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Profitability, efficiency and comparative advantage of African cattle meat and milk production: the case of trypanotolerant village cattle production

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Abstract

Trypanosomiasis is a major constraint to increased food production in Africa as it limits livestock production and mixed farming over an area of 10 million km^2. The use of African trypanotolerant breeds of cattle is one approach to control trypanosomiasis that is being given increasing attention. This paper examines under what circumstances trypanotolerant village cattle enterprises can be economically viable in regions of origin and areas of introduction. On-going production is analysed in four countries using cost–benefit analyses. Comparative advantage and subsidies received are also estimated. Results indicate that resources for trypanotolerant cattle production are efficiently allocated as the sector has a comparative advantage and contributes effectively to the national welfare. Financial returns to producers are attractive and by comparing social and private prices important constraints are identified to improve profitability.

1. Introduction

Trypanosomiasis, a disease transmitted by the tsetse fly, is a major constraint to increased food production and farm income in sub-Saharan Africa as it limits the development of livestock production and mixed farming. Sub-Saharan Africa imports dairy products and west and central African countries are also net importers of beef (ILCA, 1993). As domestic milk and beef production is growing at a slower pace than the human population (ILCA, 1993), enhanced cattle production could reduce imports and diversify and increase rural income. It is estimated that trypanosomiasis affects roughly 10 million km^2 in 37 African countries and that increases of 16% and 14% in meat and milk production can be expected following control of the disease (Jahnke et al., 1988). The exploitation of genetic resistance to trypanosomiasis through the use of African trypanotolerant breeds of cattle is one approach to control the disease that is being given increasing attention (Trail et al., 1989). Estimates of biological productivity of trypanotolerant cattle have been obtained for various sites and over several years by the African Trypanotolerant Livestock Network coordinated by the International Livestock Centre for Africa (ILCA [2]). This paper examines the economics of N'Dama and West African Shorthorn trypanotolerant village cattle enterprises in regions of origin and areas of introduction. The protection received, the profitability and comparative advantage of five production sites in four countries are analysed. Comparisons are made between sites and between private and social prices to identify constraints to increased returns and com-

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parative advantage. The findings also offer policy insights for cattle meat and milk production in West and Central Africa.

2. Cattle production systems

The sites of Gunjur and Keneba in the Gambia and Boundiali in northern Côte d'Ivoire are in regions of origin of trypanotolerant cattle, while Avetonou in southern Togo and Idiofa in south western Zaire are in areas of introduction. The four countries studied are net importers of beef and milk (Table 1) but efforts are being deployed to increase production using trypanotolerant cattle. Gunjur is located in the semi-arid zone while other sites are in the subhumid zone. The main characteristics of the farming systems are summarised in Table 1 while a more detailed description can be found in Itty (1992).

At Gunjur and Keneba, most cattle are owned by Mandinka people but managed and herded in collective herds by agro-pastoralist Fulani herders. Most herders were remunerated with a share of the milk they collected from cows. The vast majority of cattle in The Gambia are N'Dama, although crossbreeding with trypanosomiasis susceptible zebus may be increasing as the disease prevalence is now very low (Table 1). It is hypothesised that the reduction in tsetse density could be due to a less favourable environment for the fly resulting from lower rainfall and increased human population.

The cattle production system around Boundiali, Côte d'Ivoire, is stratified by breed, ownership and management. The area is at the intersection of the zebu, N'Dama and Baoulé (West African Shorthorn) zones. Zebu come from the northern drier Sahelian zone which has lower trypanosomiasis risk, while N'Dama come from Guinea and Baoulé from central Côte d'Ivoire. Of the cattle in our survey, 41% were trypanotolerant zebu crosses, 38% Baoulé, 18% N'Dama and 3% zebu. Compared with the Fulani who recently settled in the area, indigenous Senoufo and Malinke crop farmers owned higher percentages of trypanotolerant cattle. Similarly to The Gambia, cattle owned by the sedentary crop farmers were generally herded by Fulanis who were paid in kind (milk) and cash.

