Beef Cattle Expansion in the Brazilian Legal Amazon: from Land availability to Emerging Technologies

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Abstract — *The state of Mato Grosso is part of Brazilian Legal Amazon and is one of the new frontiers in world farming facing the global demand for food. It is also one of the most important regions that have contributed to increasing the size of Brazilian cattle herds. However, a better understanding of the factors driving this expansion in area and the quantity produced is needed to support public policies and domestic production planning. Consequently, the aim of this article is to analyze and describe the historical drivers of beef cattle expansion in the state of Mato Grosso, considering the beef supply chain and state economy. Key findings included indications that this expansion was based on the availability of arable land and lower land prices but mainly resulted from the use of technologies allowing increased efficiency and competitiveness in livestock in Mato Grosso.*
Keywords — Livestock, Food Production, Socioeconomic Development, Agricultural Engineering Research, Land Use Change.

I. INTRODUCTION

The growing consumption of animal protein and the increasing concern regarding the exhaustion of natural resources are major challenges for food production in all the world. This demand for meat has encouraged beef production, leading to increases in herds worldwide. In Brazil, the cattle herd increased about 30% in the last 20 years, mainly in the center-western region (IDESP & ADEPARA, 2012) where land is available and the production costs are more competitive (Arima et al., 2014). In this scenario, land price is one of the major drivers and is influenced by the potential development of this region and the economic returns for commodity crops, such as soybeans (Borchers et al., 2014).

On the other hand, investments in research and technologies to intensify productivity also contributed to establishing Mato Grosso as one of the main Brazilian livestock production centers.

Moreover, Mato Grosso consists of three important biomes, Amazonia, Cerrado (*Brazilian savanna*), and Pantanal and is part of the Brazilian Legal Amazon. This diversity offers versatility to the production systems but increases the concerns regarding the expansion of food production over natural areas, causing deforestation in this region (Arima et al., 2014).

Although cattle herd in this state presented a growth of 10% from 2005 to 2012 (McManus et al., 2016), there is a clear trend toward the stabilization of this herd, probably because of the pressure from environmental legislation, which requires 80% of farms located within the Amazonian biome to be set aside as legal reserve.

Nevertheless, the drivers and socioeconomic aspects that led to beef cattle expansion in this state are unclear because public policies and other productive strategies did not consider local particularities connected to this activity.

In addition, studies dedicated to understanding the drivers influencing the occupation in Mato Grosso can support national production planning and public policies for incentives or control (Oliveira et al., 2017) because the special relocating of the production has great implications on the region to which it moves (Bowman et al., 2012).

Therefore, this research offers a descriptive analysis of the drivers that influenced the expansion of cattle production in the state of Mato Grosso.

II. MATERIAL AND METHODS

The focus of this study was the state of Mato Grosso located in the center-western region.

