.55	1.60	(D)	(D)
Organic Table-stock Size[g]				
1) Small	0.53	0.80	92	69
2) Medium	0.50	1.00	140	74
3) Large (Wholesale)	0.30	0.63	(D)	(D)
4) Large (Partial Wholesale)	0.60	1.07	201	159

Note: (N/A) and (D) refer to farm data that were unavailable and could not be disclosed.

[a] Based on estimated yield and Farm Credit budget data (Checked with FOB price for bagged potatoes).
[b] Bureau of Labor Statistics.
[c] Maine Farmers Exchange, Presque Isle.
[d] 1999 to 2000 McCain Foods Maine contract.
[e] 1999 Frito Lay Maine contract.
[f] Industry estimates from Maine Potato Board.
[g] Survey of Aroostook County Organic Potato Farmers (2000-2001).

price of $0.09/lb, conventional farms have greater acreage and higher yields and marketable yields per acre than organic. Large organic marketable yields per acre are about 21% less than conventional (Table 5.2). This yield penalty is consistent with the results of the Maine Potato Ecosystem Project. Although certain "a" costs per acre such as chemicals may be lower for these organic farms ($43/acre) compared to conventional

Table 5.3: Average revenue and costs for tablestock ($/cwt of potatoes).

Gross Income, Item. Expenses and Costs	Conventional Tablestock	Organic Tablestock		
		Small	Medium	Large (Partial Wholesale)
Gross Income	3.69	6.66	7.00	19.62
Expenses:				
Seed	0.12	1.82	1.29	0.98
Fertilizer	0.48	0.79	2.10	0.70
Chemicals	0.57	0.04	-	0.27
Labor	0.46	3.61	1.03	3.41
Gas/Fuel/Oil	0.10	0.95	0.47	0.54
Repairs	0.21	1.42	1.70	0.51
Supplies	0.03	0.82	0.62	1.95
Insurance	0.08	0.34	0.10	0.19
Miscellaneous	0.63	4.74	2.40	7.83
Interest	0.18	0.06	-	0.51
Taxes	0.15	0.56	1.99	0.37
Depreciation	0.23	0.55	1.48	0.87
Total Expenses	3.22	15.70	13.19	18.14
Variable Costs	2.58	14.20	9.62	16.20
Fixed Costs	0.64	1.51	3.57	1.95
"a" Costs	2.56	10.09	9.63	13.86
"b" Costs	0.65	5.62	3.55	4.29

Note: Values may not sum due to rounding.

tablestock ($113/acre), total "a" costs per unit of output are higher for organic (Tables 3.4 and 3.6). Conventional tablestock and partial-wholesale organic farms have total "a" costs per cwt of potato output of $2.56 and $13.86 respectively (Table 5.3).

Organic farming systems may not shift more activity to the farming sector since "a" costs per acre for organic systems are higher due to added marketing services. This is reflected by substantially higher costs of supplies and miscellaneous expenses for large organic compared to conventional tablestock. Partial-wholesale organic tablestock farms have higher costs of supplies ($310/acre) and miscellaneous expenses ($1245/acre) compared to supplies ($6/acre) and miscellaneous expenses ($126/acre) for conventional tablestock (Tables 3.4 and 3.6).

Another reason organic potato systems in this study do not shift more activity to the farming sector is diseconomies of size. Large partial-wholesale organic potato farms in Aroostook County are about 8% the size of conventional tablestock farms (Table 3.1). Average NFI and FVA measures per farm and per acre increase for both conventional and organic farms with increasing farm size (Tables 3.7 and 3.8). Conventional potato farms have decreasing fixed costs per acre with increasing farm size. Small, medium, and large conventional farms have fixed costs per acre of $187.00, $161.00, and $128.50 respectively. Large partial-wholesale organic potato farms have higher fixed costs of $309.80 per acre (Table 3.4). These organic farms have fixed costs that are distributed over less acreage than conventional farms, resulting in higher fixed costs per acre. Small and medium sized organic farms have lower fixed costs of $104.00 and $264.09 per acre due to different capital bundles compared to large organic producers.

