Valuing the Energetic Recovery Flexibility of Sugarcane Residues: a Real Options Approach

Autoria: Rafael Igrejas, Luiz Eduardo Teixeira Brandão, Leonardo Lima Gomes

Propósito Central do Trabalho:
In this paper we value the managerial flexibilities embedded in the sugarcane trash recovery process, focusing on its use as feedstock for a cogeneration plant that powers the sugarcane mill and export surplus energy into the grid. We analyze a case of a sugarcane mill in Brazil that produces sugar and ethanol which has a cogeneration unit that supplies all its power and thermal energy needs. The bagasse by product is used as fuel for the mill processes and as raw material for the cogeneration unit, and surplus energy from bagasse is fed into the grid sold at a fixed price through long term contracts in the Regulated Trading Environment (ACR). We model a sugarcane trash recovery project where the firm has the option to invest in the recovery of the cane trash left in the field in order to expand its energy cogeneration capacity at any time during the first five years of the project and sell surplus energy in the short term market (ACL). Once the firm has invested in cane trash recovery and processing, it can also invest in briquetting equipment that will allow the firm to optimally switch between electricity generation or briquette production for sale in the market. We assume revenues from sale of bioelectricity are a function of future energy prices, which are modeled as a Geometric Mean Reverting stochastic process. The model is then solved using the non censored binomial mean reverting lattice using the DPLTM software.

Marco Teórico:
In the early 1990’s, producers began using mechanical harvesting machines, which provided greater productivity and did not require prior burning of the field (CTC, 2008). Mechanization levels have increased significantly since then reaching approximately 60% of the total crop area by 2010. Complete mechanization is expected to occur by 2017 to comply with a legal requirements of the State of Sao Paulo, the largest producer in the country, which prohibits burning of the fields beyond that date. As it has no economic value, the cane trash is traditionally left in the field after the mechanized harvest and helps provide coverage and fertilization for the next crop. On the other hand, cane trash has significant potential as an energy source if used as feedstock for power generation plants already operating with bagasse cogeneration (Seabra, Tao et al., 2010). In 2005, the CTC conducted an experimental study of the energy use of sugarcane biomass of southeast Brazil (Hassuani et al., 2005), analyzing the cane trash availability and their energy and agronomic potential in areas of unburned cane that had been mechanically harvested. Tests conducted with different varieties of cane, cutting stages and regions of harvest cane were carried out, yielding an average of 140 kg per ton of sugarcane (Seabra et al., 2010). Agribusiness projects, such as sugarcane mills, typically present many uncertainties and embedded flexibilities that require the use of option pricing methods in order to determine project value and optimal decisions. This value is not captured by the traditional Discounted Cash Flow (DCF) approach due to several limitations and restrictions of the method. One of the most important is the fact that this method often fail to take account significant portions of the project value (Trigeorgis, 1996). This includes the value of managerial flexibility to defer, expand or cancel projects in response to market conditions observed after the start of the project and the strategic value of new investment opportunities arising from the development of a new technology. The concept of modeling project flexibilities for investments under uncertainty derives from the seminal work of Black, Scholes (1973) and Merton (1973) for the valuation of financial options. Tourinho (1979) was the first to show that this method could be applied to investments in real assets, and other authors such as Dixit and Pindyck (1994) , Trigeorgis (1996) and Copeland and Antikarov
(2003) further developed what became known as the Real Options Method. As described in Silva (1999), real options have been widely used to model the effects of industrial policy in agribusiness projects. Schatzki (2003), analyzed the switch option available to landowners to choose between agricultural production or reforestation. Ge, Mourits and Huirne (2005) calculated existing flexibilities in controlling contagious animal disease, based on the uncertainties on the state of the epidemic, irreversible actions like culling and vaccination of animals, and the possibility of learning during the epidemic. Cardoso, Martin, Marçal, Kayo and Kimura (2009), applied real options to determine the optimal time to invest in a coffee plantation in Brazil. Arenaro, Bastian-Pinto, Brandão and Gomes (2011), used real options to value a sugar and ethanol production plant in Brazil which had the option to add a cogeneration unit to produce bioelectricity.