This state also belongs to the Brazilian Legal Amazon, a political-administrative region, created by the Brazilian Government in 1953. Brazil's third-largest state, Mato Grosso has 903,357 km2 of area and more than 3 million habitants, but only 549,153 of those reside in the rural areas (IBGE, 2010). Moreover, as mentioned in the introduction, Mato Grosso consists of three important biomes (Figure 1).
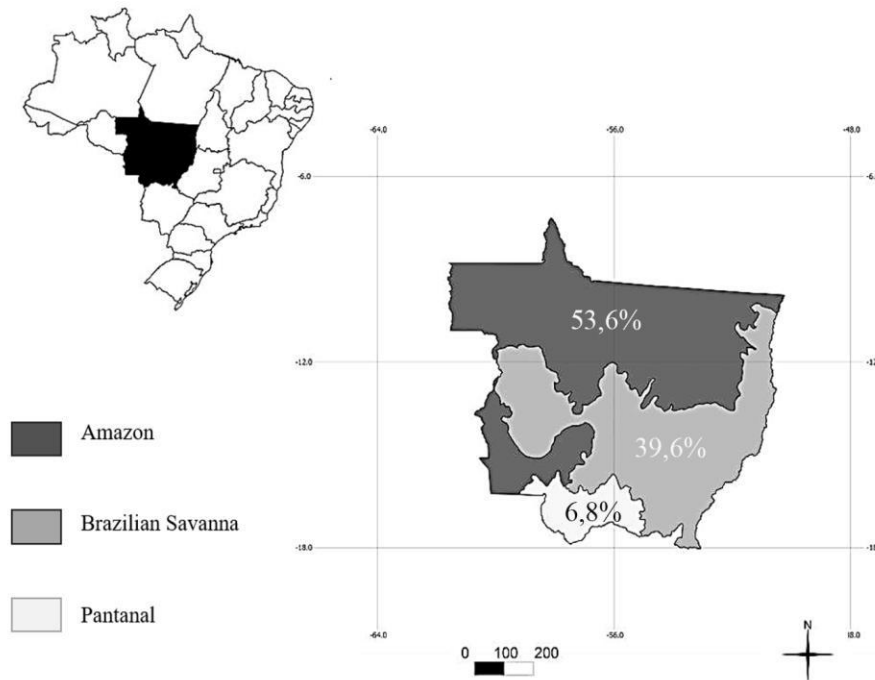

Fig. 1: Location of Mato Grosso state and local biomes, according to the distribution of Brazilian biomes Numbers in the map indicates the percentage of the state occupied by each biome

To identify the drivers of cattle expansion an exploratory analysis of the grazing areas and the cattle herd in Mato Grosso was conducted between 2000 and 2014.

Additionally, the total export volume and the number of animals slaughtered in the state during this period were compared. These comparisons were analyzed using a Spearman correlation in the SPSS 20.0 software (IBM SPSS, 2011), assuming $r^2 > 0.80$ and $P < 0.001$ to be statistically significant.

The topic was also researched in scientific publications (books, journals, proceedings, thesis, and dissertations) and in secondary data (governmental reports, universities, and research institutions).

In addition, on-site observations were conducted to identify the drivers behind technological changes in the sector and milestones of this expansion (Table 1).

To confirm the relevance of the identified drivers, interviews were conducted between 2011 and 2012 with key Brazilian stakeholders of the beef cattle supply chain (agents from government agencies, slaughterhouses and meatpacking industry, research centers, auctioneers, investors, and farmers).

Table 1: Scientific events, research group discussions, and integrating seminars discussing the expansion of beef cattle production in Brazilian Legal Amazon.

Events and discussion centers	Year
Scientific Events	
World Congress of Rural Sociology	2012
Low Carbon Agriculture Plan dissemination seminar	2011
Annual IFAMA World Forum and Symposium	2011
Sustainable Livestock Symposium	2011
NESPRO Meeting	2010/2011
International Conference on LCA in the Agri-Food Sector	2010

Sustainable Livestock Congress	2010
World Meat Congress	2010
Cong. of the Brazilian Society of Economics and Rural Sociology	2009/2010
International Pensa Conference	2009
Research discussions groups	
Center for geo-environmental studies (NUCLAMB/UFRJ)	2009/2012
Center for studies in beef production and the production chain (NESPRO/UFRGS)	2009/2012
Strategy, Competitiveness, and Development Research Group (GEComD/UNESC)	2009/2012
Integrating seminars	
CEPAN Meeting	2010/2011
PPG Animal Science Seminar	2011
NESPRO Annual Meeting	2012

