The economics of on-farm processing: model development and an empirical analysis

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Abstract

Recent trends in the developments of the Common Agricultural Policy suggest an increasing attention towards rural development issues. On-farm processing may offer an alternative for diversification, income generation and rural development in the event of increasingly deregulated agricultural markets. In this study, the economics of on-farm processing for the case of the Swedish potato industry is examined. An interregional partial equilibrium model is developed. Various stages of the potato marketing chain are explicitly modelled. It is empirically demonstrated that, in some regions, on-farm processing is a part of a socially optimal industry structure. Furthermore, it is shown that on-farm processors are more robust towards import competition than bulk product producers. Hence, the results support the notion that small scale processing may contribute towards satisfying some of the objectives of an effective rural development agenda. Published by Elsevier Science B.V.

1. Introduction and objectives

The extent of and regional dispersion of on-farm processing activities is of interest to policy makers since it affects the effectiveness as well as cost of government policies (Russel, 1987). The issue has economic implications at both the national and regional policy level. It may be argued that an increasing degree of on-farm processing in the various stages of the food marketing chain may facilitate a transition from a traditional agricultural policy, mainly characterized by price supports and direct income payments, to an integrated rural development policy. Recent trends in the European agricultural policy arena seem to support this type of transition. Given the intended eastward expansion of the EU, a

proposal has been brought forward by the EU Commissioner of Agriculture, Franz Fischler, to gradually reform the Common Agricultural Policy in such a direction. Furthermore, small scale on-farm processing may play a role in introducing appropriate technologies in the agricultural sectors of LDCs (Tribe, 1991).

However, the empirical and methodological developments pertaining to economic analysis of on-farm small scale processing activities remain scarce. The opportunities for and constraints on the development of on-farm processing have been discussed in several articles, for example Gasson (1988) and Slee (1991). Slee provides a review of definitional and conceptual problems surrounding on-farm processing. According to Slee (1991), on-farm processing are activities creating utility by altering the product in some way from its raw state. The addition of

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value through processing is often associated with the addition of value through different methods of marketing. On-farm processing activities may be considered in a wider context as activities adding value to agricultural products. Capps et al. (1988) present a view of assessing opportunities of adding value in food and fiber processing and distribution. On-farm processing in the context of this paper refers to grading and packaging of fresh potatoes at the farm level as well as marketing these products to retail stores. Both Russel (1987) and Slee (1991) regard grading and packaging as on-farm processing activities.

Some empirical studies have been conducted (Russel, 1987; Russel et al., 1991) in order to examine the extent of and the economic viability of on-farm processing at farms in the UK. Lunneryd and Andersson (1996) conducted a study of which factors contribute towards the adoption of on-farm processing activities in the Swedish potato industry. Furthermore, Tribe (1991) studied small scale dairy plants in Kenya, in a remote area situated away from large scale processing facilities. However, none of the cited studies address the economic issues pertaining to on-farm processing utilizing a partial equilibrium framework. Consequently, the aggregate and regional adjustments that occur within the industry are not accounted for when some of the individual firms choose to by-pass various stages of the food-marketing chain by entering into on-farm processing activities.

The methodology for analysing adjustments within the agricultural sector, originating from, for example, changes in agricultural policy and/or enhanced international competition, is well documented in the literature (Samuelson, 1947; Takayama and Judge, 1964; McCarl and Spreen, 1980; Norton and Schiefer, 1988; Magrath and Tauer, 1988; Apland et al., 1994; Durham et al., 1996). In general, the cited references utilize price endogenous programming models and consider spatial effects. However, none of the studies examine the case where large scale processing firms in a specific industry compete with small scale on-farm processing activities.

Hence, the objective of this paper is to develop a partial equilibrium model for a general agricultural industry where large scale processing firms and on-farm processing activities co-exist and produce vari-

ous forms of differentiated products that originate from an agricultural product. A welfare economic analysis is conducted in order to examine how producers and consumers are affected when on-farm processing is introduced in the industry. In addition, the economic effects associated with varying degree of exposure to international competition are analysed. As an empirical illustration, the case of the Swedish potato industry is utilized. The case of Sweden serves as an especially useful study object since due to the Swedish membership in the EU as of January 1, 1995, Swedish producers face enhanced import competition.