Increasing Returns to the Farming Sector

It appears that organic farming is not profitable compared to conventional farming when comparing NFI per farm. Returns to the farming sector measured by FVA_p are less for organic compared to conventional unless the organic farm is larger and has some retail markets. Returns to the farming sector may be increased for organic farmers by 1) growing more acres, assuming total crop sales and costs per acre remain comparable to current values, 2) incorporating livestock on the farm to reduce "a" costs and add value to rotation crops, 3) using new varieties or production techniques that reduce the yield penalty for organic potatoes, and/or 4) adding marketing services.

Returns to the farming sector may increase if crop acreage per farm is increased, ceretis paribus. In this study, returns to the farming sector per acre increase with increasing farm size for both conventional and organic potato farms (Tables 3.7 and 3.8). Relatively constant fixed costs per acre for organic farms that specialize in potato production could be distributed over expanded acreage. This could provide higher returns to the farming sector for these organic farms.

Organic farms could also reduce "a" costs such as fertilizer by incorporating livestock. Crop and livestock reintegration may reduce purchased fertilizers but it would also increase management complexity. Crops used for livestock feed would have to be grown on rotational acreage to minimize the cost of purchased feed. Fertilizer costs per acre are higher for partial-wholesale large organic tablestock farms ($111) compared to conventional tablestock ($96) (Tables 3.4 and 3.6). Utilizing livestock manure from reintegration may lower these higher fertilizer costs. Returns to farmers may be greater if the costs of reintegrating livestock are less than the cost of fertilizer. Returns to the farming sector are dependent on 1) the magnitude of reintegration costs compared to fertilizer costs and 2) how "a" costs and "b" costs are allocated within these costs.

Returns to the farming sector may be increased if organic farmers grew potato varieties or used production techniques that increased marketable yields to conventional levels. Many organic producers in Aroostook County have yields at least 20% less than conventional (Table 5.2). If organic potato farmers could increase their yields to conventional levels and assuming the cost of doing this was not substantially different, returns to the farming sector per acre would increase. For example, assuming the average partial-wholesale large organic farm grew 26% more marketable potatoes (40 cwt) per acre on thirteen acres of potatoes and the price received by the farm for potatoes was \$0.50/lb, additional farm revenue would be \$26,000. Assuming a 26% increase in variable costs, FVA per acre for the organic farm would increase about 15%. Organic FVA per acre would not increase from an original marketable yield of 159 cwt per acre when variable costs are increased 33%. Results would change if variable costs such as new seed potato varieties and production techniques used to boost tuber set caused greater increases in variable costs.

Providing marketing services may achieve greater returns to the farming sector. Results from this study suggest that this might be the case. Ten of the twelve organic potato farms surveyed provide marketing services such as washing and packing commodities and producing value-added processed products. Large organic farms that provide more marketing services have higher FVA measures than the large organic farm selling exclusively wholesale (Tables 3.8). However, certain "a" costs used for direct

Table 5.4: Percent of total costs for itemized expenses for conventional potato farms in Maine.

Itemized Expenses	Percent of Total Costs (%)					
	Conventional Type			Conventional Size		
	Tablestock	Seed	Processing	Small	Medium	Large
1) Seed	4	13	11	11	8	12
2) Fertilizer	15	11	11	9	14	11
3) Chemicals	18	11	14	13	10	16
4) Labor	14	15	12	14	12	14
5) Gas/Fuel/Oil	3	3	3	4	3	3
6) Repairs	6	6	7	8	7	7
7) Supplies	1	4	3	3	3	4
8) Insurance	2	4	3	5	3	3
9) Miscellaneous	20	18	17	14	22	17
10) Interest	6	7	7	7	7	3
11) Taxes	5	4	4	4	4	4
12) Depreciation	7	4	7	8	7	6

marketing such as supplies and miscellaneous costs are proportionally higher for organic compared to conventional tablestock (Tables 5.4 and 5.5). Organic farmers may be

Table 5.5: Percent of total costs for itemized expenses for organic potato farms in Aroostook County, Maine.

