Technology, research and development and the impact on the competitiveness of the South African agro-food supply chains

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AUTHORS

Dr C.J. van Rooyen, CEO, Agricultural Business Chamber, and Chair: Agribusiness Management, University of Pretoria, South Africa.

Mr D. Esterhuizen, Agricultural Economist, Agricultural Business Chamber, and Agricultural Research Council, South Africa.

Mr O.T. Doyer, Agricultural Economist, Agricultural Business Chamber and University of Pretoria, South Africa.

Agricultural Business Chamber

P.O. Box 1508

Pretoria

0001

South Africa

Tel. 27 – 12 - 322 7181

Fax. 27 – 12 – 320 0787

E-mail: lbk@agriinfo.co.za

TECHNOLOGY, RESEARCH AND DEVELOPMENT AND THE IMPACT ON THE COMPETITIVENESS OF THE SOUTH AFRICAN AGRO-FOOD AND FIBER SUPPLY CHAINS

C.J. Van Rooyen[1], D. Esterhuizen[2] & O.T. Doyer[3]

[1] Agricultural Business Chamber and Chair: Agribusiness Management, University of Pretoria, South Africa
[2] Agricultural Business Chamber and Agricultural Research Chamber, South Africa
[3] Agricultural Business Chamber and Chair: Agribusiness Management, University of Pretoria, South Africa

1. THE CHANGING ENVIRONMENT

Technology is viewed as one of the major factors determining the competitiveness position of an industry. In a recent analysis 79%, South African agribusinesses interviewed (sample = 40) indicated that the level, cost and access to technology influences their competitiveness status. The concept of competitiveness has been radically redefined for South African agriculture. Agricultural production and trade policy and practice in South Africa has changed dramatically over the past decade. The new Marketing of Agricultural Products Act, No 47 of 1996 spells out a set of rules that differ greatly from earlier legislation and interventionist approach which led agribusiness. These changes, together with changes in the forces that affect the global market for agricultural products, require that farm producers and agribusinesses now have to position themselves as business driven competitors in a less controlled, "free market" global trading environment. This new global market also proved to be quite "unequal". Countries compete in the world market with different degrees of direct and indirect government subsidies and protection. The sophisticated measures to protect/promote the agricultural economies of the USA, Canada and UK is well known. Broad sweeping statements about "equal playing fields", however, does not shed serious light on the competitiveness status of a country's agro-food industry – it may, however, contextualize it. A more refined and analytical approach to investigate is required.

One of the most prominent phenomenon in this new "global market place" is the prominence of the supply chain as basis for institutional arrangements and transactions to create and distribute value (Soler and Tangury, 1998). This new feature of the "global village" will focus this paper. A brief description of the principles and theory of competitiveness analysis will follow i.e. Balassa's "Revealed" Comparative Advantage method. Balassa's technique will be applied to seventeen selected South African agro-food and fiber commodity chains. The technology factor will then be explored. Rates on returns on expenditures for research and development on the South African agro-food supply chains will be analyses. Finally, the relationship between high rates on return on research and development expenditures and competitiveness in the supply chain will be discussed.

2. THE AGRO-FOOD SUPPLY CHAIN

A recent international survey (Zuurbier, 1999) indicated that vertical integrated supply chains and networks and trust relationships is expected to determine the structure of the food and agribusiness industry in the next decade. The most important driving forces is expected to be technology, consumer behavior and multi national companies.

Supply chain interaction is thus viewed as one of the most important phenomenon in the food and agricultural industry for the future. Added value will be added or lost if the supply chain is not functioning in an effective and efficient manner. The importance of consumer demand (mass individualization) is expected to explode in world markets and

unless such demands are transmitted rapidly and accurately to primary producers, farmers will find it difficult to compete effectively. In addition, if only certain elements in the supply chain are performed efficiently, the full potential for value adding will not be realized.