Cattle keeping was virtually non-existent in the Avetonou area of southern Togo when the German sponsored CREAT (Centre de Recherche et d'Elevage, Togo) started to promote livestock keeping in 1980. CREAT distributed cattle according to a lease system. Animals on loan had to be reimbursed in the form of offspring. In some cases, Fulanis were hired to herd the cattle. Milking was forbidden until repayment of cattle was completed. Apart from the Fulani, none of the local people did in fact consume fresh milk. A variety of breeds were promoted by CREAT: 59% of the cattle monitored were Togolese West African Shorthorn, 30% were foreign N'Dama, and 11% were remnants of a trial to cross trypanotolerant breeds with European breeds.

Cattle keeping was virtually unknown in the area around Idiofa, when a church based organisation, the Développement Progrès Populaire (DPP), introduced N'Dama in the late 1960s. These were purchased from Zairian ranches and missions which had imported them earlier. The DPP also used a lease system to introduce cattle to village cooperatives. Each cooperative purchased four to five cattle and the DPP contributed an equal number on lease. After 4 years, the animals on lease were repaid through offspring. At a later stage, the DPP also began to sell animals to private individuals and organisations. Cattle were loosely tended by paid herders. Cows were never milked as fresh milk was not consumed.

3. Materials and methods

Cost–benefit analyses were applied and the ILCA Bio-Economic Herd Model for Microcomputer was used to capture the dynamics of cattle production. The ILCA model is a deterministic model which simulates herd evolution, production and economic performance over 10 years from base parameters on herd structure, productivity and economic phenomena (Von Kaufmann et al., 1990; Itty, 1995). Private-level financial analysis was conducted to evaluate the benefits and costs of the herds to cattle

[2] ILCA has now merged with the International Laboratory for Research on Animal Diseases (ILRAD) to form the International Livestock Research Institute (ILRI).

Table 1
Farming systems at the five study sites

	Gunjur and Keneba, The Gambia	Boundiali, Côte d'Ivoire	Avetonou, Togo	Idiofa, Zaire
National self sufficiency (%):				
In beef	90–100 [a]	65 [b]	46 [b]	59 [b]
In milk [b]	28	8	36	89
Agro-ecological zone	Semi-arid/sub-humid	Sub-humid	Sub-humid	Sub-humid
Mean annual rainfall (mm)	900/1300	1200	1280	1370
Persons km^{-2}	80	14	55	34
Staple crops	Millet, rice, sorghum	Maize, rice	Maize, cassava, yam	Cassava, maize
Cash crops	Groundnuts	Cotton, groundnuts	Coffee, cocoa, oil palm	Oil palm, groundnuts
Cattle km^{-2}	30	10	2	0.3
Percent of households with cattle	48 [c]	20 [d]	4 [e]	2
Cattle management	Traditional, Fulani herders	Traditional, Fulani herders	Recent, often Fulani herders	Recent, local village herders
Milk collection	Mostly to herders	Mostly to herders	None	None
Percent of households using animal traction	70 [f]	25 [d]	0	0
Cattle breeds	N'Dama	WAS, N'Dama, zebu, crosses	WAS, N'Dama, crosses	N'Dama
Tsetse challenge [g]	0.3/0.9	8.5	0.2	3.0
Percent trypanosomiasis prevalence [h]	0.3/1.5	11.2	7.2	1.8

[a] Shaw and Hoste (1987).
[b] ILCA (1993) from FAO Agricultural Production and Trade Yearbooks Standard Tapes 1988 and 1989.
[c] Haydu et al. (1986).
[d] Schuetterle and Coulibaly (1988).
[e] GFA (1985).
[f] Sumberg and Gilbert (1992).
[g] Flies per trap per day × trypanosome infection rate (Leak et al., 1988).
[h] African Trypanotolerant Livestock Network, personal communication, 1991.
WAS, West African Shorthorn.