2. Model structure

The model developed for the empirical analysis is a non-linear programming model of the Swedish fresh potato market. GAMS (General Algebraic Modelling System) mathematical programming software (Brooke et al., 1992) is utilized to solve the model. The model is a multi-region model that includes the stages of the food marketing chain from growers to final consumers. Various stages of the marketing chain are illustrated by Fig. 1. A major contribution of the model relative to other studies is that it includes two alternative types of processing, both large scale processing in large scale centralized plants and small scale on-farm processing. Small scale processing is considered a local industry, while
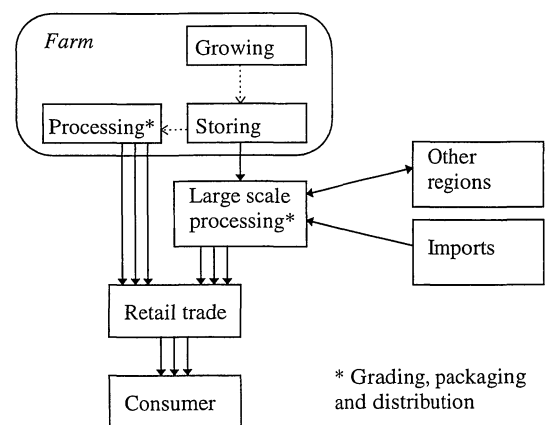

Fig. 1. Stages of the food marketing chain that are included in the model.

products processed in large scale plants may be transported from other regions across the nation or imported. In addition, the model presented in this paper considers one form of product differentiation in the final processing stage. On-farm retailing activities are not analysed.

The objective function is as usual the sum of producer and consumer surplus (Samuelson, 1947). This measure of social welfare attributable to the fresh potato market is calculated as the sum of the demand function integrals less production costs in all stages and regions of the food marketing chain, transportation costs and costs of imported potatoes. Consumption of potatoes, in Eq. (1) represented by Y_{git}, occurs during different seasons of the year, since consumer demand varies with the season. Production costs at the farm level depend on the type of production technology utilized. The model explicitly

considers the opportunity to process potatoes into differentiated consumer products. The objective function is given by Eq. (1). The notation is explained in Table 1.

Maximize: Y,XH,XS,XL,XT,T,I,XC

$$SV = \sum_{g=1}^{r} \sum_{i=1}^{n} \sum_{t=1}^{p} \left[a_{git} \cdot Y_{git} + 0{,}5 b_{git} \cdot Y_{git}^2 \right]$$

$$- \sum_{g=1}^{r} \sum_{c=1}^{q} ch_{gc} \cdot XH_{gc}$$

$$- \sum_{g=1}^{r} \sum_{c=1}^{q} \sum_{t=1}^{p} cs_{gct} \cdot XS_{gct}$$

$$- \sum_{g=1}^{r} \sum_{c=1}^{q} \sum_{i=1}^{n} \sum_{t=1}^{p} \left(cl_{gci} + tl_{gc} \right) \cdot XL_{gcit}$$

Table 1
Description of the variables and parameters in Eqs. (1)–(8)

Type	Name	Description
Variable	SV	Objective function value, social value of production and consumption
	Y_{git}	Demand for product (i) in region (g) during period (t)
	XH_{gc}	Harvested quantity on all farms with technology (c) in region (g)
	XS_{gct}	Quantity out of store in period (t) from farms with technology (c) in region (g)
	XL_{gcit}	Quantity of product (i) produced on farms with technology (c) in region (g), for consumption in period (t)
	XT_{gct}	Quantity shipped from farms with technology (c) to large scale plants (for processing or transportation to another region) in period (t), within region (g)
	T_{ght}	Quantity transported from region (g) to destination region (h) during period (t)
	I_{gt}	Quantity imported to region (g) during period (t)
	XC_{git}	Quantity of product (i) produced in large scale processing plants within region (g), for consumption during period (t)
Parameter	a_{git}	Intercept of the demand function for product (i) in region (g) during period (t)
	b_{git}	Slope of the demand function for product (i) in region (g) during period (t)
	ch_{gc}	Growing cost on farms with technology (c) in region (g), for storing to period (t)
	cs_{gct}	Unit storing cost on farms with technology (c) in region (g) for storing to period (t)
	cl_{gci}	Unit cost of on-farm processing concerning product (i) on farms with technology (c) in region (g)
	tl_{gc}	Unit transportation cost between farm and retail store for farms with technology (c) in region (g)
	tt_{g}	Unit transportation cost from farm to large scale processing in region (g)
	tr_{gh}	Unit transportation cost from region (g) to destination region (h)
	pi_{gt}	Price of imported potatoes in region (g) during period (t)
	cc_{i}	Unit cost of producing product (i) in large scale plants
	tc_{g}	Unit transportation cost between large scale processing and retail trade in region (g)
	m_{git}	Unit costs in retail level for product (i) during period (t) in region (g)
	k_{gt}	Total loss (share of harvested quantity) between harvest and final consumption, potatoes grown in region (g) and consumed in period (t)
	e_{g}	Average yield per hectare in region (g)
	d_{g}	Area available for growing potatoes in region (g)
	f_{gc}	Share of production in region (g) produced on farms with technology (c)
	u_{git}	Maximum on-farm processing capacity available for production of product (i) during period (t) in region (g)