A supply chain focus on competitiveness is necessary. Supply chain analysis (or added value analysis) indicate the competitiveness of each element or activity in the value chain. A "supply chain perspective" gives a particular description to the food and agribusiness sector. The integrated nature of the supply chain require business transactions between all production processes – from the farm, past the farm-gate right to serving the final consumer. In the agro-food supply chain analysis conducted in this paper, agribusiness will be defined to include both farming – primary agribusiness – and all transactions between suppliers, processors and service deliverers which deal directly with primary producers. This definition will include the food sector production, cooperatives, input supply companies, processors, financial institutions and other service deliverers, etc. linking with the farmer.

The objective of analyzing the South Africa's agricultural supply chain competitiveness would be to answer the following question: "Can businesses in the agro-food system compete in the global market?" In particular, such analysis would highlight the ability of each sector (or activity) in a particular chain (production, marketing, processing etc.) to adapt to market changes, to produce and adopt technological innovations, its particular access to capital and its capacity to obtain and retain market share within the international market. In short, these variables measure and evaluate the efficiency, effectiveness, and sustainability of a particular supply chain (Ismea, 1999).

3. COMPARATIVE ADVANTAGE AND COMPETITIVENESS ANALYSIS

Two concepts are frequently used to explain the issue of competitiveness *viz* the concepts of comparative advantage and competitive advantage. These concepts are important foundations for understanding the importance of international trade in agriculture and to illuminate the underlying factors responsible for current trade patterns.

Comparative advantage explains how trade could benefit nations through more efficient use of the world's resource base (land, labor, and capital inputs) when that trade is totally unrestricted, i.e. a free market environment or at least "equal playing fields". **Competitive advantage** on the other hand explains existing trading patterns as they exist in the real world, including all the barriers to free trade i.e. policy effects, product quality differences and industry marketing skills which are ignored by comparative advantage (Worley, 1996). Competitive advantage therefore reflects real business opportunities with in current policy and price distortions.

Measuring competitiveness: There are many methods developed and used by researchers to measure competitiveness. In a recent study by ISMEA (ISMEA, 1999) basically two methods were prioritized to determine the competitiveness of the European Union food chains in a global environment namely the well-known approach to the study of competition originated by Porter (1990) and the competitiveness indicators as originally developed by Balassa (1977, 1986).

Trade and "Revealed" Comparative advantage (The Balassa-method): The difficulty of measuring comparative advantage itself led Bela Balassa to investigate trade patterns directly, without reference to underlying resources, productivity, subsidies or prices. In this method, it is argued that "revealed" comparative advantage (or competitive advantage) could be indicated by the trade performance of individual commodities and countries in the sense that the commodity trade pattern reflects relative market costs as well as differences in non-price competitive factors, such as government policies.

Balassas Revealed Comparative Advantage (RCA) method compares a country's share of the world market in one commodity relative to its share of all traded goods. In Table 1 the competitiveness of selected agro-food chains in South Africa are shown and compared using FAO's trade data of the years 1980, 1985, 1990, 1995, 1996, 1997 and 1998. The Relative Revealed Comparative Trade Advantage (RTA) indexes to reflect both in and export were used which is based on Balassa's original formula. RTA is formulated as:

$$RTA_{ij} = RXA_{ij} - RMP_{ij} \quad \ldots 1$$

$$RXA_{ij} = (X_{ij}/\Sigma_{l,\, l\neq j} X_{il})/(\Sigma_{k,\, k\neq i} X_{kj}/\Sigma_{k, k\neq i}\, \Sigma_{l,\, l\neq j}\, X_{kl}) \quad \ldots 2$$

$$RMP_{ij} = (M_{ij}/\Sigma_{l,\, l\neq j} M_{il})/(\Sigma_{k,\, k\neq i} M_{kj}/\Sigma_{k, k\neq i}\, \Sigma_{l,\, l\neq j}\, M_{kl}) \quad \ldots 3$$

In equations 2 and 3, X (M) refers to exports (imports), with the subscripts i and k denoting the product categories, while j and l donate the country categories. The numerator is equal to a country's export (imports) of a specific product category relative to the exports (imports) of this product from all countries but the considered country. The denominator reveals the exports (imports) of all products but the considered commodity from the respective country as a percentage of all other countries' exports (imports) of all other products. The level of these indicators shows the degree of revealed export competitiveness/import penetration.