**Método de investigação se pertinente:**

We have not found in the literature any study that addressed the economic feasibility of sugarcane trash recovery for energy generation purposes. Based on a real case of sugarcane mill in Brazil and an experimental study of the energy use of sugarcane biomass of southeast Brazil (Hassuani et al., 2005), we consider a typical sugarcane mill producing ethanol and sugar with a processing capacity of 1.3 million tons of cane per year, using baling machines as trash recovery technique can recover at 50% of the cane trash. During the harvest, an addition of 24% of trash is removed with the stalks and discharged at the cleaning station at the mill, while at least 50% of trash remaining is left on the field as a natural cover. Due to the use of high efficient boilers, the energy produced from bagasse is already sufficient to supply the mill’s power necessity and export the surplus capacity (15 MW) to the grid at a fixed price through long term contracts under the Regulated Trading Environment (ACR). The basic project of recovery and cogeneration of the cane trash has a 5 year forecasting period, with an expected perpetual growth rate of zero beyond the forecasting horizon and corporate income tax rate of 34%. We assume that the expansion to recover the cane trash from the field and adapt the cogeneration unit to operate with this biomass can occur at any time up to year 5. Alternatively, the firm can use the cane trash to produce briquettes. Briquette biomass is formed by the combination of carbon dioxide (CO2) and water (H2O) absorbed by plant roots in photosynthesis, which creates hydrates of carbon. After a chemical reaction, the solar energy is stored in chemical bonds of the structural components of biomass (CEPEA-USP, 2009). The briquetting process requires a humidity level between 8 and 15% and a particle size between 5 to 10mm. The biomass is shredded and compressed at high pressures, which causes the lamination of lignin, a substance that acts as a binder component. The final product of this process are shaped blocks, or compressed cylinders called briquettes, which have twice the heating energy of wood, require limited storage space and allow long term storage (Ke, Wang, Chan, & Cheung, 2009).

**Resultados e contribuições do trabalho para a área:**

We analyze the case of a sugarcane cogeneration unit that has the option to invest and defer the investment in the trash recovery, storage and adaptation of the plant to burn cane trash in order to increase the amount of surplus electric energy available for sale in the short term market. Additionally, the unit can also invest in the production of energy briquettes and has the option to choose between selling energy or briquettes in the market. The key uncertainty of the model is assumed to be the future short term energy price (PLD), and the firm has up to five years to make their initial investment decision. The problem was analyzed under the real options approach in order to value the embedded flexibilities and model the uncertainty in energy price as a geometric mean reverting diffusion processes. The option to defer the investment in cane trash recovery for cogeneration is modeled as an American type option,
and the output switch option are modeled as European call option on the project free cash flows at each period. The model is solved using the non censored binomial mean reverting lattice proposed by Bastian-Pinto, et al. (2011) using the Decision Programming Language (DPLTM) software. The results show that the flexibility to choose between energy and briquette production adds R$ 9.7 million in value, or 38% to the project value of R$ 25.6 million, which is significant, considering cogeneration is not the core business of the sugarcane mill. This indicates that recovery of cane trash, which is currently wasted in the field, can represent an important source of value and an investment option for further development of bioelectricity cogeneration or briquetting production. The use of real options approach to analyze agribusiness projects can add information value when retrofitting older sugarcane mills in Brazil, providing a powerful method for financial and economic valuation. Parameters determination, however, is a problem that affects any real option model where the uncertain variable is the Brazilian short term energy price (PLD). The sensitivity analysis for the volatility parameter indicates that the results are very sensitive to the input parameters. Also, other diffusion processes may provide different results from the ones obtained here. The sensitivity analysis for the energy spot price shows that the cane trash recovery with the option to defer the cogeneration investment, compounded with a switching option, increases the project value due to the growing bias of energy spot price. On the other hand, the sensitivity analysis for the price volatility, shows the projects value does not increase indefinitely over time as the volatility grows, which can be explained by the characteristic of the mean reversion process applied to the valuation, which limits the variance and forces the price towards the long term price equilibrium level.

Referências bibliográficas: