TECHNOLOGICAL PROFILE OF BRAZILIAN INNOVATIVE BEEF FARMERS: WHICH TECHNOLOGIES THESE FARMERS ADOPT, WHICH THEY DON'T AND REASONS FOR THE DIFFERENCE

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The adoption of 45 production, environmental and managerial technologies by 26 Brazilian innovative beef farmers is analysed in relation to technology attributes and adoption rationale. The farmers were purposively selected based on their self-enrolment in an organisation or program that promotes beef farming innovations. They were interviewed using a semi structured in-depth interview. On average, farmers adopted 27 of the 45 technologies, with highest adoption rates for production and managerial technologies. Environmental technologies perceived as more compatible with production systems had higher levels of adoption compared to other environmental technologies. In general, farmers adopted technologies that were compatible with their goals, farming systems and constraints. Results confirmed and extended Rogers' proposition of technologies attributes which influence adoption behaviour, and provided evidence for a hierarchy among these attributes. Compatibility and advantages relative to alternative technologies were the most important technology attributes in explaining adoption by individual farmers. Relevant but of secondary importance were observability and trialability prior to major commitment. Complexity was a deterrent to adoption but could be overcome by highly valued attributes aspects. Non-adoption was typically a considered decision consistent with goals and farming systems. Therefore, failure to adopt amongst innovative farmers should not in itself be considered an irrational behaviour or a failure of the research, development and extension systems.

Keywords: technology adoption, diffusion, innovation

Subtheme: Farm Management

1. Introduction

Brazil has the largest commercial cattle herd in the world, with an estimated 170 million head in 2006, of which 74 percent were beef cattle (IBGE, 2006). Brazil is currently the world's second largest beef producer and the largest exporter (ABIEC, 2010). This performance is a consequence of agro-climatic conditions, agricultural policies, demand factors, modernization of processing sector, research and extension, and technology adoption. Major historical technology adoptions include the Indian Zebu cattle (*Bos indicus*), that were introduced into Brazil in the late 1800s, and improved grasses, such as *Brachiaria decumbens* and, later, *Brachiaria brizantha* (Costa, 1998). The ready adaptation of both imported cattle and grasses to Brazil's tropical conditions allowed a rapid expansion of cattle herds throughout the Brazilian 'Cerrado', which is the savannah land of Central Brazil. There are also many more recent innovations available to beef farmers, encompassing production, environmental and managerial technologies.

Although the Brazilian beef sector has been experiencing rapid development at an aggregate level, development across individual farms has been heterogeneous. The diverse outcomes in part reflect different environmental conditions and hence a range of beef production systems. They also reflect differences in farm business structures spanning subsistence farms, commercial family farms and

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corporate farms, together with a range of objectives that influence adoption and investment behaviours.

This paper focuses on a group of beef farmers that can be classed as innovative. The concept of innovativeness is usually associated with being creative or keen on new ideas. Accordingly, innovative farmers are likely to be more open to new technologies and practices than other farmers. Consequently, they are a potential target group for agricultural researchers to work with. By definition, they are likely to be the first farmers to assess new technologies. As a result, they play a role in the process of technology diffusion since other farmers (late adopters) may copy them. Finally, by adopting new technologies, they push the boundaries of the beef sector. They do this: (1) by developing new technologies themselves; (2) by 'importing' technologies developed elsewhere into their farming systems; and (3), by displaying technologies and the results thereof, reducing uncertainties of other farmers about adoption.

This paper is part of a major research project (doctorate of the first author) concerned with technology adoption of innovative beef farmers in Brazil. The objective reported here is to explore the attributes of technology which impact on adoption. In doing so, we make a clear distinction between innovativeness and adoption. Innovativeness is a behavioural attitude whereas adoption is an action. Although innovative farmers are more likely to be open to adoption of new technologies than non innovative farmers, not all technologies are adopted by all innovative farmers. Accordingly, our interest is in identifying why a specific group of innovative farmers have high adoption levels of some technologies but low adoption of others.

2. Methods

Using a qualitative approach and some descriptive statistics, this paper provides accounts for technology adoption behaviour of 26 innovative beef farmers from Mato Grosso do Sul State, Brazil. Innovative farmers were purposively selected from two sources, in which they were voluntary enrolled: (1) Best Management Practice Programme (BMPP); (2) Association of Producers of Young Steers (APYS). BMPP establishes quality standards for farming practices that participant farmers must comply with, should they want to get BMPP certification. Likewise, APYS also requires members to undertake good farming practices. The difference is the involvement of a particular retailer and a slaughterhouse under a market alliance arrangement. Under this alliance, APYS members get a premium price for producing young cattle with particular carcass characteristics. The voluntary nature of BMPP and APYS implies that farmers participating in any of these initiatives are self-selected in terms of innovativeness capacity and, possibly, technology adoption. Six of the 14 farmers enrolled in BMPP participated in this study. A stratified random sample was used to select 30 beef farmers from APYS's 120 active members. Based on herd size, farms were randomly selected so that the sample had ten farms within each herd category: small (less than 1,000 head), medium (between 1,000 head and 3,000 head) and large (more than 3,000 head). Twenty out of the 30 invited agreed to participate.

Semi-structured on-farm interviews were carried out from November/2008 to February/2009. Farmers provided detailed adoption information on 45 innovations, including 25 production, 9 environmental and 11 managerial technologies. Although there are no clear boundaries whether a technology is production or environment related, given their intertwined character, in this paper a distinction is made based on the primary focus of particular technologies. Thus, production technologies are mainly directed to increase meat quality, cattle production and/or productivity. In contrast, environmental technologies essentially focus on the conservation of natural resources and the mitigation of environmental impacts. These definitions were used here to allow for methodological treatment, even

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though we acknowledge environmental technologies also impact on beef production, particularly in the long run. The third group of technologies are managerial. These aid business administration and marketing. They focus primarily on supporting the organization and control of the farm business in order to improve its efficiency, reduce costs or increase margins.

Technological profiles of innovative beef farmers were analysed in relation to Rogers's (2003) propositions that compatibility, observability, trialability and relative advantages of technologies increase their adoption rates, while complexity limits adoption behaviour.

3. Results

This section is divided in two parts: first, characteristics of Brazilian innovative beef farmers and their farming systems are briefly described to provide some context for technology adoption; second, farmers' technological profiles are presented, followed by farmers' accounts of their adoption behaviour.

3.1 Describing Brazilian innovative beef farmers

On average, the interviewed farmers had around 20 years of beef farming experience (Table 1). A typical farmer was a well-educated male in his 50s, married, with two children (varying age) who lived in town with his family. He usually visited the farm once a week. The average farm was 2,784 ha with 1,749 ha of pasture and 2,540 cattle. 'Nelore' (*Bos indicus*) was the prevailing breed (in 92% of farms), although 15% of farmers raised 'Brangus' and several had crossbreeds (particularly with Angus). The average farm employed six people permanently and some temporary workers during peak times (weaning and vaccination) or for particular jobs (e.g. fencing). On average, 74% of these farmers' total gross income was from farming, with beef farming providing US$ 757,340 of annual gross sales. Farmers whose gross income from farming was zero had off-farm businesses and reinvested net revenue (sales less purchases) in the farm development. Some 73% of these farmers had completed tertiary education, of whom 63% had agricultural-related degrees and 21% degrees in business administration.

Table 1. Farm and farmers' characteristics (n = 26)

Farm and farmers' characteristics	*Mean*	*Minimum*	*Maximum*	*Std. Deviation*
Age (years)	53	28	75	14.3
Number of children	2	0	4	1.2
Farming experience (years)	20	3	45	12.5
Farm size (hectares)	2,784	162	19,200	3,962
Pasture area (hectares)	1,749	50	10,700	2,186
Crop area (hectares)[1]	468	20	2,400	706
Herd size (head)	2,540	300	13,980	2,836
Stocking rates (head/hectare)	1.8	1.0	6.0	1.0
Number of permanent employees	6.3	1	20	6.0
Gross income from farming (%)	74	0	100	40.1
Annual gross sales from beef farming (US$/year)[2]	757,340	107,580	3.2 million	776,403

[1] Results from 11 farmers who produced crops
[2] Exchange rate: 1.00 BRL (R$) = 1.71050 USD (US$), retrieved from www.xe.com on 14 September 2010.

The majority of farmers inherited their farms (54%) while others bought (42%) or leased land (4%). Off-farm business activities were undertaken by 46% of farmers. Some farmers had beef farming as their only farm activity (31%) while others had on-farm diversification, particularly sheep (27%) and crops (23%). Around 23% ran purebred studs along with their commercial herd. The most common production system (65%) was the complete cycle, encompassing the cow/calf, rearing and finishing phases. Combined rearing and finishing but without breeding was also an important production system (23%), with exclusive cow/calf (8%) and exclusive finishing systems being less frequent (4%). Age of cattle at slaughter ranged between 20 and 36 months.

The main overall goals of these farmers were to increase beef production and/or productivity (e.g. finish cattle within 30 months), to be in the forefront of innovation, and to be proactive in marketing the product to ensure good returns. Profit, in general, was not regarded as an end-goal but as a 'means to an end'; this end being to keep farming and remain competitive. In these farmers' views, profit is a consequence of good farming practices. Besides these shared goals, there was also important diversity in goals between specific farmers, but this aspect is beyond the scope of this paper and will be reported elsewhere.

3.2 Technological profiles of Brazilian innovative beef farmers

On average, the 26 farmers adopted 27 (61%) of the 45 technologies analysed in this study. As farmers' age increased, adoption first increased and then decreased (Table 2). One reason was farmers' attitude to risk, as illustrated: *"...I used to risk a lot* [when he was younger] *but now I take fewer risks"* (F11). Farmers' priorities (e.g. farm development vs. retirement) and health conditions also change with age, impacting on adoption. Technology adoption also increased with larger pasture area and herd size; in the literature, these are usually proxies for farmers' wealth (Kaliba, Featherstone and Norman, 1997) and, as such, relate to their ability to afford technologies.

Table 2. Adoption rates according to farmers' age, pasture area and herd size

Adoption rate compared to age group		Adoption rate compared to pasture area		Adoption rate compared to herd size	
< 45 years	60%	< 500 ha	50%	< 1,000 hd	49%
46 – 60 years	65%	501- 1,500 ha	55%	1,000 – 3,000 hd	62%
> 60 years	57%	> 1,500 ha	90%	> 3,000 hd	69%

Of the three technology types, the most frequently adopted were production and management technologies (62% and 60% respectively) whereas environmental technologies were less adopted (53%) (Table 3).

Adoption of production technologies (Table 3) was facilitated by many of them being divisible, allowing for trialling, and therefore reducing the adoption risk. Several farmers mentioned that whenever possible they experiment with a technology on a small scale before implementing it on the whole farm. Additionally, most of these technologies and their results were observable, and this is supported by farmers' comments that they visit other farms or research institutes to learn more about these technologies.

Table 3. Percentage of farmers adopting particular technologies*

Levels of adoption	Types of technologies		
	Production	Environmental	Managerial
Low	Early weaning - before 7 months of age 5 Embryo transfer 11	Permanent private reserve area 8 Heavy-use area protection 12 Expansion of headspring protection area 25	Production cost analysis 15 Futures trading 17 Formal investment planning 23
Moderate	Grass and legumes mix 31 Deferred grazing 36 Pasture diversification 42 Silage 42 Creep feeding 47 Pasture maintenance 48 Feedlot to finishing cattle 54 Pasture recovery 55 *Capineira* - paddock for harvest and consumption during winter 58 Strategic control of worms 62 Artificial insemination 63 Cross-breeding 67	Manure management 38 Soil conservation practices 54 Agricultural terracing 65 Tree conservation 69	Financial control 38 Staff evaluation and reward 46
High	Rotational grazing 76 Genetic improved bulls 78 Cattle supplementation 81 Soil testing (occasional) 81	Water management and facilities 92 Fire is **not** used for pasture management 100	Participant in market alliance 77 Managerial software 81 Sanitary control 81 Animal identification 88

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	Castration 84 Certified pasture seed 88 Cows pregnancy test 89 Bull fertility test 89 Culling based on reproductive performance 89 Breeding season – 3 to 6 months where breeding cows should be mated 95 Care of newborn calves 100		Scale to weigh cattle 92 Technical records (control) 100

* The cut-off points to define adoption levels were: less than 30% of adoption rate, between 30% and 70%, and above 70% for low, moderate and high levels of adoption respectively.

Negative factors influencing adoption of production technologies included complexity, relative disadvantage, and lack of compatibility. Complexity was particularly a negative factor in relation to adoption of pasture diversification, and similarly for 'grass and legumes mix'. Regarding the latter, farmer 25 claimed, and other farmers agreed, that *"it is hard to keep the legume and after a few years it's all gone"*. These farmers had discontinued the adoption. For some farmers, relative disadvantage was a negative factor for feedlot finishing of cattle, pasture maintenance and pasture recovery, either because the cost of implementation was prohibitive or the cost-benefit of alternative practices was more attractive. Perceived lack of compatibility was the key reason for the low adoption rate of early weaning, while complexity plus non-compatibility were relevant for embryo transfer.

However, complexity was not by itself a sufficient condition to prevent adoption. For example, the majority of farmers implemented rotational grazing despite its complexity. This complexity arises from the dynamic elements of plant growth, climatic conditions and animal intake, and the associated need for skilled and specialist staff to manage. Given that farmers were convinced about the technology benefits, they were prepared to pay the costs involved. As farmer 24 illustrated: *"I'm going to use it if returns are clear (...) even if it's difficult"* (F24).

The adoption rate of some environmental technologies was influenced by whether the technologies were seen as compatible with production goals. For example, setting aside of permanent private reserve was considered incompatible with production goals, whereas manure management (for soil fertilization), agricultural terracing and other soil conservation practices (e.g. no-tillage farming) were generally seen as compatible. The environmental technology with the highest adoption was 'water management and facilities' and this too had high compatibility with farmer goals and overall farm systems. In contrast, the low adoption of 'expanding the headspring protection area' and 'protecting heavy-use area' (e.g. around feeders) was influenced by uncertainty as to their impact on production.

There was a range of managerial technologies, such as futures trading, use of formal planning techniques and analysis of production costs, which had low adoption rates because farmers lacked full understanding of these technologies and believed *"this is for economists"* (F25). Other reasons that could have influenced adoption of these technologies, and consistent with Rogers' Diffusion Theory (Rogers 2003), are that for these technologies either the technology itself or the results thereof are not readily observable. Non-observability impacts on farmers' ability to assess these technologies. Given these circumstances, such technologies seemed too complex, reinforcing farmers' non-adoption decisions. 'Staff evaluation and reward' was also considered complex to implement, but had a moderate adoption level because of its alignment with farmers' goals. Managerial technologies with high adoption, such as animal identification, animal weighing and technical records, were perceived by farmers as directly linked to their production goals and were relatively simple to adopt.

4. Discussion

In this study, all technologies found to have high levels of adoption have compatibility with farmers' goals and farming systems. The high adoption technologies tend to relate to animal genetics, reproduction, and performance, whereas pasture and nutrition related technologies tend to be within the moderate adoption group. In general, the higher adoption technologies are relatively less complex and less expensive to implement, and in some cases are more observable and divisible (i.e. enable trialling). The perceived advantages of the highly adopted group include economic returns, reduced risk, ease of use, implementation cost, quality improvement, rapid achievement of results, premium price, time saving, and low requirement for specialized workforce.

Rogers' Theory of Diffusion posits that technology adoption is preceded by an awareness phase (Rogers 2003, p. 169). Farmers who are unaware about a technology, or are aware but have low level of information about it, will either not judge it at all or misjudge its characteristics. However, farmers in this case study were, in general, well aware of the technologies under investigation, and this is not surprising given the criteria by which the farmers were selected. Accordingly, this has allowed a strong focus in this study on the post awareness situation and Rogers' set of technology attributes; these being compatibility, relative advantage, observability, trialability and complexity.

The results obtained in this study are consistent with Rogers' propositions. However, there is also some evidence that Rogers' propositions can be extended. In particular, Rogers establishes no hierarchy of attributes. In contrast, this study from Brazil and for these farmers provides evidence that the most important technology attributes are compatibility and relative advantage. Observability and trialability facilitate, but do not by themselves either determine or preclude adoption. Similarly, technology complexity does not preclude adoption, but is given consideration relative to the technology advantages. If the benefits of a technology are sufficient, then innovative farmers will adopt despite negative issues related to complexity.

5. Conclusions

The farmers in this study can be characterised as innovative farmers who are open to adopting new technologies. Most were tertiary educated and all were passionate about farming. The process of adoption of a technology was not considered individually by farmers, but as part of a major system, which this technology must fit in and contribute to. The key criteria determining whether or not a particular technology was adopted was compatibility with farmers' goals, farming systems, and constraints, together with the advantages of the technology relative to alternative technologies. These advantages were mostly assessed in terms of relative prices and returns, impact on productivity and demand for workforce. Secondary factors influencing the final decision were observability, trialability and complexity. In general, farmers who did not adopt particular technologies did so for considered and logical reasons consistent with their objectives, resources and constraints. Accordingly, failure to adopt amongst innovative farmers should not in itself be considered a failure of the research, development and extension system.

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