The Impact of Inefficiency on Diversification

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The theory of multiple outputs/multiple inputs is relevant in the conceptualization of resource allocation throughout the economy. Few important real-world analyses of production or marketing operations (in the agri-food complex or elsewhere) are single product in nature. A complete understanding of multiple output production decisions requires developing meaningful technological specifications and measures reflecting the potential for multiple output decisions. The consideration on non-jointness in production decisions has preoccupied economists for the last half century starting with Carlson's 1939 classic study (reprinted 1965, pp. 74-102,) and Frisch (reprinted 1965, pp. 269-281) who initiated close attention to the relation of nonjoint technology to total costs refined by others [e.g., Mundlak (1964), Samuelson (1966), Lau (1972), Hall (1973), Hasenkamp (1976), Kohli (1983), Mittelhammer et al. (1981), Shumway et al.(1984)]. Panzar and Willig (1977) and Baumol, Panzar and Willig (1982) introduced the notion of multiple output scale and scope to characterize the effects of size and output diversification for the firm producing more than one output. Measuring economies of scale and scope is essential to understanding the forces influencing structural, efficiency and productivity changes.

This paper focuses on measuring and explaining economies of scope on Dutch crop farms. There are a myriad of forces beyond technological jointness that encourage operators to diversify their crop activities. Diversification is often seen as a risk management tool, but equally important, it also yields direct benefits in the control of soil borne diseases. As such, diversification reduces the negative externalities to the environment and diversified crop farms do not suffer from the reduction in crop yields that is observed in monoculture over time. On the other hand, specialization allows operators to exploit scale economies in single outputs and offers specialized operators more opportunities to fine-tune their skills which can promote a greater degree of technical proficiency.

Measuring economies of scope facilitates the assessment of the benefits from output diversification versus specialisation for operators and provides a metric for explaining and predicting trends towards specialisation or diversification. However, the current literature on economies of scope provides little insight into the potential trade off between the benefits of diversification and the presence of inefficiency in production and decision making. To remedy this shortcoming, this paper develops a measure of an effective (or behavioural) measure of scope economies which measures the benefits of diversification accounting for the contributions of allocative, congestion and technical efficiency in scaling the perfectly efficient version of scope economies.

Olesen (1995) reviews the potential of DEA approaches to address issues related to multiple output production and identifies the need to define indicators which can inform the analyst of the degree the estimated technology is a joint technology. He equates the economies of jointness with economies of scope and concludes that while DEA can always provide an estimation of the multiple output technology, there are no indicators available to advise the analyst whether or not the structure of the data supports the existence of a joint technology. While this is the case for nonparametric analyses, there have been econometric efforts focusing on the empirical determination of the presence of jointness [e.g., Just et al. (1983), Shumway (1983), Chambers and Just (1989), Fernandez-Cornejo et al (1992)]. Chavas and Aliber (1993) investigate scope and efficiency in Wisconsin dairy farms following a nonparametric framework and find that positive economies of scope exist for a variety of farm sizes, albeit it decreases for significantly larger operations. In addition, they find that economic losses do result from allocative and scale inefficiencies.

Färe, Groskopf and Lovell (1994, pp. 263-69) present a nonparametric framework to compute the gains from combinations of farms and the diversification of products, where diversification is characterized by farms of different types embodying different cost functions. Delineating between specialized and diversified technologies, the measure of the gains from diversification is the ratio of the sum of diversification to the cost of producing all products together. This measure is in subtle contrast to Hall (1973) [and elaborated on by Baumol, Panzar and Willig (1982)], which compares the cost of operating separately to the cost of operating jointly, and necessarily maintains the presence of a common cost (or production) structure. Färe, Grosskopf and Lovell create a pseudo set of (or subsets of actual) specialized and diversified farms by building upon the frontier performance. As such, this measure presents the potential gains from diversification as the hypothetically diversified farms are constructed.

The decomposition of the nonparametric measure of effective or behavioural economies of scope is presented in the next section. This is followed by an empirical investigation of Dutch cash crop farms, covering the period 1995-1999 where up to three outputs (rootcrops, cereals and other outputs) and six inputs (i.e. pesticides, fertilizers, other variable inputs, land, labor and capital) are distinguished. This empirical investigation explores the causes of scope economies and their impact on the production structure.