producers and social-level economic analysis was conducted to estimate the profits to the overall economy of the countries examined. Market prices were used in the private analysis and shadow prices in the social analysis (Gittinger, 1982). The profitability of the cattle enterprises is evaluated through returns to capital invested in cattle production. The efficiency and effects of policy and possible market failure were examined through the application of the Policy Analysis Matrix (PAM) which uses private and social prices (Monke and Pearson, 1989). As Table 2 shows, the PAM considers not only the profits (horizontal lines) but also distortions and divergences between private and social prices (vertical columns). To establish the matrix we categorised costs as tradable inputs or domestic factors. Non-traded items, such as veterinary services, were disaggregated into tradable inputs and domestic factors (Corden method, see Tsakok, 1990). The social and private prices computed for the PAM were the values obtained through the herd model projections and discounted to obtain present values.

Domestic resource costs (DRC) and subsidy ratio to producers (SRP) were calculated by rearranging the discounted results of the financial and economic analyses. The DRC compares the opportunity costs of domestic factors to the value added at border prices. The domestic factors are land, labour and capital and the value added is equal to the revenues minus the costs of tradable inputs. The DRC is frequently used as indicator for comparative advantage (Morris, 1989; Murphy, 1989; Morris, 1990; Tsakok, 1990; Gonzales et al., 1993). The SRP is the net policy transfer as a proportion of total social revenues. It shows the proportion of revenues in world prices that would be required if a single subsidy or tax were substituted for the entire set of policies and market failures (Monke and Pearson, 1989).

An economic survey and a rapid rural appraisal conducted at one point in time provided the economic data and the qualitative information on the farming systems. Economic data were collected in 1987 in Togo, 1988 in The Gambia and Côte d'Ivoire and in 1989 in Zaire (Itty, 1992). Constant prices were used which assumes that inflation exerts the same relative effects on all costs and benefits.

Standard protocols were followed to collect monthly data on animal health and productivity (Murray et al., 1983; Leak et al., 1988). Between 6 and 17 herds were monitored at each site for periods of 4 years (1986–1989) except at Avetonou where this took place from 1984 to 1986. Herd sizes varied between 15 and 240 animals. Parameters for the average herds were generated as the simple mean of the herds at each site.

In the regions of origin (Gunjur, Keneba and Boundiali), trypanotolerant cattle have long been raised for meat and milk production, and, in recent years, have increasingly been kept for animal traction. Oxen were, however, excluded from the herd structures as no data were available to assess the returns from animal traction. In the areas of introduction (Avetonou and Idiofa), trypanotolerant cattle were only kept for meat production. The cattle introduction schemes were simulated using the herd model.

Details of the individual case studies and price computations can be found in (Itty et al., 1993) for the Gambia, in Itty et al., 1994 for Côte d'Ivoire and in Itty et al. (1995a) and Itty et al. (1995b) for Togo and Zaire. This paper concentrates on comparisons

Table 2
Policy analysis matrix

	Revenues	Costs		Profits
		Tradable inputs	Domestic factors	
Private prices	A	B	C	$D=(A-B-C)$
Social prices	E	F	G	$H=(E-F-G)$
Divergences and distortions	$I=(A-E)$	$J=(B-F)$	$K=(C-G)$	$L=(D-H)$

Source: Monke and Pearson (1989).

between sites and on implications derived from using the PAM. The production parameters and the results of the social analysis presented here for Togo and Zaire differ slightly from those given in the above mentioned publications. To apply the PAM, we had to use the same sample of herds in the social and private analysis. To standardise the samples in all sites and simplify presentation, we only considered the herds owned by farmers, leaving aside those owned by institutions.