Finally, the Business Process Model (BPM) was adopted (see Vanthienen et al., 2007) to elaborate the framework model (Fig. 2), for the description of and the resulting figure for the drivers of the cattle herd expansion in the state of Mato Grosso (Fig. 7)
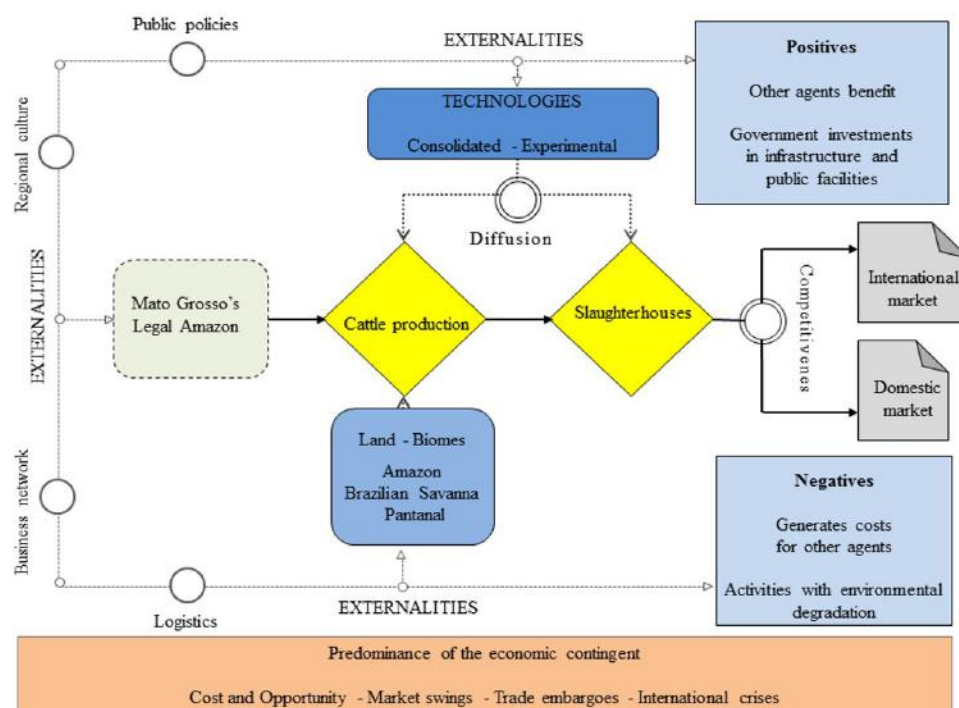

Fig. 2: Analysis Model for the cattle herd expansion in Mato Grosso, located in the Brazilian Legal Amazon

III. RESULTS AND DISCUSSION

We identified three dimensions that directly affected the beef supply chain in the Brazilian Legal Amazon, the socioeconomic outlook, the installation of meatpacking industries, and diffusion of technologies in the region. The characteristics and main events for these dimensions in Mato Grosso were determined to identify the drivers behind the occupation of cattle production in this state.

3.1 Socio-Economic outlook and the beef supply chain in Mato Grosso

In 2010, approximately 208 farms dedicated to cattle production were placed in Mato Grosso. Although 85% have up to 300 animals (24% of the state's herd), most of the herd (52%) was concentrated in 5% of the farms (INDEA, 2010). Despite the land and herd concentrations, the state still maintains small proprieties, normally managed by rural families. Most of these families come from other Brazilian states in search of opportunities and land availability. The migration in the past decades, along with the availability of land with low prices, also contributed to the beef production growth.

Moreover, despite 35% growth in the population, Mato Grosso remains one of the least populous and settled states (INDEA, 2010). Consequently, its population is unable to absorb its own beef production, which is currently exported overseas (19%) and to other states (81%) (IMEA, 2011).