Non-parametric Measures of Scope

The decomposition of economies of scope requires a measure reflecting the benefits of joint production vis-à-vis production in separate production units. Baumol, Panzar and Willig (1982) and Panzar and Willig (1977) propose a measure of economies of scope using cost functions. Assuming a farm is minimizing costs of variable inputs (x) used to produce a bundle of outputs, minimum costs to produce the output bundle *y* given fixed inputs *z* and variable input prices *w* are given by the cost function *C(y,w,z)*, defined as $w \cdot x$. The measure of *Behavioural Economies of Scope* (*BES*) is a modification[1] of the Baumol, Panzar and Willig measure that is used in Chavas and Aliber (1993):

(1)
$$BES = \frac{C^*(y^i, w, z) + C^*(y^{N-i}, w, z)}{C(y, w, z)}$$

where $C^*(y^i,w,z)$ is the minimum variable cost of producing the subset *i* of outputs, i.e. the vector y^i. Furthermore, y^{N-i} denotes the subvector of all *N-i* outputs, i.e. all outputs except the subset *i*. Minimum variable costs, assuming a variable returns to scale technology are calculated from:

(2)
$$\begin{aligned} &\min_{x^*} \ w \cdot x^* \\ &s.t. \\ &-y^i + \lambda Y^i \geq 0 \\ &\lambda Y^{N-i} \geq 0 \\ &z - \lambda Z \geq 0 \\ &x^* - \lambda X \geq 0 \\ &N1'\lambda = 1 \\ &\lambda \geq 0 \end{aligned}$$

Where x^* denote cost minimizing quantities of variables inputs; Y (X,Z) is a vector of observed outputs (variable inputs, fixed inputs) of all firms in the sample; λ is a vector of weights that are positive for firms on the frontier and zero otherwise; *N*1 denotes an *(NxN)*

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[1] Our measure differs from the Baumol et al. and Chavas and Aliber definition in that we use minimum costs net of inefficiencies as the numerator. Moreover, our measure of *BES* uses actual rather than minimum costs as the denominator.

identity matrix. $C^*(y^{N-i},w,z)$ are minimum variable costs of producing the subvector N-*i* of outputs given fixed inputs z and variable input prices w that are calculated from:

$$\begin{aligned} &\min_{x^*} \; w \cdot x^* \\ &s.t. \\ &-y^{N-i} + \lambda Y^{N-i} \geq 0 \\ &\quad \lambda Y^{i} \geq 0 \\ &z - \lambda Z \geq 0 \\ &x^* - \lambda X \geq 0 \\ &N1'\lambda = 1 \\ &\lambda \geq 0 \end{aligned} \tag{3}$$

BES can be defined as the product of pure economies of scope (*PES*) and overall efficiency (*OE*), $BES = PES \cdot OE$:

$$\frac{C^*(y^i,w,z) + C^*(y^{N-i},w,z)}{C(y,w,z)} = \frac{C^*(y^i,w,z) + C^*(y^{N-i},w,z)}{C^*(y,w,z)} \cdot \frac{C^*(y,w,z)}{C(y,w,z)} \tag{4}$$

$PES > 1$ $(= 1, < 1)$ suggests cost economies (neutrality, diseconomies) from joint production of outputs. The term *OE* denotes overall efficiency (under variable returns to scale) which can be decomposed in the usual way in allocative efficiency, congestion efficiency and pure technical efficiency. The denominator of *PES* in (4) is calculated from:

$$\begin{aligned} &\min_{x^*} \; w \cdot x^* \\ &s.t. \\ &-y + \lambda Y \geq 0 \\ &z - \lambda Z \geq 0 \\ &x^* - \lambda X \geq 0 \\ &N1'\lambda = 1 \\ &\lambda \geq 0 \end{aligned} \tag{5}$$

Multi-product economies of scale (*MSCALE*) is defined according to Panzar and Willig (1977) as:

$$MSCALE = \frac{C^*(y,w,z)}{\sum_{i=1}^{N} y_i C_i^*(y,w,z)} \tag{6}$$

where $C_i^*(y,w,z)$ is the dual value of y^i associated with (5), and *product-specific economies of scale* (*PSCALE$_i$*) are defined as:

$$PSCALE_i = \frac{C^*(y,w,z) - C^*(y^{N-i},w,z)}{y_i C_i^*(y,w,z)} \tag{7}$$

The dual value is not unique for observations making up the frontier (Coffey and Featherstone, 2004). This paper addresses this problem by using only non-frontier farms for the computation of scale economies (6) and the indicator for product-specific inputs (7).