$$- \sum_{g=1}^{r} \sum_{c=1}^{q} \sum_{t=1}^{p} tt_g \cdot XT_{gct}$$

$$- \sum_{g=1}^{r} \sum_{h=1}^{r,h \neq g} \sum_{t=1}^{p} tr_{gh} \cdot T_{ght}$$

$$- \sum_{g=1}^{r} \sum_{t=1}^{p} I_{gt} \cdot pi_{gt}$$

$$- \sum_{g=1}^{r} \sum_{i=1}^{n} \sum_{t=1}^{p} \left(cc_i + tc_g \right) \cdot XC_{git}$$

$$- \sum_{g=1}^{r} \sum_{i=1}^{n} \sum_{t=1}^{p} Y_{git} \cdot m_{git} \tag{1}$$

.Losses occurring between harvest and final consumption arise mainly during the storage period and in the processing stage. In the model, all losses between field and consumer are aggregated into one total loss which depends on the storage period. Consequently, the harvested yield in each region (XH_{gc}) is reduced by a factor k_{gt} depending on the length of the storage period (Eq. (2)). The fact that losses/culling occur also in the processing stage is taken into account when calculating processing and transportation costs.

$$XH_{gc} - \sum_{t=1}^{p} XS_{gct} / \left(1 - k_{gt} \right) = 0 \quad g = 1 \dots r$$

$$c = 1 \dots q \tag{2}$$

After storage, the potato crop is either processed on the farm in the small scale processing system or transported to a wholesale dealer. In Eq. (3) the small scale processing activity is represented by XL_{gcit}. Small scale processing can take place on farms with different types of production technologies (c) for the potato growing activity. The small scale processing system also enables product differentiation of the final consumer product, such as packaging potatoes in Bins (250 kg boxes to be used in retail stores), 3 kg bags and 10 kg bags. Consequently, product differentiation is possible even at the farm level.

$$XS_{gct} - \sum_{i=1}^{n} XL_{gcit} - XT_{gct} = 0 \quad g = 1 \dots r$$

$$c = 1 \dots q, \quad t = 1 \dots p \tag{3}$$

Potatoes transported from primary producers to wholesale dealers within the region can be processed in large scale processing plants, represented by XC_{git}. Another alternative includes transportation to other regions defined by T_{ght}, representing shipment of potatoes from region (g) to region (h) during period (t) (Eq. (4)). Import of potatoes from other regions or from the international market is also feasible. In the model formulation it is assumed that processing takes place in the region where potatoes are finally consumed independent of their origin. As in the small scale processing case, product differentiation is also available in the large scale processing system.

$$\sum_{c=1}^{q} XT_{gct} + I_{gt} + \sum_{h=1}^{r,h \neq g} T_{hgt} - \sum_{h=1}^{r,h \neq g} T_{ght}$$

$$- \sum_{i=1}^{n} XC_{git} = 0 \quad g = 1 \dots r, \quad t = 1 \dots p \tag{4}$$

Market clearing conditions for various products originating from the large and small scale processing systems, in each region and during each period, are defined by Eq. (5). Consumers are assumed not to be able to distinguish between potatoes from small and large scale processing or domestic and imported potatoes. What especially characterizes potatoes from on-farm processing is that they are transported directly from the farm to the retail level of the marketing chain. The large scale system is much more logistic intensive. Transportation costs are included as a part of the objective function.

$$XC_{git} + \sum_{c=1}^{q} XL_{gcit} - Y_{git} = 0$$

$$g = 1 \dots r, \quad i = 1 \dots n, \quad t = 1 \dots p \tag{5}$$

Since it is not possible to transport potatoes processed in the small scale on-farm system between regions, production of a specific product in the small scale system can never exceed the demand of local consumers during a specific period. This feature of the model is ensured since the on-farm processing activity (XL_{gcit}) is not included in the shipment Eq. (4).

Fresh potato production in each region is restricted by the area available for growing. Maximum

regional fresh potato production is calculated as the acreage available for potato growing times average yield per hectare of land.

$$\sum_{c=1}^{q} \mathrm{XH}_{gc} - e_g \cdot d_g \leq 0 \quad g = 1 \ldots r \qquad (6)$$

In order to account for the actual shares of different production technologies available on farms, the maximum use of each technology in each region is restricted by a parameter f_{gc} defining the percentage of total farm production in region (g) produced with technology (c).

$$\mathrm{XH}_{gc} - f_{gc} \cdot \sum_{c=1}^{q} \mathrm{XH}_{gc} \leq 0$$

$$g = 1 \ldots r, \quad c = 1 \ldots q \qquad (7)$$

Volume of potatoes packed on farms is restricted by Eq. (8). The model formulation makes it possible to restrict the production of each product in each period and region to the maximum available capacity u_{git}. Hence, it is possible to account for the maximum available on-farm processing capacity when economic analyses of the industry are conducted for a short run scenario where no immediate expansion of processing capacity is assumed to occur as well as a long-run scenario with capacity expansion.