The structure and main interactions between the stakeholders were determined by the researched in scientific publications, secondary data, discussion center and in the interviews. A basic structure for the beef supply chain in Mato Grosso was elaborated according to the information and data analyzed in this research, this result was also an adaptation from the proposition of the Beef Breeders Association of Mato Grosso (ACRIMAT, 2011) (Fig. 3).
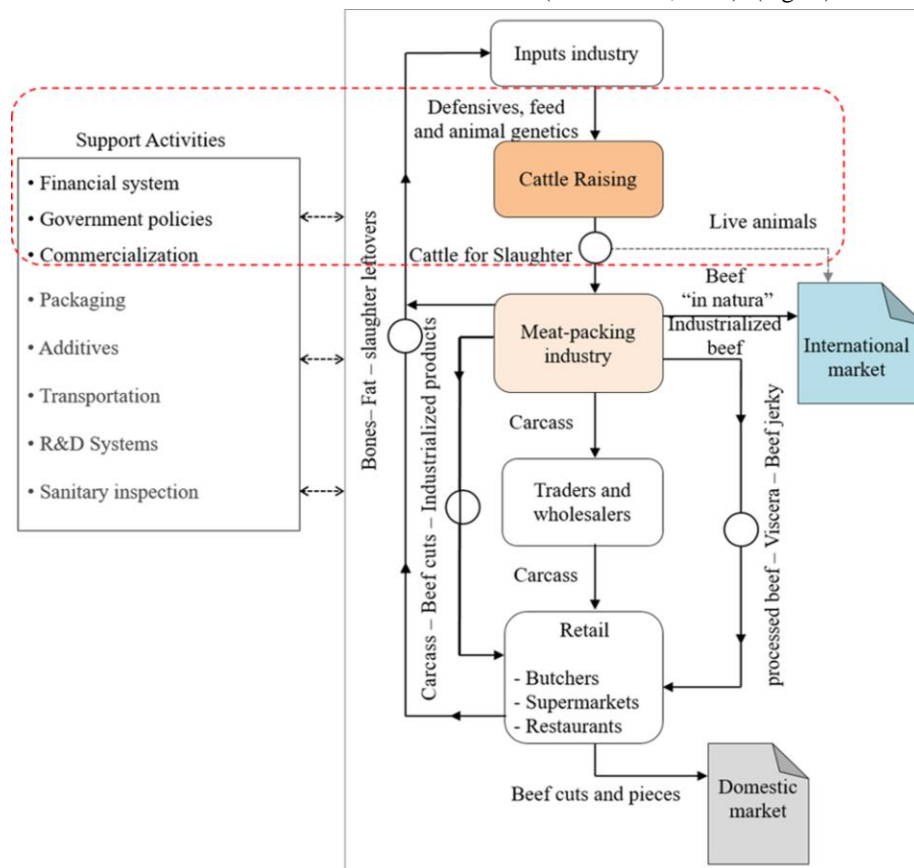

Fig. 3: Structure of the beef supply chain in the state of Mato Grosso, located in the Brazilian Legal Amazon
Source: Elaborated based on Wiazóvsky & Lírio (2003); FAMATO & FABOV (2007).

In Mato Grosso, most of cattle production systems are extensive, complemented with feed supplementation in the dry season, between April and September (Moraes, 2010). However, these systems do not provide adequate financial returns, requiring productive improvement and the adoption of new technologies to improve productivity and economic indicators. Recent technologies have introduced new relationships into the productive space, an important fact that has led the stakeholders to seek sustainable production strategies, like shortening the production cycles of the cattle.

Beef cattle integration with agriculture or forestry has contributed to grassland recovery and increased productivity and profitability. This is because, after the harvest of grains (soybeans and/or corn), these areas can be used for grazing, fattening the animals with grain by-products, forage, or pasture from July to September (the end of the dry season). This integration can increase the organic matter in the soil, encouraging biomass production and allowing higher stocking rates. These integrating strategies have the potential for sustainable intensification of agricultural activities in Brazil, particularly in Mato Grosso. However, little is known regarding these systems, and few farmers have adopted it till date (Gil, 2015). This proposal has been implemented in other Brazilian states through a process of agricultural occupation associated with greater coordination to the national economic space (IBGE, 2005).