Data

Data on specialized cash crop farms covering the period 1995-1999 come from a stratified sample of Dutch farms in the accounting system of the Agricultural Economics Research Institute (LEI). The farms typically remain in the panel for a maximum of five to eight years leading to an incomplete panel. Farms are replaced in the sample to avoid a selection bias, which arises when farms improve their performance by their presence in the accounting system.

Three outputs (cereals, rootcrops and other outputs) and six inputs (pesticides, fertilizers, other variable inputs, land, labor and capital) are distinguished. Variable inputs are pesticides, fertilizers and other variable inputs. Cereals include wheat, barley and oats; other outputs are mainly protein crops, vegetables and other crops. Rootcrops (mainly potatoes and sugar beet) are the main source of income for most cash crop farms in the Netherlands. The typical crop rotation of specialized cash crop farms consists of potatoes sugar beet, cereals and one other crop. Four observations report zero output for rootcrops; 118 for cereals and 123 for other outputs. Two farm types are distinguished in the sample, with rootcrop farms defined as farms with an above average (36%) share of revenues from rootcrops in total revenues; the other farms are denoted as cereal production-oriented enterprises. The data sets used for the estimations contain 527 and 764 observations on rootcrop-oriented farms and cereal-oriented farms, respectively (the total number of observations is 1291). A detailed description of the data can be found in Table 1.

Fixed inputs are land, labor and capital. Land is measured in hectares; labor is measured in quality-corrected man years, and includes family as well as hired labor. In this study, labor is assumed to be a fixed input since a large share of total labor consists of family labor. Flexibility of hired labor is further restricted by the presence of permanent contracts and by the fact that hiring additional labor involves search costs for the farm operator.[2] The quality correction of labor is performed by the LEI and is necessary to aggregate labor from able-bodied adults with labor supplied by young people (e.g., young family members) or partly disabled workers. Capital reflects replacement costs[3] of buildings, machinery and installations and is measured at constant 1995 prices.

Implicit quantity indexes are generated as the ratio of value to the price index. Tornqvist price indexes are calculated for the composite outputs and variable inputs with

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[2] As table 1 indicates, the average man-years for total labor is under 2, suggesting hired labor is a small part of the variable input decisions process.

[3] The deflators for capital in structures and machinery and installations are calculated from the data supplied by the LEI accounting system. Comparison of the balance value in year t and the balance value in year *t-1* gives

prices obtained from the LEI and Central Bureau of Statistics (LEI/CBS). The price indexes vary over the years but not over the farms, implying differences in the composition of inputs and output or quality differences are reflected in the quantity (Cox and Wohlgenant, 1986).

Results

Solutions for the mathematical programming problems in (2), (3) and (5) are obtained using GAMS. The models are run for each farm in the sample in each year, using all other farms in the sample in the same year as reference group. *BES* by farm type and year and its decomposition into *PES*, allocative, congestion and pure technical efficiency are generated.[4]

Table 2 presents results indicating that the *BES* are in the range of 0.66-0.78, while *PES*, on average, are greater than unity for all years suggesting that the farms in the sample face lower total costs when producing more than one output. Further, allocative efficiency is the most important determinant of *BES* in all years, averaging in the range of 0.68-0.79 in the period under investigation implying that the farms in the sample could reduce their variable costs by 21 to 32 percent through an optimal re-allocation of variable inputs. Pure technical inefficiency is the smallest component of *BES*, with an average inefficiency of 6%. This is consistent with the Chavas and Aliber findings that allocative inefficiency is relatively more severe than technical inefficiency.[5] Congestion is the second most important contributor to inefficiency, as it can lead to a 7 percent reduction of the use of the variable inputs. Congestion is often caused by the failure to adjust input quantities instantaneously,

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the yearly price correction used by the LEI. This price correction is used to construct a price index for capital and a price index for buildings, machinery and installations. These price indices are used as deflators.

[4] The decomposition into allocative, congestion and pure technical efficiency is demonstrated in Färe, Grosskopf and Lovell (1994).

[5] Chavas and Aliber (1993) generate both short run and long run efficiency estimates for nine different Wisconsin dairy production districts. For comparison in this study, the weighted group means are calculated from their Table 2, page 10, the short run measures for TE and AE are 0.93 and 0.83,

which is plausible for inputs like pesticides and fertilizers. Their use is largely determined by the composition of the crop mix which cannot change instantaneously. Changing the use of pesticides requires new (e.g. resistant) crop varieties and new cultivation practices, replacing chemicals by mechanical weeding. Similarly, applications of fertilizers like Potassium and Phosphates are part of a multi-year crop plan.