Itemized Expenses	Percent of Total Costs (%)					
	Org. Type		Organic Tablestock Size			
	Table-stock	Seed	Small	Med.	Large (Wholesale)	Large (Partial wholesale)
1) Seed	6	14	12	10	4	5
2) Fertilizer	5	14	5	16	14	4
3) Chemicals	1	4	0.3	-	2	1
4) Labor	19	5	23	8	11	19
5) Gas/Fuel/Oil	4	6	6	4	5	3
6) Repairs	4	9	9	13	11	3
7) Supplies	11	5	5	5	26	11
8) Insurance	1	3	2	1	1	1
9) Miscellaneous	39	32	30	18	24	43
10) Interest	2	-	0.4	-	-	3
11) Taxes	3	8	4	15	1	2
12) Depreciation	5	-	4	11	-	5

receiving higher revenues by providing marketing services but face increased costs and complexity by providing these services.

Small and medium sized organic farms have lower NFI and FVA measures than large organic and conventional potato farms. These smaller farms are not generating enough revenue to cover costs. Many of these smaller producers are able to stay in business since farming is not their primary source of income. If organic potato farming in Aroostook County is not profitable, then why have more farmers in this area become certified organic in recent years? Survey respondents reported other motivations to farm aside from profitability. These include 1) supporting regionally-based sustainable agriculture, 2) self-sufficiency by growing a diverse mixture of crops, 3) being able to work outdoors, 4) intrinsically valuing work, 5) close connection to children, 5) being involved in a community of producers and consumers that share many of these values, and 6) raising a family under these value sets.

Manufacture of Potato Chips and Crisps

The results for Lay's Classic®™ potato chips and Baked Lay's®™ potato crisps demonstrate the concept of substitutionism if costs are assigned to producing low-grade potatoes for dehydration proportionate to their value. Returns to the farming sector measured by farming share are about 69% less for potato crisps than for potato chips while returns to the marketing sector measured by marketing share are about 3.2% greater. The reason for this is that whole potatoes are replaced with dehydrated potato flakes as the primary ingredient in potato crisps. Dehydrated potato flakes return less per unit of potato to the farming sector than chipping potatoes. The consumer price for

Baked Lay's®™ of $5.73/lb is about 47% greater than the price for Lay's Classic®™ of $3.91/lb when weighted by bag size.

The total value that farmers receive for potatoes in one pound of Lay's Classic®™ potato chips assuming a 25% recovery rate is about $0.18. The total value farmers receive for potatoes used to produce dehydrated potato flakes in one pound of Baked Lay's®™ potato crisps is about $0.09, which is approximately 50% of the value of chipping potatoes. The price of about $0.07/lb that Maine farmers receive for chipping potatoes is higher than the price of about $0.02/lb that a hypothetical Maine farmer would

Table 5.6: Value farmers receive for raw product in each ingredient in one pound of Lay's Classic®™ potato chips and one pound of Baked Lay's®™ potato crisps.

Ingredients	**Value farmers receive for raw product in each ingredient in one pound of**	
	Potato Chips ($) (25% Recovery Rate)	**Potato Crisps ($)**
Starches and sugars		
1) Potatoes	0.1813	-
2) Dehydrated Potatoes	-	0.0878
3) Modified Food Starch	-	0.0024
4) Sugar	-	0.0001
5) Dextrose	-	0.0001
Oils		
1) Corn	0.0010	0.0001
2) Cottonseed	0.0119	-
3) Sunflower	0.0336	-
4) Partially Hydrogenated Soybean	-	0.0008
5) Soy Lecithin	-	0.0002
Salt	(No Value)	(No Value)
Leavening	-	(No Value)

Note: Ingredients with (No Value) were assumed to have no value to farmers.

receive for potatoes going to dehydration plants. Other ingredients in both potato chips and crisps contribute very little to the value of either snack food product (Table 5.6).

However, this assumes that farmers assign a cost to producing low-grade potatoes for dehydration proportionate to their value. If no costs are assigned to producing low-grade potatoes, then the proportion of consumer expenditures on Baked Lay's®™ returned to the farming sector is better approximated by PS for potato crisps (0.016), which is greater than FS for potato chips (0.013) (Table 4.7). Returns to the farming sector are slightly greater for Baked Lay's®™ potato crisps compared to Lay's Classic®™ potato chips if no costs are allocated to producing low-grade potatoes for dehydration. This case demonstrates the possibility of substitutionism where manufacturing processes displace raw farm products assuming costs are assigned to producing low-grade potatoes for dehydration.