3.1. Biological and economic data

3.1.1. Biological data

The biological values used in the analyses are summarised in Table 3. The herds at Avetonou and Idiofa were smaller one reason being that the numbers of animals which were used for the simulation refer to the initial stock purchased and leased through the introduction schemes. The liveweight, reproduction, lactation and mortality statistics also indicate differences between Avetonou and Idiofa and the other sites. Compared with the sites in The Gambia and Côte d'Ivoire, the cows at Avetonou and Idiofa showed better reproductive performance and animals in all age and sex categories were heavier and had lower mortality rates. Lactation offtake was highest at Gunjur and Keneba and zero at Avetonou and Idiofa.

3.1.2. Private prices

Information for farm budget data was collected at each site in terms of quantities involved and market prices.

The veterinary treatments given were monitored during the productivity survey and annual averages for both drugs and minerals were calculated per age class. Veterinary services were always provided free of charge and did not represent a private cost for the farmers.

Ropes used to tether the animals at night were valued at their opportunity cost for Keneba, whereas at Gunjur provision of ropes was one of the herders' tasks and the costs come under herding expenses. At the other sites, paddocks and sometimes crushes were required. These were often built by the farmer using local materials.

Herding costs were accounted for in terms of actual remuneration in cash and kind when herdsmen were employed. Remuneration in kind included milk from the herd, food, lodging, land use and clothes. The estimated cost of milk given was obtained by deducting from the gross revenues the cost of milking and marketing the milk by the herders. Whenever

Table 3
Summary of average biological values at the five study sites

Statistic	Gunjur, The Gambia	Keneba, The Gambia	Boundiali, Côte d'Ivoire	Avetonou, Togo	Idiofa, Zaire
Herd size	92	68	137	15	10
Liveweight					
1-year-old calves	76	70	100	123	101
> 3-year-old females	234	218	230	232	233
> 3-year-old males	241	264	263	323	306
Reproduction					
Calving rate (%)	48	53	65	58	65
Age 1st calving (months)	50	47	41	39	37
Lactation offtake (kg)	442	508	215	0	0
Mortality rate					
< 1 year	27	15	26	10	14
1–2 years	11	6	10	2	5
> 2 years	5	2	8	5	3

Source: African Trypanotolerant Livestock Network, personal communication, 1991.

family members were herding, we took the opportunity cost of labour from the farmer's perspective. Feed supplements and fodder were very rare. No costs for grazing were accounted for as this took place on either communal savannas, fallow or marginal land, or under tree plantations.

Taxes were levied on livestock producers with the exception of Togo.

At all sites the value of cattle for either slaughter or breeding was identical. In general a price per animal was fixed between producer and buyer. Survey data were adjusted to obtain an average annual price per kilogram liveweight. This price was used to value cattle as an input, the breeding herd purchased in year 0, and as an output, the cattle offtake during the projected years and the remaining herd value in year 10.

The local market price obtained for milk was used in all sites except in Togo and Zaire where milk was not extracted.

Table 4 provides average values of the major inputs and outputs expressed as private (market) prices and as social (shadow) prices.

3.1.3. Social prices

Social prices were obtained by adjusting the private prices for distortions. Transfers such as taxes and subsidies were eliminated, opportunity costs were used in the case of imperfect or missing markets affecting non-traded items while traded goods were valued through border prices. For imported items, the border price was obtained by computing the import parity price which is the world market price adjusted for marketing and transport costs to the domestic market. For exports, the export parity price was computed by correcting the world market price for marketing and transport costs from the farmgate to the international reference market.