While the indices RXA and RMP are calculated exclusively based on either export or import values, the RTA considers both export and import activities. From the point of view of trade theory and globalization trends, this seems to be important and due to the growth in intra-industry and/or entrepot trade, this aspect is becoming increasingly important (ISMEA, 1999). The RTA indicator implicitly weights the revealed competitive advantage by calculating the importance of relative export and relative import competitive advantages. Values below (above) zero point to a competitive trade disadvantage (advantage).

4. THE STATUS AND TRENDS OF AGRO-FOOD INDUSTRY COMPETITIVENESS

The analyses show the degree of competitiveness within and between agro-food supply chains in the South African agro-food business sector. The following features are important:

(i) **Marginal competitiveness**: From Table 1 it is evident that the South African food and agricultural industry is generally marginal as far as international competitiveness is rated. Most RTA values are situated around zero (wheat, sugar, soya beans, potatoes, tomatoes, beef processing, milk, pig meat). This implies that minor adjustments related to increased productivity can contribute to changing negative situations into positive status. It will however be important to identify the particular set of supply chain interactions, which needs to be upgraded. More comprehensive analyses, using inter alia the determinants of competitive advantage (Porter's method) and the Policy Analysis Matrix (PAM) is thus required.

(ii) **Decreasing competitiveness in the supply chains**: The maize, pineapple, wool, and apple chains are competitive albeit marginal in some cases, while the meat, milk, sunflower, and soybean chains are non-competitive. Except for the wheat, maize, apple, and pineapple chains the competitiveness in the other chains decrease from primary to processed products (see also Table 2). This implies that benificiation or "value adding" opportunities in South African agribusiness are restricted. Farm production, on the other hand, is relative or marginal competitive. One possible explanation for this could be the high rates of returns recorded for farm level applications of technology for most primary commodities (Thirtle *et al*, 1998) (see next section). It will, however, be important to "discover" the various underlying reasons for non-competitiveness in each chain. Does it relate to a lack of technological innovation, unproductive labor, high input cost, low quality or maybe government trade policy, etc.?

(iii) **Variations over time in competitiveness (1980-1998)**: The agricultural sector as a whole shows a variable competitive status over time. Since 1993 however an increase in competitiveness is observed, despite a negative terms of trade ratio (see figure 1). On individual level flour of wheat, bread, the whole maize chain, groundnuts in shell, groundnuts shelled, sunflower seed, tomato juice, oranges, apples, grapes, wine, pineapples and pineapples canned show positive trends in competitiveness from 1980 onwards. Wheat, cake of soya beans, cake of sunflower, apple, pineapple and grape juice, cattle, butter, wool, wool greasy, pig meat and the whole sheep chain shows a negative trend from 1980. The whole maize chain, orange chain, apple chain, cattle meat chain, wool chain, groundnuts shelled and processed pineapple have competitive trends the last four years. The whole sheep chain, oil of sunflower and cake of soya beans have negative trends from 1995 to 1998.

Table 1: Competitive advantage of selected food chains in South Africa based on the Relative Revealed Trade Advantage (RTA) index