Returns to farming areas are also impacted by choices of technology regimes. These returns to increased crisp production depend on farmers having a dehydration market for their low-grade potatoes in addition to tablestock, seed, or processing markets. There is a limited market for low-grade potatoes used for dehydration in Maine. A shift from chip production to crisp production would likely shift potato acreage from Maine to areas with dehydration plants, primarily the Pacific Northwest.

Policy Implications

The choice of one technology over the other for these two sets of technology regimes is dependent on the objectives of input firms, farmers, marketing firms, and government. If the objective is to increase activity in the farming sector, then technologies that increase returns to the farming sector should be supported by those involved in the agro-food system and encouraged by government. While technologies are adopted by the private sector, policy influences the choices that are made. Policy choices can influence technology choices that determine the relative viability of farming.

Returns to the farming sector per acre are higher for large organic compared to conventional potato farms in Maine. Contrary to Goodman et. al.'s suggestions, returns to the farming sector as a proportion of farm revenues appear to be comparable for conventional and organic. This appears to result primarily from the smaller scale of organic production and lower marketable yields. There appears to be the potential for capturing more returns to the farming sector as a proportion of farm revenues by increasing the scale of organic potato production to a level that is not currently practiced in Maine. Policy makers could assist organic farmers to increase acreage through loan programs and by providing tax incentives and subsidies on equipment and organic inputs. This could be done until the volume of organic production is adequate to support a permanent infrastructure that provides goods and services to organic agriculture. Government programs could also direct tax dollars to land grant university research to investigate cultivars and production techniques that reduce the yield penalty for organic systems.

Returns to the farming sector as measured by farming share is greater for Baked Lay's®™ potato crisps compared to Lay's Classic®™ potato chips in Maine, assuming that costs are assigned to producing low-grade potatoes for dehydration. This appears to weakly support Goodman et. al.'s suggestion that returns to the farming sector should be greater for more manufactured products like potato crisps than for less manufactured products like potato chips. If the objective is to maintain farming, then policy makers should be sensitive to what type of processing technologies are developed with public funds. By supporting technology regimes involving more highly processed products, policy makers may inadvertently be diminishing the size of the farming sector.

Chapter 6

CONCLUSION

Comparing returns to the farming sector between conventional potato farms in Maine and organic potato farms in Aroostook County does not appear to support the concept of appropriationism for this situation. Returns to the farming sector are lower for organic tablestock farms when compared to conventional. However, when comparing returns as a proportion of producers' share, large organic farms that market at least 25% of their produce to retail stores or directly to consumers do as well as conventional farms. When comparing returns as a proportion of consumer expenditures, these organic farms do better than conventional farms.

There may be a number of reasons why appropriationism is not supported in this analysis. Large partial-wholesale organic potato farms may have lower returns to the farming sector due to lower yields compared to conventional. Although non-farm input costs as a percent of total costs are lower for these organic farms, these non-farm input costs per unit of output are higher. Returns to the farming sector may be increased if organic farmers grew potato varieties or used production techniques that increased yields to conventional levels and if the costs of new varieties and techniques were not disproportionately high. Organic potato farmers may also capture more farming value than conventional if livestock are reintegrated with cropping systems. Returns to the farming sector may be greater for organic compared to conventional for crops that take a lower yield penalty such as grains.

These lower returns to the farming sector may also be due to an inability of organic farmers to reduce the costs they pay for marketing farm commodities and products more directly to consumers. These marketing services include brushing, bagging, boxing, and mail and Internet ordering. It also appears that providing such marketing services may increase returns to the farming sector as demonstrated by large organic potato farmers selling at least 25% of their potatoes more directly to consumers. These organic farms may be getting higher revenues by providing marketing services but face increased costs and complexity from these services.

These large organic potato farms on average are only 8% of the size of conventional tablestock, resulting in diseconomies of size. If organic potato acreage per farm was expanded, reduction in costs could occur from relatively constant fixed costs being distributed over more acres, assuming organic potato prices did not change. Large partial-wholesale organic potato farms have fixed costs per acre that are over twice that of conventional tablestock. However, increasing acreage is complicated by the marketing services provided by these organic farms.