Overall, many factors influence this beef cattle supply chain, especially regarding the variation in the number o animals allocated to grasslands and send to the slaughterhouses, both fluctuate according to the management strategies of each farmer. The main results observed comprise the dynamic cycle of beef cattle activity in Brazil (Fig. 4).
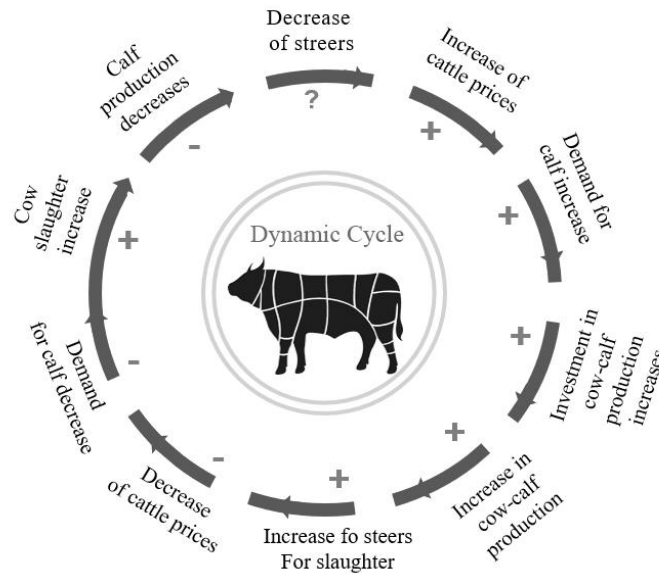
Fig. 4: Dynamic of the law of supply and demand applied to beef cattle in Brazil.

Based on the dynamic cycle of beef production (Fig. 4), the reduction in prices for farmers led to an increase in the slaughter of females, which accounted for 47% of the total herd between 2005 and 2007. This, in turn, inflated the overall supply and reduced calf production, causing a reduction in the slaughtering of steers between 2008 and 2010, raising the price of calves, and reducing the female slaughter rate to 36% (IMEA, 2011).

This dynamic resumed the growth of the state's herd, pushing farmers to increase their use of technologies and lead to a reduction in the average slaughter age of males, but also caused significant losses for the slaughterhouses and meatpacking groups.

Moreover, the quick and intense establishment of slaughterhouses in small towns, without proper strategic planning and scaling, influenced the production, particularly for cattle transport conditions and costs (Capanema et al., 2012). In this case, the movement of slaughterhouses toward Mato Grosso's Amazonia reflects a logical reduction of acquisition costs. Recently, the international market witnessed the internationalization of Brazilian meatpacking industry, a process that stimulated the sector's growth.

However, the market dominance of this sector raised doubts to the credibility of the relationship between large companies, the government, and local farmers, indicating the importance of trust mechanisms between the parties (Fröhlich & Bluhm, 1991), because of the beef production for export targets demanding markets. Those partnerships included distribution networks and have increased since the end of the sanitary blockades, opening new export markets (Rivero, 2009).

Furthermore, an increase in grasslands was observed and was associated to the economic stability of the state, which allowed the investment in livestock production encouraged by governmental incentives and the availability of cheaper land in the 1990s (Fig. 5).
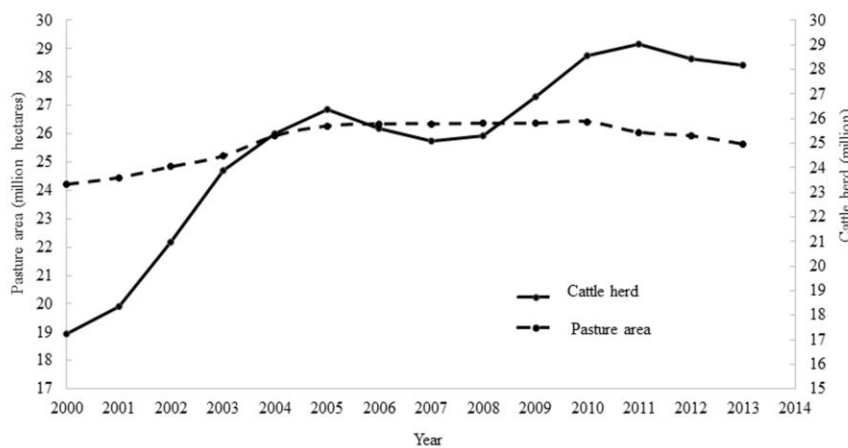

Fig. 5: Pasture area and cattle herd in the state of Mato Grosso, Brazil

The impressive growth observed in the cattle herd was based on the advance of this activity over areas in the Amazon Biome, north of Mato Grosso (Fig. 5). The stabilization that followed was the result of environmental laws, as well as the awareness among farmers regarding the importance of pasture renewal and correct management.