The value of all traded items was converted using a shadow exchange rate in the case of Côte d'Ivoire and Togo because the local currency, the FCFA, was overvalued by an estimated 30% (World Bank estimate quoted in Huband, 1990). In these two countries this increased the social price of traded items such as drugs and minerals, transport and equipment costs of the veterinary services and the import parity price of milk and beef. In the other countries, the currencies were, at the time of the survey, not over-

Table 4
Average values of major inputs and outputs associated with cattle production at the five sites

	Gunjur, The Gambia	Keneba, The Gambia	Boundiali, Côte d'Ivoire	Avetonou, Togo	Idiofa, Zaire
Local currency unit	Dalasi	Dalasi	Franc CFA	Franc CFA	Zaire
Private (market) prices					
Official exchange rate (price/$)	6.7	6.7	300	300	380
Herding labour (cost per animal year^{-1})	192.1	79.0	5326	5143	2135
Paddock/tether (price per animal year^{-1})	0	7.5	148	727	438
Vet. services (price per animal)	0	0	0	0	0
Vet. treatments (price per animal)	3.3	3.3	1565	1283	1514
Beef (price kg^{-1} liveweight)	5.9	4.7	300	325	306
Milk (price kg^{-1})	2.8	1.6	112	–	–
Cattle (price kg^{-1} liveweight)	5.9	4.7	300	325	306
Social (shadow) prices					
Shadow exchange rate (price/$)	6.7	6.7	429	429	380
Herding labour (price per animal year^{-1})	93.5	32.9	1200	5857	2135
Paddock/tether (price per animal year^{-1})	7.5	7.5	455	15273	438
Vet. services (price per animal)	5.8	5.8	593	1121	1475
Vet. treatments (price per animal)	3.3	3.3	2515	2132	1286
Beef (price kg^{-1} liveweight)	5.9	4.7	300	503	306
Milk (price kg^{-1} Liquid Milk Equivalent)	2.6	2.8	215	–	–
Cattle (price kg^{-1} liveweight)	5.9	4.7	300	471	306

Note: all prices expressed in local currency.

or under-valued and the official exchange rate could be used as shadow exchange rate.

In Côte d'Ivoire, veterinary drugs and minerals were explicitly subsidised, whereas they were taxed in Zaire and Togo. In Togo, these were, however, provided free of charge by the cattle introduction scheme during the first 4 years of production. Veterinary services were disaggregated into domestic factors (personnel) and traded items (transport and equipment). The social costs of veterinary services per bovine were thus estimated at each site, using opportunity costs for domestic factors and border prices for traded items.

Subsidies for the paddocks were excluded in Côte d'Ivoire.

The social costs of labour for herding differed from the private costs in the Gambian sites and in Boundiali, as this work was carried out by Fulani pastoralists who have a low opportunity cost of labour: most are reluctant to take up any other activity and employment possibilities are very limited. The wage rate given to herdsmen on ranch-like farms was taken as the opportunity cost.

As grazing took place on unexploited savannas or under tree plantations without any imposition on existing uses, the social cost of land was set to zero.

For Avetonou, the price of breeding cattle was calculated according to the weighted price of the breeds represented: the price of N'Dama was the import parity price as they were imported from Zaire and Côte d'Ivoire and the market price was used for the other breeds.

The import parity price was used to determine the economic value of milk in The Gambia and Côte d'Ivoire and of beef in Togo and Côte d'Ivoire. The procedure used to calculate these prices follows Williams (1993). The case of beef deserves precision. FAO statistics indicate that the Gambia was a net importer of beef whereas data from the country indicate that the country traded minor quantities of beef and that exports more or less equalled imports (Central Statistics Division of the Ministry of Economic Planning and Rural Development quoted in Shaw and Hoste, 1987). Imports concerned primarily prime cuts for the tourism sector. Because of this market segmentation and because Gambian beef was exported, we valued the social price of local beef at its export parity price which equalled the domestic market price. For Côte d'Ivoire, although this country has been also importing beef from overseas, it has traditionally been supplied by Mali (Williams, 1993). As Boundiali is located far from the port and towards the border with Mali, the border price was calculated by using the producer price for beef in

Table 5
Results of financial private analysis of cattle production at the five study sites