The results of this analysis illustrate the difficulties of organic potato production. On the one hand, increasing marketing services to increase returns to the farming sector puts limits on the amount of potatoes that can be produced. The farmer has to devote more time to providing these marketing services and less time to expanding production. However, it is an increase in production that appears to be a way for organic farmers to increase net farm income and returns to the farming sector. Increasing size may be constrained since these more complex organic production systems are more difficult to manage, requiring more labor, cultivation, and direct marketing per unit of output.

Even if returns to the farming sector are not increased, organic potato farmers receive certain returns that are harder to quantify. These include supporting sustainable agriculture, self-sufficiency, the intrinsic value of work, and close community and family connections. Though financial sustainability is important to organic potato farmers, many put equal importance on these non-monetary values. Some of these farmers would rather improve production on current acreage than expand. Expanding production is viewed as a way to pass farming on to their children and not as a way to increase returns to the farming sector. Other organic potato farmers have additional sources of income or prefer to farm part-time.

Comparing returns to the farming sector between Lay's Classic®™ potato chips and Baked Lay's®™ potato crisps does not clearly support the concept of substitutionism. Premium potatoes are used to produce potato chips while low-grade potatoes are used to produce the dehydrated potato flakes used to make potato crisps. The price that consumers pay for potato crisps is greater than the price they pay for potato chips. Returns to the farming sector are about three times greater for potato chips than crisps since farmers receive less for potatoes used to produce dehydrated potato flakes than to make potato chips. However, this assumes that farmers assign a cost to producing low-grade potatoes for dehydration proportionate to their value. If no costs are allocated to producing low-grade potatoes for dehydration, then returns to the farming sector are slightly greater for crisps than for chips.

If there is a shift in consumer preference from potato chips to crisps and the consumption of such snack products remains relatively constant, there may be impacts to Maine farmers. Maine currently markets virtually no low-grade potatoes for food dehydration. Assuming no food-grade dehydration facilities are built in the Northeast and a shift in consumer preferences from chips to crisps, there may be a geographical shift of potato production from Maine to the Pacific Northwest. These western states produce and process much of the U.S. potatoes used for dehydration. Chipping potatoes make up about 15% of the total volume of potatoes grown in Aroostook County, Maine, making such shift in production to the west significant.

Returns to the farming sector may change over time. This thesis considers returns to the farming sector for just one year for both conventional and organic potato farms and for potato chips and crisps. Analyzing returns to the farming sector over a multi-year period could be useful to see how returns to the farming sector change over time. Both conventional and organic potato farm data were based on small samples and populations respectively. Future studies may want to do more thorough and detailed surveys of conventional potato farms in Maine and organic potato farms outside of Aroostook County. Such surveys may provide more information than the currently used data from Farm Credit of Maine and survey of organic potato farms in Aroostook County. Returns to farming for organic compared to conventional technology regimes may also be different with other products. A similar analysis for other crops and products could contribute toward better understanding the impacts of appropriationism and substitutionism in American agriculture.

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BIOGRAPHY

Aaron K. Hoshide was born in Honolulu, Hawaii on September 2, 1972. He lived with his parents in Palolo Valley in Honolulu. Tokiko, Aaron's mother, died from pancreatic cancer on May 19, 1980. After living with his father, Henry, for three years, Henry unexpectedly died from a fall fixing the family lanai, or balcony, on July 28, 1983. In August of 1983, he moved to Simi Valley, California with his uncle Bob and aunt Georgian. Aaron attended high school at the Northfield Mount Hermon School in Northfield, Massachusetts where he graduated in June of 1990. He attended Wesleyan University in Middletown, Connecticut and graduated in June of 1994 with a Bachelor of Arts degree with Honors in Earth Science. He worked at the Brian House, Inc. as a cook and organic farm assistant from November of 1994 until May of 1999. After investigating the Sustainable Agriculture program at the University of Maine, he decided to apply for the Master of Science program in Resource Economics and Policy. Aaron is a candidate for the Master of Science degree in Resource Economics and Policy from the University of Maine in August, 2002.