$$\sum_{c}^{q} \mathrm{XL}_{gcit} - u_{git} \leq 0$$

$$g = 1 \ldots r, i = 1 \ldots n, t = 1 .. p \qquad (8)$$

3. Empirical data

In order to demonstrate the applicability of the model upon the Swedish fresh potato market, data regarding production, transportation and consumption are collected for 5 regions of Sweden. Most of the data are available through earlier studies of the Swedish potato market. Official yield data and acreage of fresh potato per region during 1994 are obtained from Statistics Sweden (1995a,b). Average costs for growing, storing, transportation and processing activities are calculated using data and a software program developed by Orrenius (1994). Growing and storage costs are calculated for five

representative farm types in each region. Each of these farm types is characterised by a specific technology for harvesting and storing. Consumption data in this study are divided into 5 regions, 4 periods and 3 consumer products.

Some general facts regarding the studied regions are presented in Fig. 2. It ought to be especially noted that a large difference exists for the yields per hectare between the southern and most northern parts of Sweden. Furthermore, given the existing production pattern as of 1994, potatoes are transported from the growing districts in southern Sweden to the consumption centre in the middle parts of Sweden.

The processing stage, subsequent to the storage period, includes grading, packaging and distribution/marketing. Three types of consumer products can be produced, namely potatoes in packings of a 3 kg bag, 10 kg bag and bulk potatoes in 250 kg boxes, so-called Bins, to be used in retail stores. Similar products are produced by large scale processing plants. Processing costs in large scale processing plants are assumed not to vary between regions (Table 2).

Processing costs in small scale processing vary among regions because the costs depend on quantity of potatoes produced per farm. Farms in the most northern parts of Sweden, represented by regions 4 and 5, are characterized by higher processing costs mainly due to low yields and a limited acreage of the potato crop per farm. Further, farms in each region are divided into two sub-categories based upon the size of the potato digger on the farm. On average, farms with a two-row potato digger have a larger potato acreage than farms with a one-row digger and consequently the processing cost is lower on farms with a two-row digger (Table 3). In region 1, 2 and 3 the 'two-row' category farms have even slightly lower processing costs, for 10 kg bags and Bins, than large scale processors. This is possible since administration and building costs are low in small scale on-farm processing. The building cost at the farm level is only the incremental cost for adding processing equipment building space to an existing storehouse. The storehouse is required irrespectively of if the farmer produces a bulk product or engages in on-farm processing.

An estimate of maximum available small scale processing capacity per region is obtained from a
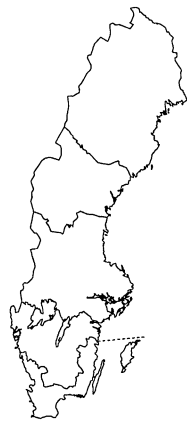
	Percent of population	Percent of fresh potato area (1994)	Potato yield per hectare (kg)
Region 5	6%	8%	15 978
Region 4	4%	4%	17 754
Region 3	41%	24%	24 806
Region 2	27%	28%	32 872
Region 1	21%	36%	37 614

Fig. 2. General overview of the examined regions. (Source: Statistics Sweden, 1995a,b)

study by Lunneryd (1996) (Table 4). Those estimates represent the maximal available capacity in a short run scenario prior to any adjustments having occurred in the industry.

Transportation costs between regions are calculated based on the premises of road transport between selected cities in each region. Transportation costs within regions are calculated using an estimate of the average distance between the farm and the most adjacent urban district with more than 5000 inhabitants, according to Lunneryd (1996). The same distance is assumed for all transportation within a region (Tables 5 and 6). Farmers involved in small scale processing activities are assumed to deliver packed potatoes to retail stores, restaurants etc. with a truck once a week, year around. Potatoes handled in the large scale processing system are initially transported to the processing plant and subsequently to the retail level (Table 6).

It may seem surprising that on-farm processors in the southern regions can obtain lower transportation

costs than large scale processors. However, at short distances loading and unloading accounts for a large part of the total transportation cost. When the farmer carries out the transportation with an inexpensive truck, which is typically the case for on-farm processors in this study, low transportation costs can be obtained if the distance between farm and retail stores is short and weekly deliveries represent a full truck load.

Table 2
Processing costs in large scale processing

Packing	Cost (SEK per kg)
3 kg bag	0.67
10 kg bag	0.55
Bins	0.41

Source: Orrenius (1994).

Table 3
Processing costs in small scale on-farm processing

	Output per farm (tons)	Processing cost for (SEK per kg)		
		3 kg bag	10 kg bag	Bins
Farms with one-row potato digger				
Region 1	225	0.85	0.62	0.46
Region 2	211	0.88	0.63	0.47
Region 3	165	0.93	0.70	0.51
Region 4	103	1.12	0.89	0.63
Region 5	91	1.17	0.95	0.66
Farms with two-row potato digger				
Region 1	429	0.70	0.49	0.38
Region 2	440	0.69	0.48	0.38
Region 3	390	0.71	0.49	0.39
Region 4	120	1.04	0.81	0.58
Region 5	106	1.09	0.87	0.61

Source: Orrenius (1994); Lunneryd (1996).

Table 4
Maximum small scale packaging capacity available in each region

| | Packaging capacity (tons per year) | | |
	3 kg bag	10 kg bag	Bin
Region 1	17,400	34,400	34,800
Region 2	17,200	34,500	34,500
Region 3	12,000	24,100	24,100
Region 4	2400	4800	4800
Region 5	4700	9300	9300

Source: Lunneryd (1996).

Table 6
Within region transportation costs in small scale processing

| | Distance km | Farm category (SEK per kg) | |
		One-row digger	Two-row digger
Region 1	15.8	0.16	0.08
Region 2	15.9	0.16	0.08
Region 3	22.3	0.22	0.09
Region 4	41.0	0.43	0.37
Region 5	47.2	0.51	0.44

Source: Orrenius (1994); Lunneryd (1996).

Data regarding fresh potato consumption in Sweden are obtained from Swedish Board of Agriculture (1994). Those data are used to calculate total consumer purchases of fresh potatoes, excluding early potatoes and potatoes grown for household use. Total purchases during 1992 amounted to 376,000 tons. Division of total quantity among regions, periods and packings and corresponding price levels are calculated using data from Statistics Sweden (1992), Andersson et al. (1994) and Andersson and Senauer (1994). In the model, linear demand functions are constructed utilizing a price elasticity −0.701, which is based on a Swedish study conducted by Andersson et al. (1994). This elasticity corresponds reasonably well to the findings of Rickertsen et al. (1995) and Miranda and Glauber (1993), who reported price elasticises of −0.72 (short run) and −0.359 respectively. It should be noted that currently available estimates do not allow for differentiation between locally produced potatoes and potatoes from large scale plants, that may be either domestic or imported. Besides, it is actually often the case that information regarding product origin is not available for the consumer at the retail level.

Table 5
Within region transportation costs in large scale processing

| | Distance km | Transport from—to (SEK per kg) | |
		Farm to processing[a]	Processing to store
Region 1	15.8	0.14	0.21
Region 2	15.9	0.14	0.21
Region 3	22.3	0.14	0.22
Region 4	41.0	0.17	0.25
Region 5	47.2	0.18	0.26

Source: Orrenius (1994), Lunneryd (1996).
[a] Includes the cost of transporting potatoes that are subsequently culled in the processing plant.

4. Results

In this section, some results from utilizing the model in order to analyse small scale processing in the Swedish fresh potato market are presented. The economic conditions for small scale on-farm processing are analysed according to the regional distribution of production as well as the relative competitiveness of this industry segment in the presence of increasing import competition. Welfare economic effects for consumers in some of the scenarios are also presented. In the study, the actors in the wholesale or retail level are assumed not to be able to exercise market power.

4.1. Optimal level of on-farm processing

Initially, a distribution of potato acreage according to the year 1994 is assumed in order to analyse a scenario with optimal short run adoption of on-farm small scale processing activities. In this first scenario, prior to Sweden joining the EU as of 1995, there is no import competition. Regional production and optimal quantities processed through on-farm processing activities in this scenario are presented in Fig. 3.

Evidently, there exist substantial economic incentives for farmers in the southern and middle parts of Sweden to enter into the small scale processing industry. In regions 1–3 on-farm processing is clearly a viable alternative for farmers, but the opposite holds for regions 4 and 5. Growers in southern and middle parts of Sweden benefit by short distances to
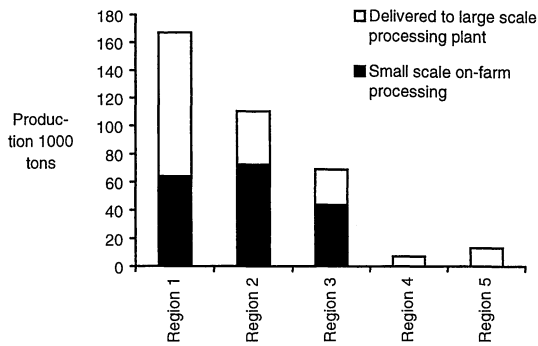
Fig. 3. Optimal on-farm processing in the short run with total potato acreage per region at the year 1994 level.

retail traders and a high volume of production per farm, making small scale processing an economic alternative to marketing potatoes as a bulk product. On the other hand, in northern Sweden it is obviously economically rational for farmers to deliver potatoes to a large scale processing plant. Even if small scale processing is a competitive alternative in the southern regions, not all farmers are better off by processing potatoes at the farm level (Fig. 3). Farmers with a low volume of production are better off selling potatoes as a bulk product. On-farm retailing may be an alternative for the latter category, but this opportunity is not considered in the analysis.

Results in this study concerning the socially optimal level of on-farm processing can be compared with the actual level reported by Lunneryd and Andersson (1996). In the latter study, which included a mail survey to 1500 potato growers in Sweden during 1994, the definition of the on-farm processing activity is somewhat wider than the definition used in this study. Lunneryd and Andersson also regarded farmers selling potatoes directly to consumers as on-farm processors. However, Lunneryd and Andersson reported that 46.2% of Swedish potato growers process potatoes on the farm. The results in this

study indicate that the socially optimal level of on-farm processing is 48% of total production volumes with an acreage distribution as of 1994 (Fig. 3). Contrary to this study, Lunneryd and Andersson report that a considerable percentage of farmers in northern Sweden engage in small scale processing. This finding may partly be attributable to the assumption that the regional demand functions are invariant to the product origin and form of processing.

It is obvious from Table 7 that the introduction of small scale on-farm processing in the potato industry enhances the social value of production. Consumers are nearly unaffected by the introduction of on-farm processing, while producers derive the major benefits. In spite of the positive effect for the society there is some disparity between the economic interests of actors in the different stages of the food marketing chain. Primary producers (farmers) as a collective benefit by the introduction of on-farm processing, while actors in the latter stages of the food-marketing chain become somewhat worse off. The welfare of farmers is on average increased by 0.15 SEK/kg potato (approximately 7% of the producer price) when on-farm processing is introduced in the sector. Without small scale processing, large scale processors and actors in the retail level operate at zero excess profits, which follows by the construction of the sector model. When small scale processing is introduced the latter actors lose 10 million SEK due to a price increase at the farm gate. The introduction of small scale processing in the sector causes a minor decrease in total consumer surplus (Table 7). The loss of consumer surplus is due to a 1% increase in the price paid by consumers, as an average across all regions, seasons and products.

Evidently, the level of small scale on-farm processing may affect the market price of potatoes. How and to which extent the level of small scale process-

Table 7
Effects upon the welfare of producers and consumers by introducing small scale processing in the sector[a]

	Consumer surplus (mill. SEK)	Producer surplus[b] (mill. SEK)	Farmer surplus (mill. SEK)
With small scale processing	1171	125	135
No small scale processing	1177	77	77

[a]Regional potato acreage according to the year 1994 level.
[b]The surplus of all actors in the potato marketing chain, farmers included.

ing influences market prices at farm and retail level may ultimately depend on prevailing supply and demand conditions. The fact that introducing/expanding local small scale processing activities may affect market prices is a frequently overlooked aspect when designing policies to enhance or promote added-value activities in the agricultural sector. In general, the distribution of economic gains among various categories of actors in the food marketing chain is not analysed in any greater detail or not considered at all in several other studies (Apland et al., 1994; Durham et al., 1996).

In the previous analysis concerning the optimal level of on-farm processing, total potato acreage in each region is set at the same (1994) level independent of the market share for on-farm processed potato. A sensitivity analysis indicates that the acreage constraint has limited effects on the optimal supply of on-farm processed potatoes. (In regions 2 and 3, the supply of on-farm processed potatoes is to some extent bounded by the packaging capacity constraint (Table 4)). However, in principle, it may be argued that the introduction of small scale processing in the sector may increase the long run supply of potatoes. The argument, for the case of the Swedish potato industry, is that some primary producers are able to increase profits in potato production if they integrate vertically. In the absence of import competition, which is the case in this specific analysis, an increase in the domestic supply of potatoes may lead to lower

consumer prices and reduce the benefits to producers of expanding small scale on-farm processing.

4.2. Import competition

The Swedish membership in the EU causes increasing import competition, which affects the domestic potato industry. However, decreasing producer prices in a scenario with enhanced international competition may affect farmers' decisions to engage in on-farm processing activities.

The impact of increasing import competition on the quantity grown by domestic farmers, compared with the 1994 production level, is presented in Fig. 4. In the scenario labelled 'Maximum import competition' the import price to region 1 is 1.39–1.53 SEK per kg, depending on season. This is the Rotterdam quote for fresh potatoes as an average over 7 yr plus transportation cost to the region (Kartoffelbau, 1988–1995; Orrenius, 1994). During the period June to September no import takes place, since early potatoes dominate Swedish consumption. Scenarios, with imports restricted to 20 and 40% of domestic consumption and potato production in each region limited to the 1994 production level, are also examined. A striking result is that, due to high production costs, production in regions 4 and 5 is not economically justifiable even in scenarios with limited import competition. Region 2 appears to possess the best economic prerequisites to compete with foreign
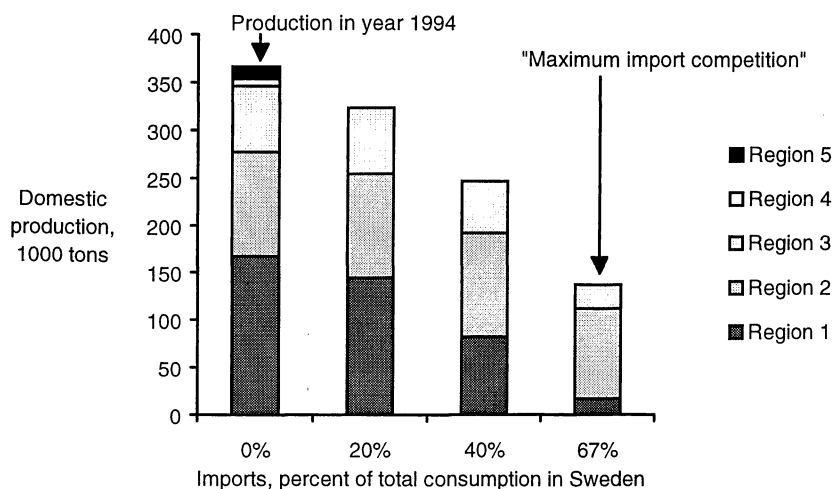

Fig. 4. The impact on regional production of some scenarios with varying import competition for fresh potatoes.
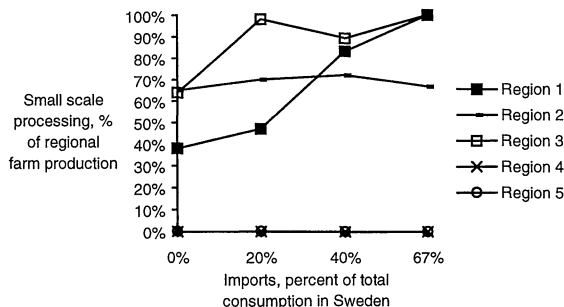
Fig. 5. The impact of increasing imports on farmers' decision to process potatoes on the farm.

growers. The decrease in domestic production in the 'Maximum import competition' scenario might be less drastic if consumers are willing to pay a premium for domestic potatoes, compared to imported potatoes, provided that information concerning product origin is available to the consumer.

Farms that are able to sustain an enhanced level of foreign competition appear to be characterized by a more pronounced economic incentive to engage in on-farm processing (Fig. 5). Especially in the densely populated regions 1 and 3, the share of domestic production that is allocated to local on-farm processing activities increases with increasing import com-

petition. In the scenario labelled 'Maximum import competition' farmers in region 1 and 3 are not able to compete if they remain bulk producers. In region 2 there is no apparent tendency towards a higher percentage of farmers engaging in on-farm processing. In the latter region, also farms with a low production volume are able to compete with foreign producers. As mentioned before, farms with a low production volume are, in most cases, better off selling potatoes as a bulk product. A result in Fig. 5 that might seem somewhat surprising is that a lower percentage of farm production in region 3 is processed on farms when imported potatoes account for 40% of the domestic consumption versus scenarios with 20 and 67% imported potatoes. The main reason for this result is the restriction that potatoes are not imported during the summer period. In region 3, there are no small scale processing activities conducted during the summer period in the absence of import competition, but with a 20% import share this appears to be a rational alternative for some growers.

Not surprisingly, enhanced international competition not only affects domestic farmers, but also consumers and processors in the subsequent stages of the food marketing chain. Consumers benefit from lower prices. Nevertheless, the reduction of consumer prices arising in the 'Maximum import com-
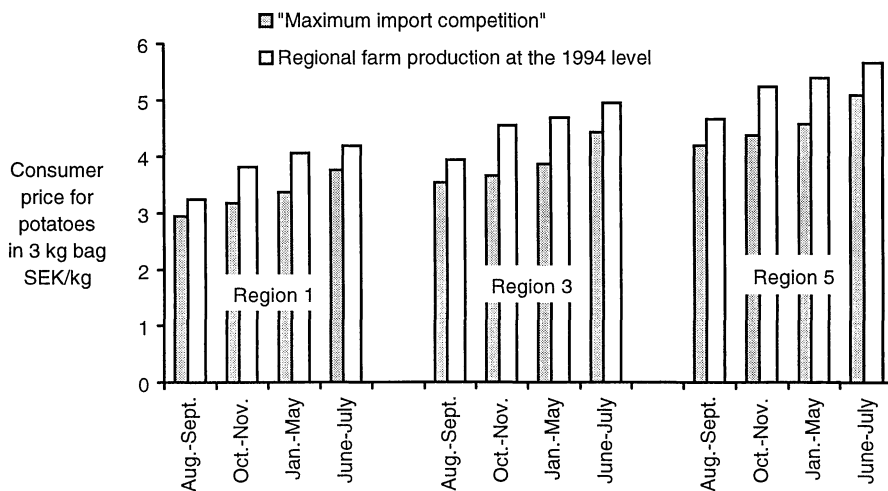

Fig. 6. Consumer price for potatoes packed in a 3 kg bag, depending on region and season. The scenario labelled 'Maximum import competition' is compared to a scenario without imports and a regional production pattern according to the year 1994. (SEK/kg excluding value-added tax.)