	Gunjur, The Gambia	Keneba, The Gambia	Boundiali, Côte d'Ivoire	Avetonou, Togo	Idiofa, Zaire
Local currency unit	Dalasi	Dalasi	Franc CFA	Franc FCA	Zaire
Discounted costs per animal (local currency)	2340	1230	98740	49584	44034
Percent of discounted costs due to:					
Herd purchase	47	57	54	6	38
Herding	51	37	34	65	31
Paddock/tether	0	4	1	14	7
Veterinary services	0	0	0	0	0
Veterinary treatments	1	2	8	9	13
Other inputs	1	1	3	6	11
Discounted revenues per animal (local currency)	2352	1986	105260	74011	71078
Percent of discounted values due to:					
Milk	45	38	26	0	0
Cattle offtake	39	44	53	62	62
Final herd value	17	18	21	38	38
Internal rate of return (%)	10.2	25.6	11.8	23.7	20.2

Table 6
Results of economic social analysis of cattle production at the five study sites

	Gunjur, The Gambia	Keneba, The Gambia	Boundiali, Côte d'Ivoire	Avetonou, Togo	Idiofa, Zaire
Local currency unit	Dalasi	Dalasi	Franc CFA	Franc CFA	Zaire
Discounted costs per animal (local currency)	1815	1017	89510	143807	67786
Percent of discounted costs due to:					
Herd purchase	61	69	60	54	49
Herding	33	20	8	26	20
Paddock/tether	3	5	4	5	5
Veterinary services	2	4	4	6	15
Veterinary treatments	1	2	20	10	11
Other inputs	0	0	4	0	0
Discounted revenues per animal (local currency)	2458	2792	138290	136551	74279
Percent of discounted values due to:					
Milk	47	56	44	0	0
Cattle offtake	37	31	40	70	64
Final herd value	16	13	16	30	36
Internal rate of return (%)	19.4	45.9	23.2	8.9	11.8

Table 7
Results of policy analysis matrix at the five study sites

	Gunjur, The Gambia	Keneba, The Gambia	Boundiali, Côte d'Ivoire	Avetonou, Togo	Idiofa, Zaire
Local currency unit	Dalasi	Dalasi	Franc CFA	Franc CFA	Zaire
Revenues					
Private prices (A)	2352	1986	105260	74011	71078
Social prices (E)	2458	2792	138290	136551	74279
Relative divergences ($(A-E)/E$) (%)	−4	−29	−24	−46	−4
Costs: tradable inputs					
Private prices (B)	1128	720	63490	10413	26024
Social prices (F)	1163	753	72252	95868	48500
Relative divergences ($(B-F)/F$) (%)	−3	−4	−12	−89	−46
Costs: domestic factors					
Private prices (C)	1210	510	35053	39221	18010
Social prices (G)	650	263	17258	47939	19286
Relative divergences ($(C-G)/G$) (%)	86	94	103	−18	−7
Profits					
Private prices (D)	14	756	6717	24377	27044
Social prices (H)	645	1776	48780	−7256	6493
Relative divergences ($(D-H)/H$) (%)	−98	−57	−86	436	317
Domestic resource cost ($G/(E-F)$)	0.50	0.13	0.26	1.18	0.75
Subsidy ratio to producers ($(D-H)/E$)	−0.26	−0.36	−0.30	0.23	0.28

Note: all prices given in local currency.

Mali. As transport and marketing costs from Mali were extremely difficult to quantify, these were left out. The price we used and the resulting economic returns are therefore slightly underestimated. For Avetonou which is situated at a short distance from the Togolese coast, we calculated the import parity price by adjusting the world market price of beef. For Idiofa, beef was considered as a tradable non-traded commodity because beef is imported into Zaire but not to Idiofa which is located far inland and is without electricity (for beef refrigeration). The social price of Idiofa beef was hence determined by the market price. In all cases, the reference market used to calculate border prices was the nearby town as output was locally sold.