This consciousness is a key issue because the productivity of cultivated pastures in Brazil is no more than 34% of its potential. If 50% was reached, the resulting yield would be enough to meet beef demands until 2040, with no need for further conversion of natural ecosystems (Strassburg et al., 2014). Nevertheless, the herd increased more than the pasture area, with a 56% growth in occupancy rate from 2010 to 2014.

3.2 The meatpacking industry and its impact on Mato Grosso beef supply chain

Mato Grosso was divided in 1977, creating the state of Mato Grosso do Sul, officially established in 1979. This division led to a movement of the slaughterhouses, which first settled in the lowlands surrounding Cuiabá (capital of Mato Grosso) and Várzea Grande, later expanded to all microregions of Mato Grosso. In 2014, the north and west regions of Mato Grosso had the highest monthly slaughter capacities in the state, approximately 20% and 18% of the statewide production, respectively (IMEA, 2015).

The establishment of the first slaughterhouse unit in Mato Grosso was associated to the expansion of beef cattle in the southern part of the state (currently Mato Grosso do Sul) and logistics facilities, such as the railway

to São Paulo. Most of the slaughterhouses were established in small towns, which lead Mato Grosso to the first position in slaughtering capacity among Brazilian states in 2005 (IBGE, 2010).

In recent years, the commercialization of animals with adequate fattening degree in Mato Grosso has mainly targeted the supply of entire beef (hind quarter/front quarter/flank) to wholesalers of urban centers in the southeast region, as well as boneless cuts for the foreign market through three leading slaughterhouses (FAMATO & FABOV, 2007).

However, only approximately 46% of the installed slaughter capacity was used in 2014, slaughtering 5,521,878 units compared with the slaughter capacity of over 11 million units (IMEA, 2015). This low utilization rate reflects a crisis in the meatpacking industry, which began in 2008. From 2009 to 2010, large groups opened a legal request for judicial recovery, ceasing their operations.

Despite almost 300% growth in the cattle herd, in 2008, we observed a significant decrease, which may be related to the slaughter of breeding stock, a previous outbreak of foot-and-mouth disease (2005/2006), and the increase in the exportation of live animals, as well as the economic downturn observed during that period.

Even with the slaughterhouses working below their potential processing capacity, national and international demand fell short of supply, lowering prices for farmers. The expansion of Mato Grosso's herd (Fig. 5) also resulted in a higher slaughter rate for the period analyzed, as well as an increase in the beef export volumes (Fig. 6).
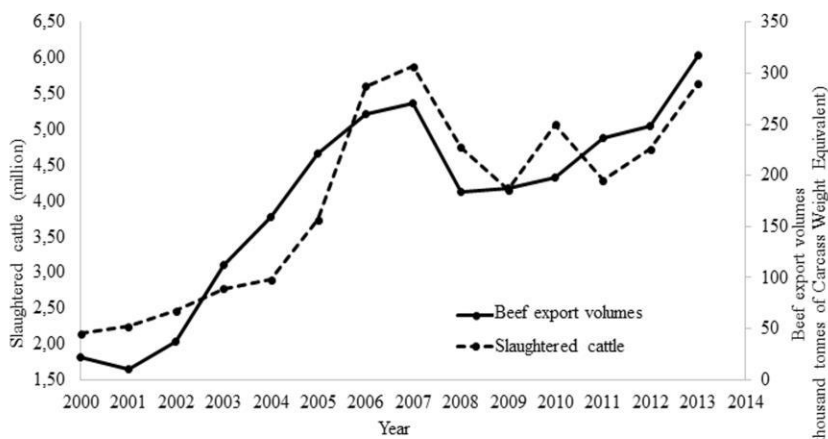

Fig. 6: Slaughtered cattle and beef export volumes of Mato Grosso state, Brazil.