Table 3 decomposes the *PES* and the efficiency components of the cereal-oriented versus the rootcrop-oriented farms and reveals that on rootcrop-oriented farms the total scope economies are slightly smaller indicating that these farms have lower cost savings from joint production than cereal-oriented farms. A non-parametric Mann-Whitney U test is employed to test for the significance of the differences between farm types. The test results show that all differences between farm types are significant at the 5% level for *PES*, congestion efficiency and pure technical efficiency. The rootcrop-oriented farms generally have a lower score for these components. The lower score for *PES* implies that rootcrop farms achieve lower cost savings from joint production than the cereal-oriented farms. Although both farm types benefit from diversification cereal oriented farms have a larger incentive for joint production than rootcrop farms. This result may reflect the negative impact of rootcrops on soil fertility, thereby partly undoing the benefits of joint production. The lower congestion efficiency on rootcrop farms suggests that it is more difficult for these farms to adjust the inputs instantaneously than for other farms. This result is in line with the observation that sugar beet and potatoes are more intensively using variable inputs (fertilizers and pesticides) than other crops.

In analyzing the relation between farm size and *BES*, for each farm type, a category of small (large) farms is defined as those farms having a smaller (larger) land area than the

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respectively. The weighted mean for the measure of scope economies from the same table is 1.50; albeit farm type's average. When focusing on farm size, a different profile emerges. While table 2 indicates that allocative inefficiency is the most important determinant of *BES*, Table 4 indicates that smaller farms present a substantially greater degree of allocative inefficiency and lesser degree of congestion inefficiency. Overall, small and large farms present the same level of technical efficiency. On balance, smaller farms have a higher *PES* measure but a smaller *BES* measure compared to larger farms. The higher *PES* measure on small farms suggests that joint production is more beneficial on small farms than on large farms. This suggests that part of the benefits of diversification is lost when producing at a larger scale.

The product-specific components of multi-output returns to scale by farm size and farm production orientation are presented in table 5. The product-specific returns to scale is substantially in the decreasing returns to scale range when considering the single-output perspective of production decision making, while the multi-output returns to scale is in the constant or increasing returns to scale range. Cereal production presents the lowest product-specific returns to scale in all cases, while rootcrop production presents the highest product-specific returns to scale in all cases, except small rootcrop-oriented farms. Farm size has the most significant impact on the multi-output returns to scale with small farms at or close to the constant returns to scale production, and larger farms exhibiting substantial increasing returns to scale. This suggests that regulatory or infrastructure factors constrain the ability of larger farm operators to exploit economies of scale[6].

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this is a long run measure (no short run measure is reported).

[6] The economies of scale for large farms are larger than what is often found in the literature, but are in line with the findings of Abdullahi et al. (2006) for Kansas wheat and beef-cow operations. The large economies of scale may also be associated with the nonparametric method that is used in this paper. The size of the economies of scale depends on derivatives at the frontier which may become very small or large.

The frequency distributions of the *PES* for the small and large farms are both distributed normal.[7] Table 6 presents the frequency of the presence of negative, neutral and positive economies of scope for small and large farms, where the indication of neutral economies of scope is generously interpreted as 1.0 ± .01. The small farms present a greater frequency of positive scope economies, which is in line with the finding of a higher average score for *PES* on small farms in Table 4.

Table 7 presents the results of the investigation of the forces impacting scope economies with the presentation of a log-linear regression of *PES* on three sets of explanatory variables. The first set comprises a set of dummies reflecting farm production orientation (1, if rootcrop-oriented) and farm size (1, if large). The results indicate that farms that are rootcrop-oriented or large will lower *PES*, *ceteris paribus*.[8] There is a significant negative impact of the rootcrop-oriented farming operations on scope economies which reflects the fact that crop rotation restrictions are constraining the sharing of land across the production of different outputs more severe for rootcrop farms rather than for other farms. This is because on rootcrop farms, the pressure of soil born diseases is higher.

The second set of variables involves the variable input prices. The marginal impact of a variable input price on the *PES* measure can be expressed into a dimensionless measure by multiplying through by price to yield

$$w_j \frac{\partial PES}{\partial w_j} = PES \cdot \left[s_i^{separate} - s_j^{joint} \right], \tag{9}$$

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[7] The Komolgorov-Smirnoff test does not reject normal distributions of *PES* with a test statistic of 0.124 and 0.082 for small and large farms, respectively, both significant at < 0.001. Small farms have a sample mean of 1.14 and standard deviation of 0.198, while large farms have a sample mean of 1.09 and standard deviation of 0.152.