Externalities were considered in terms of environmental degradation. This was not a problem at the recorded stocking rates except perhaps for The Gambia. However, conflicting reports for this country (Trolldalen, 1991; Sumberg, 1992) do not yet permit a clear qualitative evaluation of this issue, let alone a quantification of externalities.

At all sites it was assumed that the opportunity cost of capital was 10% in real terms for both society and producers. As the internal rate of return is given as a criterion of profitability, readers having different estimates of opportunity cost of capital can compare the analyses results with their values.

4. Results

4.1. Financial private results

Trypanotolerant cattle production yielded, at all five sites, private rates of return greater than the assumed opportunity cost of capital of 10% (Table 5). The returns were modest in Gunjur and Boundiali because of the high implicit costs of herding: in addition to cash and kind receipts the herders in Gunjur received all the extracted milk and in Boundiali most of it. Even though most of the milk was also given to the herders in Keneba, returns were highest because of the largest total quantity of milk produced per cow (lactation yield × calving rate × survival rate). Revenues in Keneba were significantly lower than in Gunjur as Gunjur benefits from its peri-urban situation where prices for beef and particularly for milk are superior. Attractive profits were achieved in Avetonou and Idiofa thanks to the subsidised acquisition of cattle and despite benefits limited to cattle and meat offtake. In Idiofa, cattle introduction was more successful and the number of herds and cattle has been increasing. Farmers' involvement in the scheme and their financial participation were both higher. Financial returns were more robust: without subsidies, the IRR reached 16.0% whereas in Avetonou, it dropped to 8.9% (Itty et al., 1995a; Itty et al., 1995b).

4.2. Economic social results

The economic rates of return (Table 6) were outstanding in the case of Keneba and high in the case of Boundiali and Gunjur. All three sites had very moderate herding costs as the pastoralist Fulanis had low opportunity costs of labour. In addition, long domestic transport increased the import parity price of milk in Keneba and Boundiali. The social returns were modest in Idiofa and did not reach 10% in Avetonou. All the costs to society had to be accounted for in the social analysis. These were particularly high in Avetonou because of the N'Dama breeding stock which was imported and the diseconomies of scale due to the small herds. The latter affected the costs of herding and paddocks. Even though the level of social revenues was relatively high—through the high import parity price of beef and N'Dama cattle—this was insufficient to compensate for the large costs. Fresh milk is not consumed in sites where cattle have been introduced (Avetonou and Idiofa). There is therefore no economic value and this is a strong economic limitation since in the other sites, the revenues from milk represent almost half the total social benefits. The importance of milk in determining the level of revenues has been highlighted and discussed in Itty (1995).

4.3. Policy analysis matrix

The results of the policy analysis matrix are presented in Table 7. The original matrix (Table 2) had to be reorganised in columns to facilitate the presentation. Divergences between private and social prices are provided in relative terms for ease of comparison

between sites. Divergences indicate policy distortions or market failures and reveal constraints and possibilities for cattle meat and milk production.

Divergences in revenues were strong in Boundiali and Avetonou because of the exchange rate policy which overvalued the local currency and discriminated against traded products such as milk (in Boundiali) and beef and N'Dama cattle (in Avetonou). Keneba and Boundiali located inland recorded also large divergences for milk which is imported: high transport costs increase the border equivalent producer prices. Transport costs were high also because of the poor infrastructure generally available in Africa. In the sites of Keneba, Boundiali and Avetonou, policies implicitly taxed outputs of cattle producers.

Some divergences in tradable inputs were also apparent in Boundiali and Avetonou because of the overvalued exchange rate but as these inputs were subsidised in these sites and in Idiofa, producers were net beneficiaries. The strongest case was Avetonou where veterinary treatments and services and purchase of N'Dama cattle were very heavily subsidised.

