Title: **An Integrated Model to assess energy-environmental-economic-social trade-offs in Brazil**

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The relationship between GDP and energy consumption is not consensual (Fallahi, 2011; Lee, 2006); nevertheless, the correlation between these indicators is determinant for the energy and economic policy making process. Economic growth usually leads to an increase of energy consumption and since the current pattern of energy consumption is heavily reliant on fossil fuels, a scarce resource and an important source of Greenhouse Gas (GHG) emissions, the environment is also affected. On the other hand, energy and environmental policies may have a negative impact on economic growth and social welfare. Therefore, it is noteworthy to assess the trade-offs between economic growth, energy demand/supply, as well as environmental and social effects, in order to provide reliable tools for planners and decision makers (Oliveira and Antunes, 2004).

Social welfare and infrastructure levels have been recording a steady increase in Brazil mainly due to the current economic growth, which has also influenced energy consumption. Although Brazil has been improving energy supply and the contribution of renewable sources in the energy mix, fossil fuel production has also been raised by the exploitation of new oil extraction areas in order to satisfy this economic growth. Since fossil fuel represents a significant part of the energy consumed in the country, the impacts from GHG emissions are a drawback for the current and prospective economic growth.

Input-Output Analysis (IOA) has been traditionally used to study the inter/intra-relationships among different sectors in the economic system, describing the correlation between the inputs used and the outputs produced (Leontief, 1985; Miller and Blair, 1985). The IO models have also been modified to account for environmental impacts (see Cumberland, 1966; Mäenpää and Siikavirta, 2007), as well as for the explicit analysis of the energy sector (Wright, 1974; Liu et al., 2010). In addition, conventional IO models have also been widely applied to analyze the E3 (energy-environmental-economic) interactions (Proops et al., 1993; Lenzen, 1998), utilizing also Hybrid IO models (Miller and Blair, 1985; Chung et al., 2009). Some of them have been applied to assess the Brazilian economic system (Hilgemberg and Guilhoto, 2006; Figueiredo et al., 2009).

There are several studies in the scientific literature that use linear programming (LP) models coupled with the IO framework (Muller, 1979; Hristu-Varsakelis et al., 2010). However, the complexity of real world problems is fully captured and models become more realistic if multiple, conflicting and incommensurable axes of evaluation of different potential policies are explicitly considered, which enables to exploit the trade-offs between those competing objectives. In this context, Multi objective linear programming (MOLP) models coupled with the IO framework have been developed for different purposes (Cho, 1999; Chen, 2001; Oliveira and Antunes, 2004, 2011, 2012).

Since, in general, energy, economic, environmental and social concerns have conflicting interactions, a broad scrutiny of these evaluation aspects and a thorough appraisal of the trade-offs at stake are required to assess the merits of adopting distinct policies associated with different efficient solutions to the MOLP model. In this sense we have developed a hybrid IO MOLP model applied to the Brazilian economic system. This model utilizes the System of National Accounts (SNA) and the National Energy Balance to create a hybrid IO framework that is extended to assess Greenhouse Gas (GHG) emissions. This framework is used as basis to develop the MOLP model with the aim is to assess the trade-offs associated with the maximization of GDP and employment levels and the minimization of the total energy consumption for energy purpose and GHG emissions, considering the time frame of 2017.

Therefore, the Syllf Research Abroad in Brazil was important to gather some data (which are not available in the internet) to be used in my model, to establish many valuable contacts with professors and students, as well as to participate in some training courses[1] and Conferences[2]. In addition, the excellent feedbacks from my host tutors Professor Joaquim Guilhotto (University of São Paulo) and Professor Marcelo Cunha (State University of Campinas), specialists in Input Output Analysis, will contribute significantly to improve my PhD thesis. For this reason, I would like to thank the Tokyo Foundation, the Nippon Foundation and The Ryoichi Sasakawa Young Leaders Fellowship Fund for the Sylff Research Abroad award that supported and funded this

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[2] Simpósio sobre inovações tecnológicas aplicadas a cadeia sucroenergética, III Congresso Brasileiro em Gestão do Ciclo de Vida de Produtos e Serviços, Simpósio Brasileiro de Pesquisa Operacional and Congreso Latino-Iberoamericano de Investigación Operativa.

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