[8] Dummy variables reflecting soil type and characteristics related to the farm operator (education, presence of a successor, and tenure status) did not contribute significantly to the explanatory power of the regression.

where $s_j^{separate} = \frac{w_j x_j(y^i, w, z) + w_j x_j(y^{N-i}, w, z)}{C^*(y^i, w, z) + C^*(y^{N-i}, w, z)}$ and $s_j^{joint} = \frac{w_j x_j(y, w, z)}{C^*(y, w, z)}$, reflect the j^{th} input cost share of producing separately and jointly, respectively.

Price changes can lead to input substitutions that eventually impact costs of production. The presence of economies (diseconomies) of scope magnifies (contracts) the cost share differences. Table 7 shows that variable input price changes can have a substantial impact on scope economies. Price increases in agricultural chemicals (pesticides and fertilizers) have a negative impact on scope economies while a price increase for the miscellaneous input variable enhances scope economies. The changes in input mixes driven by relative price changes can have a substantial impact on the organization of these farms. *PES* is highly elastic, ranging from 3.3 to 20 percent reduction in scope economies from a one percent increase in the prices of fertilizer and pesticide, respectively, to a 9 percent increase in scope economies from an increase in the miscellaneous input variable.

The third set of variables comprises the fixed inputs in the production process. Shared fixed inputs are fixed inputs used by several outputs in the production process; output-specific fixed inputs are used for the production of specific outputs. The presence of shared or output-specific fixed inputs is inferred from the impact on *PES* of increasing fixed inputs in the regression model.[9] A positive (negative) impact of the fixed input on *PES* suggests the fixed input is a shared (product-specific) fixed input. Results in Table 7 show that all three fixed

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[9] A discrete approximation of the marginal impact can be achieved by: $\frac{C_z^*(y^i, w, z) + C_z^*(y^{T-i}, w, z) - C_z^*(y, w, z)}{C_z^*(y, w, z)^2}$, where $C_z^*(y, w, z)$, $C_z^*(y^i, w, z)$ and $C_z^*(y^{N-i}, w, z)$ are the dual values associated with the constraint on the *z*-inputs in the cost minimization problems in (5), (2) and (3), respectively. However, corners on the surface can be encountered, leaving this an unsuitable option.

factors have a significant impact on *PES*, revealing a highly inelastic response with a 10 percent increase in capital and labour leading to a less than 4 percent increase and decrease, respectively, in scope economies The impact of land is negative suggesting increases in this asset will decrease incentives for joint production, albeit it, at half the response in absolute value as the other assets marginally. Thus, capital is a shared (or farm-specific) asset, on balance, while labor and land are product-specific assets suggesting that no production expertise spillovers are evident and that many of these cash crop farms rent land purely for growing potatoes. There is a significant negative impact of the rootcrop-oriented farming operations on scope economies which reflects the restrictions of crop rotation restrictions, which facing higher pressure of soil borne diseases compared to other crop farms. In contrast, Goodwin, Featherstone and Zeuli (2002) find a robust correlation between a farm's historical yield on other crops and a newly produced crop when considering wheat, corn and soybean production in Kansas.

Conclusion

Measuring economies of scope provides a tool for explaining and predicting trends towards specialisation or diversification within sectors like agriculture and horticulture. This paper focuses on nonparametric measurement and decomposition of scope economies into a perfectly efficient measure of scope economies and adjustments attributed to allocative, congestion and pure technical efficiencies. These efficiency-related adjustments reveal that operators, who as perfect optimizers would be diversified, can be driven to specialisation to accommodate inefficient behaviour.

Results for a sample of Dutch cash crop farms over the period 1995-1999 show that the potential economies of scope are lowered largely by allocative inefficiency and to a lesser extent by congestion inefficiencies and technical inefficiency, and the contraction impact of the various sources of inefficiencies drive these farms, on average, well into the diseconomies of scope range. While the economic incentives for joint diversification exist given the structure of production, the economic losses associated with allocative, congestion and technical inefficiencies lead to the potential to reduce costs by 25%, 7% and 6%, respectively. Rootcrop production-oriented farms and larger farms tend to have lower (albeit, still positive) scope economies potential. This study also finds that capital is a shareable factor of production, while labor and land are not.

Analysis of results of diversified vis-à-vis specialized farms shows that policies should enhance particularly small and cereal farms to diversify. Also, increases of prices of pesticides and fertilizer substantially reduce the potential for cost savings from diversification. Hence fertilizer and pesticides taxes may have a large impact on the decisions of operators to either diversify or specialize.

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Table 1: Descriptive statistics of the variables used in the DEA models.

Farm type	Variable	Dimension	Mean	Standard Deviation
Other	Rootcrops	1000 guilders	91.55	100.49
	Cereals	1000 guilders	20.56	24.71
	Other Outputs	1000 guilders	86.55	104.33
	pesticides	1000 guilders	6.08	4.80
	Fertilizer	1000 guilders	9.38	8.91
	Other inputs	1000 guilders	50.42	66.31
	Land	hectares	48.41	32.66
	Labor	Man years	1.98	1.54
	Capital	1000 guilders	191.67	172.38
Rootcrops	Rootcrops	1000 guilders	247.98	188.24
	Cereals	1000 guilders	22.92	23.16
	Other Outputs	1000 guilders	27.44	37.54
	Pesticides	1000 guilders	10.43	7.27
	Fertilizer	1000 guilders	20.20	13.51
	Other inputs	1000 guilders	50.96	36.10
	Land	hectares	74.21	50.43
	Labor	Man years	2.00	1.19
	Capital	1000 guilders	262.77	199.76
All	Rootcrops	1000 guilders	184.13	176.05
	Cereals	1000 guilders	21.96	23.82
	Other Outputs	1000 guilders	51.57	78.21
	Pesticides	1000 guilders	8.66	6.72
	Fertilizer	1000 guilders	15.78	12.99
	Other inputs	1000 guilders	50.74	50.64
	Land	hectares	63.68	45.83
	Labor	Man years	1.99	1.35
	Capital	1000 guilders	233.75	192.20

Table 2: Decomposition of Behavioural Economies of Scope.

Year	Farms	BES	PES	Allocative	Pure Technical	Congestion
1995	279	0.78	1.14	0.77	0.94	0.94
1996	282	0.77	1.10	0.79	0.94	0.95
1997	268	0.66	1.16	0.68	0.92	0.89
1998	244	0.75	1.16	0.74	0.93	0.93
1999	218	0.74	1.06	0.78	0.94	0.94
Period	1291	0.74	1.12	0.75	0.94	0.93

Table 3: Decomposition of Behavioural Economies of Scope by Farm Type.

Farm type	BES	PES[a]	Allocative	Pure Technical[a]	Congestion[a]
Cereal	0.77	1.16	0.74	0.94	0.94
Rootcrops	0.72	1.10	0.76	0.93	0.92
All farms	0.74	1.12	0.75	0.94	0.93

a) Significant difference (at 5%) between rootcrop-oriented and cereal-oriented (Mann-Whitney U test).

Table 4: Decomposition of Behavioural Economies of Scope by Farm Size

Farm Size	BES[a]	PES[a]	Allocative[a]	Pure Technical	Congestion[a]
Small	0.72	1.14	0.71	0.94	0.94
Large	0.78	1.09	0.82	0.94	0.92
All farms	0.74	1.12	0.75	0.94	0.93

a) Significant difference (at 5%) between rootcrop-oriented and cereal-oriented (Mann-Whitney U test).

Table 5: Product-Specific and Multi-Output Returns to scale by Farm Type and Size

Farm Type & Size		Product-Specific Returns to Scale		Multi-Output Returns to Scale
	Cereal	Rootcrops	Other	
Cereal Farms				
Small	0.48	0.63	0.58	1.08
Large	0.39	0.59	0.42	2.33
Rootcrop Farms				
Small	0.49	0.53	0.57	0.99
Large	0.40	0.69	0.45	2.24
All farms	0.44	0.61	0.51	1.61

Table 6: Frequency of presence of diseconomies, neutral and economies of scope by farm size (in percentages).

	Small	Large
Diseconomies	11.37	19.09
Neutral[a]	6.77	7.38
Economies	81.86	73.82

[a] Neutral defined as $0.99 < \text{PES} < 1.01$.

Table 7: Results OLS regression of Pure Economies of Scope on the Fixed Arguments.

Variable	Parameter	t-value
Intercept	0.089*	1.901
Dummy Farm Size	-0.022	-1.468
Dummy Rootcrop	-0.055**	-5.945
Pesticide Price	-20.180**	-6.230
Fertilizer Price	-3.315**	-6.555
Other Inputs Price	9.134**	5.181
Land	-0.19*	-1.635
Labor	-0.039*	-4.398
Capital	0.038**	4.579
R^2(adjusted)	0.091	

*) significant at 10%; **) significant at 5%