Thus, slaughter capacity in the state was associated with the sale of beef abroad and to other states ($r^2 = 0.89$; $P < 0.001$). During the period under study, the Mato Grosso economy presented increasing positive results in its trade balance. In 2007, for instance, the total beef exports were approximately six times higher than in 1996.

Moreover, even though the international crisis had affected the results in 2008 and 2009, the general trend pointed toward a recovery.

3.3 Technology and competitiveness in beef cattle production

Despite the importance of the economic management in the modern hypercompetitive environment, many farmers still consider beef production to be different from other economic activities, ignoring basic principles, such as the law of supply and demand. This is also true for Mato Grosso.

In this state, we observed that the technological advances in cattle production are more related to the increase in the number of animals than to the increment of the pasture area.

Considerable technological advances have been observed in various countries, resulting in productive efficiency and superior quality in the final product (Bellows, 2000). In beef cattle, high production can be achieved by increasing the productivity of pastures and the herd itself (Strassburg et al., 2014).

However, these strategies involve the landowner, who must understand and accept the technological changes because the landowner is the producer who decides what actions will bring success or failure to the production systems (Dziuk & Bellows, 1983). Moreover, Brazilian production systems are very different among the country and range from traditional to intensive farms (Bungenstab, 2012), which difficult the understanding of farmers' characteristics and beliefs, as well as their aspirations, needs, and dreams.

Although the intensification of livestock farming may compromise local traditional practices, particularly for small farmers (Strassburg et al., 2014), it can contribute to sustainability and overall productivity of the supply chain. In beef cattle production, this efficiency depends on the adoption of technologies, which is influenced by technical and extension support and communication among farmers (Genius et al., 2014).

Furthermore, cost is the main competitive advantage of low differentiated products, such as beef (Porter, 1990), imposing the challenge of selecting technologies with consideration to the availability of capital, technical resources, farmers vocation, logistics, human resources, market, and the respect for the legislation for the environment (Barcellos & Suñe, 2011; Marques et al., 2011). Consequently, new technologies for efficient production and adaptation to the new regulatory framework require the farmers to have professional conduct and practices (Barcellos et al., 2011).

A final representative scheme was elaborated for the identified drivers of beef cattle expansion in Mato Grosso, including the historical and macroeconomic facts of this phenomenon (Fig. 7).

The BPM framework model was able to identify the drivers for the cattle herd expansion and provided an interesting analysis of the agricultural landscape in the Mato Grosso state. The Mato Grosso State Federation of Agriculture and Livestock Production used the structure proposed by this research as a tool to broaden the administrative vision of roles and responsibilities and as the foundation for its regional studies (FAMATO & FABOV, 2007).