☐ Large scale processing, including imported potatoes
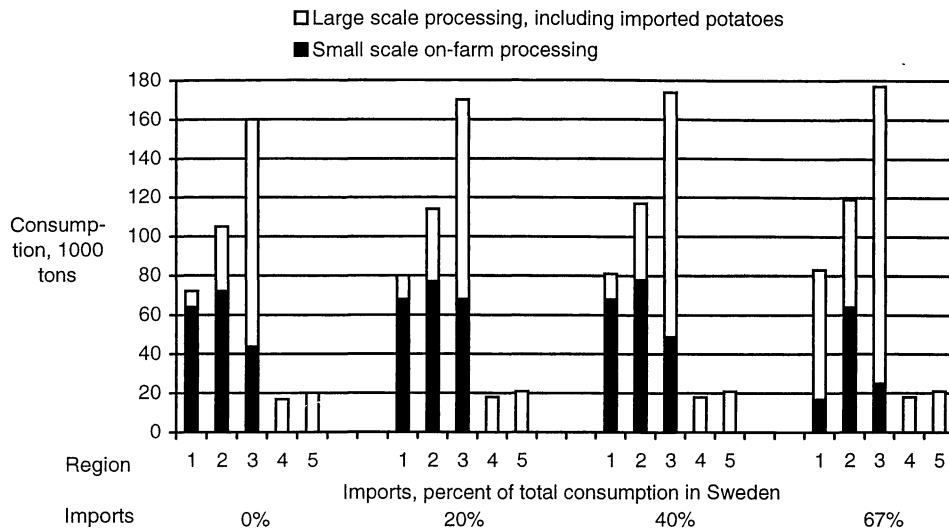■ Small scale on-farm processing

Fig. 7. Processing of potatoes in regions as a function of the import share of the Swedish fresh potato market. Processing takes place where potatoes are consumed.

petition' scenario seems to be moderate compared to the reduction of the domestic potato production (Figs. 4 and 6). As an example, the difference between the consumer price in region 1 and region 5, during a specific period, is actually larger than the difference in consumer prices between the scenarios (Fig. 6).

Fig. 7 summarizes consumption and on-farm processing in the five regions and the effects of imports. Without import competition, the share of potato consumption that is processed on farms diminishes as we move from the southern region (region 1) to the northern region (region 5). Quantities handled through on-farm processing activities are quite unaffected by increasing imports, except for the 'Maximum import competition' scenario with 67% imported potatoes. Lower market prices due to increasing imports tend to increase total consumption in all regions. A striking result, taking the results illustrated in Figs. 4, 5 and 7 together, is that farmers that integrate vertically in the food marketing chain are far better off than bulk producers in adjusting to changing economic conditions resulting from increased import competition. Farmers that produce potatoes as a bulk product are forced to assume a

major part of the economic adjustments occurring in the industry.

5. Conclusion

The analysis in this paper indicate that incorporating on-farm processing activities in a partial interregional equilibrium model of an agricultural industry offer some interesting insights. From a methodological point the inclusion is straight forward and the insights provided are relevant from a regional as well as an agricultural policy perspective. Hence, the model structure is of interest for examining various policy problems in DCs as well as LDCs where the role of on-farm processing and/or selection of appropriate technologies is of interest to policy makers.

For the case of the Swedish potato industry it is demonstrated that locally specialized on-farm processing activities are part of a socially optimal industry structure. Economic incentives exist for growers in the southern regions to process potatoes on the farm, while growers in the northern regions are better of selling potatoes as a bulk product.

The analysis indicate that the introduction of small scale on-farm processing in the sector enhances the social value of production. On-farm processing activities increase farm income and consequently strengthen the rural economy. Furthermore, the analyses demonstrate that local on-farm processors in a geographically limited area appear to be relatively more competitive than bulk producers if the industry is facing substantial import competition. Farmers that produce a bulk product appear to have the largest difficulties to survive in a scenario with fierce import competition.

Hence, at least the results attributable to an analysis of the Swedish potato industry, show that on-farm processing may facilitate an adjustment process occurring as a result of a deregulation of international agricultural markets. A transition from a traditional price support oriented agricultural policy towards a more integrated rural development policy could be simplified. It may be argued, that on-farm processing serves as an effective diversification scheme for producers since some of the problems attributable to increasing import competition and lowered product prices arising from a deregulation of agricultural markets are mitigated.

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