Chain	Product	RTA 1997	RTA 1996	RTA 1995	RTA 1990	RTA 1985	RTA 1980
Wheat chain	Wheat	-0.77	-1.73	-1.56	-0.88	-0.10	0.11
	Flour of wheat	1.60	2.52	2.47	1.34	0.52	-0.03
	Macaroni	-0.39	-0.63	-0.44	-0.36	-0.26	-0.06
	Pastry	0.06	0.03	0.18	0.14	-0.48	-0.02
	Bread	-0.11	-0.16	-0.12	-0.18	-1.32	-0.22
	Breakfast cereals	-0.20	-0.43	-0.09	-0.07	-0.02	0.03
Maize chain	**Maize**	3.72	4.47	1.04	3.57	-0.29	3.64
	Flour of Maize	10.10	17.96	12.73	0.14	-19.12	-4.48
Potatoes chain	Potatoes	0.86	0.73	0.34	0.17	0.17	0.44
	Potatoes, frozen	0.05	0.13	0.08	0.01	N/A	N/A
Sugar chain	**Sugar (Centrifugal, Raw)**	3.00	2.17	1.76	3.64	1.78	4.16
	Sugar refined	1.86	1.97	0.83	1.95	0.85	0.01
	Sugar confectionery	0.39	0.36	0.27	0.25	-0.16	0.07
	Maple sugar and syrups	-0.03	-0.06	-0.04	0.03	N/A	N/A
Soybeans chain	Soybeans	-0.11	-0.23	-0.88	-0.01	0.00	0.00
	Oil of Soya beans	-0.43	-0.55	-0.37	-0.16	-0.78	-0.25
	Cake of Soya beans	-1.53	-1.54	-0.23	-0.51	-0.48	N/A
	Soya sauce	-0.27	-0.20	-0.23	-0.42	N/A	N/A
Groundnuts chain	**Groundnuts in shell**	8.69	8.97	10.52	-0.10	0.08	-0.09
	Groundnuts shelled	5.12	2.27	-1.54	2.80	0.98	3.63
	Oil of groundnuts	4.17	4.05	6.61	4.89	4.29	2.98
	Prepared groundnuts	0.05	-0.06	-0.05	0.02	N/A	N/A
Sunflower chain	Sunflower seed	-0.36	1.50	0.04	-0.03	0.03	-0.92
	Oil of sunflower	-6.62	-4.42	-7.72	-3.96	-10.84	0.74
	Cake of sunflower	-5.97	-4.65	-4.19	-0.11	-0.33	N/A
Tomatoes chain	Tomatoes	0.07	0.10	0.01	0.04	0.03	0.02
	Tomato juice	-0.08	-0.07	0.00	-0.01	N/A	N/A
	Tomato paste	-0.06	-0.14	-0.78	0.02	N/A	N/A
	Peeled Tomatoes	-0.78	-0.58	-0.84	-0.03	N/A	N/A
Oranges chain	**Oranges**	13.67	10.45	14.37	8.32	10.08	6.21
	Orange juice	0.39	0.14	0.33	0.84	0.23	0.63
Apples chain	**Apples**	6.62	5.24	7.13	6.03	5.62	4.85
	Apple juice	11.35	9.22	7.89	8.68	12.89	N/A
Grapes chain	**Grapes**	10.29	8.35	11.31	5.66	3.84	6.21
	Grape juice	-1.29	-1.63	3.41	1.79	N/A	N/A
	Wine	2.49	2.73	3.23	0.30	0.05	0.15
Pineapple chain	**Pineapples**	0.90	1.31	1.64	0.98	0.47	1.03
	Pineapples, canned	7.18	4.70	5.59	5.29	3.00	6.65
	Pineapple juice	7.25	4.71	5.73	9.16	8.49	8.50
Cattle meat chain	Cattle	-3.76	-4.03	-2.65	-2.01	-2.19	-3.17
	Beef and veal	-0.13	-0.26	-0.58	-1.33	-0.01	0.45
Milk chain	Cow milk (whole, fresh)	0.27	-0.05	-0.07	0.04	0.01	-0.10
	Butter of cow milk	-0.70	-0.38	-0.23	0.03	0.04	0.03
	Cheese	-0.24	-0.16	-0.14	-0.06	-0.13	-0.06
Sheep meat chain	Sheep	-5.17	-5.49	-6.66	-7.28	-2.77	-1.33
	Mutton and lamb	-1.73	-1.60	-0.81	-0.05	0.07	0.03
Wool chain	Skin with wool	4.78	11.21	11.28	4.51	5.83	6.92
	Wool, greasy	5.56	6.04	8.23	3.70	4.05	2.76
	Wool, scoured	1.60	2.29	1.61	1.73	2.00	2.10
Pig meat chain	Pigs	0.02	-0.01	-0.04	0.00	-0.02	0.00
	Pig meat	-0.42	-0.67	-0.89	-0.03	0.06	0.06
	Bacon-ham of pigs	0.00	-0.04	-0.02	-0.05	-0.07	-0.06