In addition, the communication of this Mato Grosso outlook to other researches, investors, and policymakers can offer opportunities to advance in the development of technologies applied to beef also from a sustainable perspective (Gianezini, 2014). Moreover, although the level of technological intensification has increased, to achieve better efficiency in production, farmers must be aware of the regulatory framework guided by elements, such as traceability and environment/land legislation. Besides, despite the dominance of large groups in the meatpacking industry, it is necessary to emphasize the difficulties regarding logistics infrastructure, labor quality, and the distance from the main consumer markets.
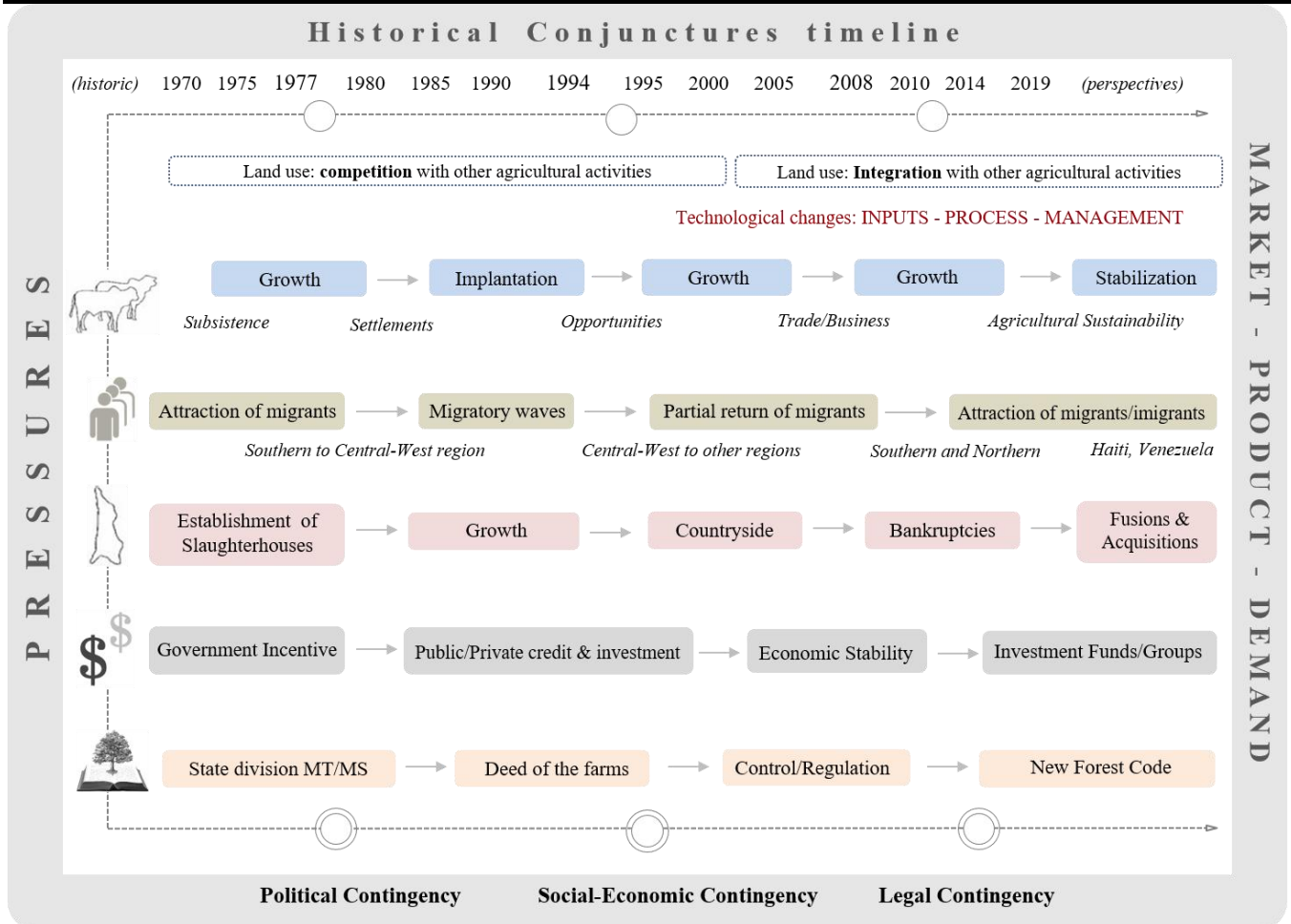
Fig. 7: Drivers and milestones for the expansion of beef cattle herds in the Mato Grosso State, Brazilian Legal Amazon

IV. CONCLUSION

The socio-economic landscape of Mato Grosso offered conditions for the expansion of the cattle herd. One of the most important factors in this scenario is the technological change that led to alterations in land use patterns, different from the geopolitical division that landmarked beef cattle expansion in the years 1970-1980. Some farmers have observed how grain farmers can be competitive and seek to copy them or integrate grain crops into their activities. Thus, instead of reproducing preexisting productive structures, recent agricultural advances in Mato Grosso have created a frontier where a technological change is a central element behind the state's agribusiness related to a new productive profile.

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