Divergences in costs of domestic factors increased private prices in the Gambian sites and Boundiali. These were essentially due to market imperfections (Stiglitz, 1988; Singh, 1989): the high private costs of herding were paid to elicit herders' loyalty so they could be trusted to perform tasks that are inherently difficult to monitor. The problem here is similar to share cropping which is a response to uncertainty and asymmetrics of information (crop farmers know little about cattle and cannot observe their stock at all times and there is a risk of the herder absconding with the herd) while providing the herders with a stake in the enterprise.

Divergences in profits are the sum of all the divergences detailed above. The resulting higher private costs and lower private revenues depressed private profits in Gunjur, Keneba and Boundiali. Herding labour appears as a major constraint in these sites as well as the exchange rate policy in Côte d'Ivoire. The exchange rate also discriminated against cattle producers in Togo but subsidies more than compensated this and in Idiofa, subsidies were responsible for the divergence in profits. The overall effect is quantified in terms of SRPs which indicate that producers were implicitly subsidised in Idiofa and Avetonou whereas in Gunjur, Keneba and Boundiali producers were implicitly taxed. In the case of Idiofa for instance, the result means that divergences—almost entirely due to the subsidy policy—increased the gross revenues by 28%. The DRCs show that there is a comparative advantage in producing cattle meat and milk for the local market in Gunjur, Keneba and Boundiali and in producing beef in Idiofa. This supports the findings of other authors (AIRD, 1992 quoted in Rolland, 1994). The rank order of the DRCs in our sites was naturally the same as for social profitability.

5. Conclusions

This study shows that trypanotolerant cattle represent a solution to the problem of producing cattle in regions of Africa affected by trypanosomiasis. Trypanotolerant cattle systems are viable and constitute a flexible solution, especially when breeding stock is locally available and when the level of disease risk is low to medium (Itty, 1992). Expansion of trypanotolerant cattle systems cannot, however, be recommended without a comparison with other tsetse and trypanosomiasis control strategies. This comparison should take the local conditions into account. For instance, and as our results show, in sites where cattle are to be introduced, the level of costs needs to be kept particularly low because benefits are limited to the production of beef and breeding stock. Further work is also required to understand farmers' evaluation and acceptance of the different control techniques.

In all the sites studied, unexploited grazing land (savanna and land under tree plantations) was brought into productive use and economic returns and comparative advantage were high. This indicates that resources for trypanotolerant cattle production are efficiently allocated as the sector is competitive and contributes effectively to the national welfare. In spite of distortions in market prices, financial returns to producers were also attractive.

Price divergences and constraints were identified through comparison of economic and financial analyses. At Idiofa and Avetonou, producers were explicitly subsidised. This can be justified as the risks are

high for farmers starting to keep cattle in regions devoid of this species. The case of Idiofa provides a vivid example of successful and profitable introduction of village cattle production. Active participation in the livestock development scheme by farmers with very few alternatives to increase and diversify income, the approach of the implementing agency (particularly the modest explicit subsidies granted) and the domestic availability of trypanotolerant cattle were key elements of success. In the absence of such factors, technology transfer using trypanotolerant cattle for introduction in villages might be neither profitable nor successful. In Avetonou, the incentive structure was heavily distorted by the subsidies and thus carried minimal information on how resources should best be allocated in the longer term. Information on farmers' adoption of interventions is not clear when the level of subsidies is high. The herding system was a major impediment to increased returns in Gunjur, Keneba and Boundiali. The secondary role of cattle to crop cultivators and their specialisation explains the share contract applied to herding at these three localities. In Togo and Côte d'Ivoire, significant distortions which were due to the overvalued FCFA have since been corrected as the currency was devalued by 50% in January 1994. This should improve competitiveness of the livestock sector in the countries of the FCFA zone as the traded outputs are produced with the use of few traded inputs. In the past, price distortions due to EU export subsidies for livestock products have seriously affected African livestock producers. The reductions in export subsidies brought in by the GATT and initial reforms in the EU Common Agricultural Policy represent positive developments which should boost the African livestock sector.

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