Source: Own calculation based on data from FAOSTAT 1999

Figure 1: Competitveness, Terms of Trade, Exchange rate (R/$) and Labour productivity in South Africa's agro food industry

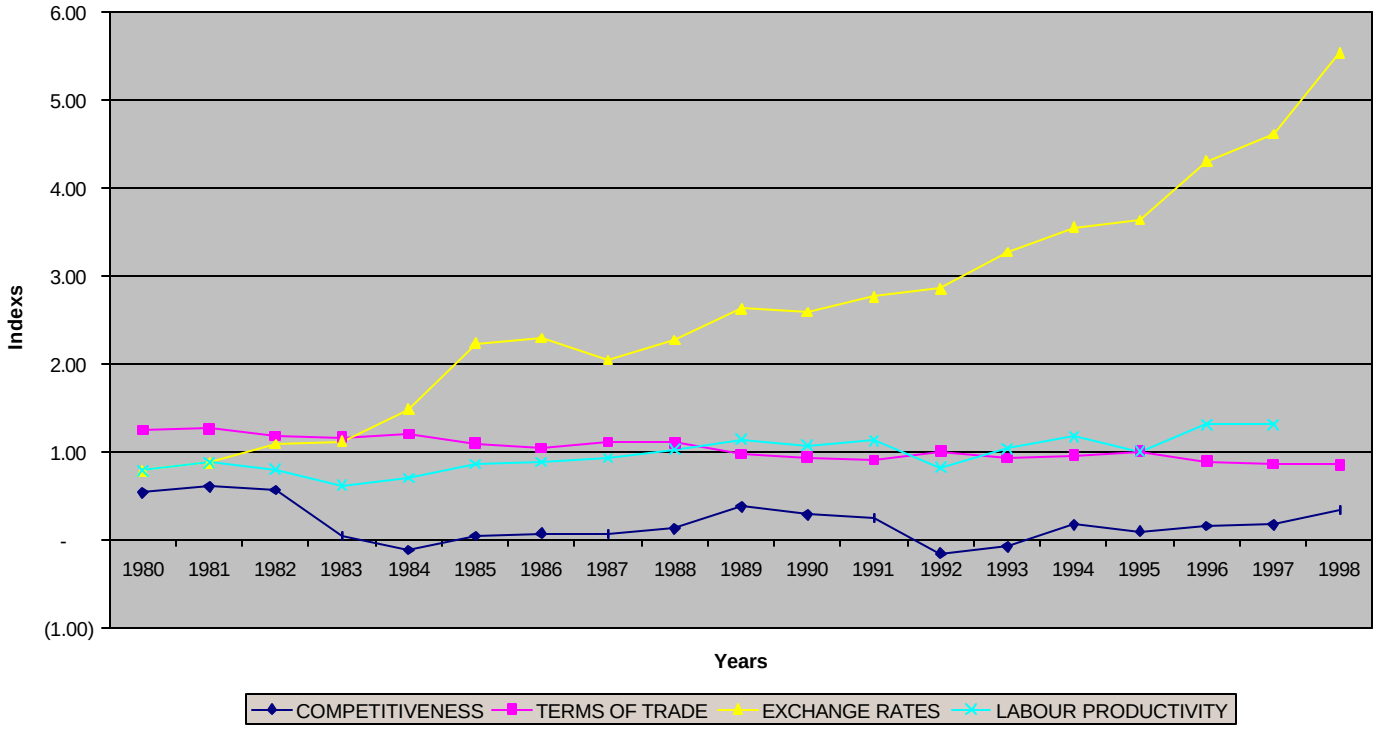


Table 2: Inter-chain competitiveness (average 1995 to 1998 data)

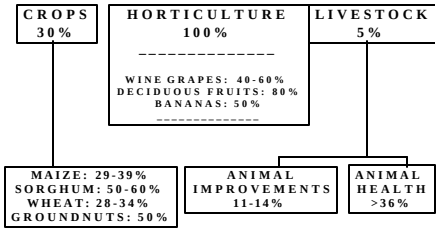
	COMPETITIVENESS OF PRIMARY PRODUCT		
COMPETITIVENESS OF VALUE-ADDING IN CHAIN	+	***MARGINAL***	-
T R E ↑	Maize, Apples	Wheat, Pineapple	Cattle, Sheep
N D ↓	Sugar, Groundnuts, Oranges, Grapes, Wool	Potatoes, Sunflower, Tomatoes, Milk, Pigs, Soya beans	

Source: Own calculations based on data from FAOSTAT, 1999

5. RATES OF RETURN ON AGRICULTURAL RESEARCH

In studies done by Tirtle et al (1998) the majority of Total Factor Productivity growth in South African commercial agriculture in the period 1947-91 was explained by public research and development (R&D) and extension expenditures, farmer education, and the weather. The gross return on investment in technology development in this sector is between 60% and 65%. For farm level extension, the results vary far more with the choice of model, from 62% to 162%. All else being equal, this suggests that rates of return are high and there is under-investment in the generation and diffusion of agricultural technology (Thitle et al, 1998).

Figure 2: Returns to Agricultural Research and Development (%



*% = ROR's ON INVESTMENT IN R&D

Source: Thirrtle et al, 1998

Sector level: The application of the integrated, single-stage approach by fitting a residual profit function, which incorporates the technology variables, produces short term and long term run estimates of the output-supply and input-demand price elasticity, elasticity of the effects of relaxing the non-variable input constraints, and shadow prices for these non-variable factors. Local public sector agricultural research and international research spillovers are incorporated directly in the profit function. Shadow values of these conditioning factors are derived, providing measures of their implicit values in production. The shadow value of research is used to derive the marginal internal rate of return to public sector agriculture research (R&D), that is estimated to be between 44% and 53%. Since the profit function was estimated with three outputs, namely crops, horticulture and fruit and animals, the coefficients allow for separate rate of return (ROR) calculations for these sectors. Thus, crops have ROR of 30%, horticulture and fruit an unusually high rate of 100% and animals fare poorly with an ROR of only 5% (see Figure 2).

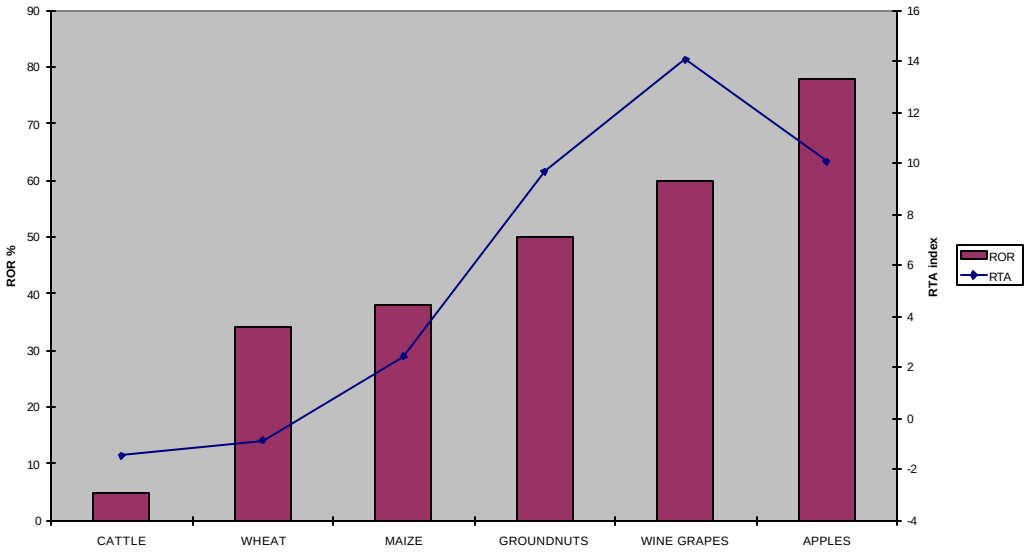
Industry level analysis: Industry level results are entirely consistent with these figures, despite the difference in methodology. The wine and fruit industry have high returns, from 40% to 78%, while the ROR on animal production improvements and range and forage research is lower at 11% to 16%.

At the crop level, the results are also consistent with the outcomes at the higher level of aggregation. Maize and wheat are very close to the 30% figure, while sorghum appears to have been under-funded, which has been shown true for several other African countries. Groundnuts have a higher returns. Tropical and sub-tropical fruit research contributes to the high ROR for the fruit and horticulture group.

The relationship between the competitive indexes and R&D at industry level: An analysis of agribusinesses indicate a strong expectation that research and technology development plays an important role in improving the competitiveness status.

In Figure 3 the high correlation (R^2 = 0.69) between competitiveness and high ROR on research and technology is confirmed for cattle, wheat, maize, groundnuts, wine grapes and apples.

Figure 3: The correlation between ROR and competitiveness in agricultural industry



R&D in the supply chain: The link between R&D and competitiveness was also confirmed in a recent study (Esterhuizen et al, (2000)) to determine the major factors influencing the competitiveness of agribusiness's further up in the chain, 78.57% of the 40 agribusinesses investigated indicated that cost of tegnology is currently a constraint to their competitive success. Half of the respondents indicated that the cost of knowledge (research) is a constraint to their competitive success. Only 22% of the respondents indicated that the availability and quality of tegnology are an enhancement to their competitiveness. Only 33.33% of agribusinesses indicated that the availability and quality of research are enhancing their competitive success.

These statements must be viewed against the background that the public sector expenditures, historically large focussed on farm level R&D. Vale added activities higher up in the supply chain was somewhat ignored within agricultural R&D expenditures. Government is also currently dramatically reducing their investment in such research and development activities. The Agricultural Research Council (ARC) responsible for primary and secondary R&D in the agricultural sector experience a 33% decline in the government grant since 1994. This grant counted for more than 90% of R&D investment in agriculture.

This phenomena can also, to some extend, explain why there is a decline in competitiveness in same chains when moving from the primary to the processed product for example the orange, sugar, wool, milk, tomatoes etc. chains.

6. CONCLUSIONS

While positive spillovers was recorded (Fig 2) the optimal situation was clearly not achieved ie competitiveness in all sectors of the chain. The current spillover benefits may also not be sustainable due to reductions in the R&D budget. No clear solution to this dilemma has emerged yet. However, partnerships between the ARC and the private sector which will also direct funds to value added R&D is under discussion.

In this paper, the competitiveness status of agribusiness in seventeen food and fiber supply chains was determined. Many commodities are marginally competitive. Some encouraging increases in competitiveness are observed however. Except for the wheat, maize, apple, and pineapple chains the competitiveness in most of the other chains decrease when moving from the primary to processed products. One possible explanation for this could be the high rates of returns recorded for farm level applications of technology for most primary commodities.

From the analysis it is clear that R&D has a direct impact on the level of competitiveness of an industry (supply chains). Historically agricultural R&D focussed on farm level innovation. This did lead to high rates of returns at this level. This also resulted in positive spillovers in supply chain processes. To sustain such spillovers a more direct investment approach is required ie direct investments in R&D within the value adding activities in the industry supply chain. The declining public sector support for R&D was also addressed. Private sector partnerships with the public sector should enhance the ability of South Africa agro-food and fiber industry to compete in the global environment.

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