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Energy policy and regional inequalities in the Brazilian economy

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ABSTRACT

The objective of this paper is to evaluate the long-run regional impacts of the tariff policy of the Brazilian electric power sector. This sector has undergone a reform process that started in the 1990s. Since the beginning of the reform, two spatial trends of distribution of electric power tariffs have emerged among the Brazilian states, one of convergence and another of spatial divergence. These trends have been guided by the new electric power tariff policy and by the spatial features of the Brazilian economy, which is marked by a high degree of spatial concentration and hierarchical distribution of large markets. In addition, because of the presence of strong economies of scale, the recent electric power prices differentials might be caused by differentials in market size that provide better conditions for the achievement of economies of scale for electric power utility companies located in larger markets. Given the role of electric power as an important intermediate input in the production process and the interdependence between sectors, an Energy Interregional Computable General Equilibrium model was used to simulate the long-run regional impacts of electric power tariff policy in Brazil. The simulations showed that the heterogeneity of energy-intensity and the differentials of energy substitution drive the spatial impacts of changes in electric power prices. On the other hand, the recent trend of spatial dispersion of electric power prices might contribute to a decrease in the long-run economic growth and to an increase in the regional inequalities in Brazil.

1. Introduction

Since the 1990s, the energy sector in Brazil has been the subject of a variety of reform initiatives that are changing the market structure and the energy price levels. These reforms were triggered by the implementation of *Plano Real* and new liberal policies in the Brazilian economy. In this context, energy policy has stimulated energy diversification to increase the inter-fuel substitution. This policy might have changed the sectoral and regional consumption pattern of energy in the country towards sectors and regions that are more or less energy-intensive. In the electric power sector, these reforms led to a new industrial organization and a new tariff policy implemented through a price-cap regime by the Brazilian Electric Power Regulatory Agency (*ANEEL*). During the implementation of the reforms and the tariff policy, the spatial evolution of tariffs presented a trend of spatial convergence. However, after the consolidation of the tariff policy, the spatial evolution of tariffs has shown that the richest regions are experiencing lower tariffs than the poorest regions. This outcome has raised some issues about the impacts this tariff policy may have had on regional inequalities.

The Brazilian economy is marked by a high degree of heterogeneity in industrial composition on the one hand and spatial concentration on the other (Azzoni, 2001; Haddad, 1999). After several decades of government policies designed to decrease this concentration, the effectiveness of these policies has been modest. Table 1 shows that in 2004[2] the Southeast region, the richest, concentrated 55.4% of the Brazilian GDP, while the North, the poorest, only 5.0%. On the other hand, the poorest regions had the highest electric-power-intensity. The analysis of the impacts of changes in the electric power prices faced by differentials of demand, income level and energy substitution provide important elements to the evaluation of the impacts of energy policies in Brazil.

According to the literature, energy-intensive sectors are the main channel through which energy price shocks affect the economy. These sectors and energy sectors themselves were in the core of the development policies of the country in the 1970s. As a consequence, the growth of these sectors strengthened the sectoral and spatial links in the Brazilian economy. In addition, the spatial concentration

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[2] The year of the interregional input–output table developed to calibrate the CGE model used in the simulations.

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Table 1
Economic concentration and electric-power-intensity in Brazil, 2004.
Source: Brazilian Institute of Geography and Statistics and Brazilian Electric Power Agency.

Regions	GDP	Electric power consumption	Electric-power-intensity*
North	5.0%	6.6%	0.168
Northeast	12.9%	16.9%	0.165
Center-West	9.1%	5.4%	0.075
South-East	55.4%	53.5%	0.111
South	17.6%	17.6%	0.127
Brazil	100.0%	100.0%	0.126

*(GWh/10^6 GDP in R$ of 2004).[11]
[11] GWh is abbreviation of Gigawatts/hour.

of energy-intensive sectors followed the same pattern of the spatial concentration of the whole economy. In 2004, 82.6% of the value-added of the energy-intensive sectors was concentrated in the Center-South region of Brazil. However, electric power consumption of these sectors amounted to 70.6% in the same region. This 10% difference can be attributed to a set of regional factors such as energy diversification, product differentiation that increases value-added, economies of scale and more efficient energy uses. As result, there is pronounced spatial heterogeneity of the electric-power-intensity in the energy-intensive sectors and in the economy as a whole (Santos et al., 2009). For this reason, energy price changes may result in differential regional impacts.

Considering the sectoral and spatial input–output linkages and factor mobility, the main focus of this paper is to explore the regional impacts of the tariff policy of the electric power sector on the Brazilian economy. To answer these questions three important elements must be considered. First, electric power price differentials in Brazil might be emerging from the relative differences among market sizes. Secondly, the regional impacts of price differentials might have been strengthened by economies of scale in the larger markets. Thirdly, the heterogeneity of energy supply in Brazil might determine an unequal pattern of energy substitution among regions. To incorporate all these elements in the analysis, an Inter-regional Computable General Equilibrium Model (ICGE), ENERGY-BR, will be calibrated and used to simulate the regional impacts.

In addition to this introduction, the paper has seven other sections. Section 2 presents the tariff policy and the spatial distribution pattern of electric power tariffs in Brazil. Section 3 describes the main findings of past studies about energy in the regional science field and some New Economic Geography elements (NEG) that combine vertical linkages and capital mobility to explain agglomeration economies. Section 4 describes the structure of the ICGE model that will be used to simulate the results while Section 5 reports the data set and key parameters used to calibrate the ENERGY-BR model. Section 6 accounts for the simulation strategy and basic experiments, with the results presented in the following section. Finally, Section 8 provides some summary commentary.

2. Spatial distribution of electric power tariffs in Brazil

The Brazilian electric power system is a large-scale hydrothermal system, where the high voltage networks interconnect transmission systems and generation plants to form the National Interconnected System (NIS). The NIS is a national grid composed of four interconnected subsystems. It optimizes the operation of public and private generation and transmission companies in the whole country and is responsible for 96.6% of the electric power supplied in Brazil. The remaining 4.0% is supplied through the small isolated systems located in the Amazonian region.

In 2007, the electric power sector system produced 444.5 TWh[3] of electric power. Hydroelectric with 84.1% and gas-fired thermoelectric generation with 3.5% were the two main sources of electric power. From this amount, 89.4% was produced by public services electric power companies and 10.6 by independent and self-producers. The distribution to final consumers is performed by 64 private electric power utilities companies operating under a public services concession regime together with 34 rural electrification companies.

The sector is still adjusting to a set of reforms that began in 1993. These reforms were introduced to stimulate private investments after a long period of finance imbalances in the sector. As a first step, in 1993, the rules for the private agents to supply public services were defined under the auspices of the well known Concession Law.[4] Subsequently, in 1995, the privatization of the state-owned electric power utility companies began. A year later, the *ANEEL* was created; this is an independent regulatory agency responsible for enforcement rules, tariff policy and consumers' rights regarding the electric power sector. The same law that created the ANEEL also created a new industrial organization for the sector through the segmentation of the vertically integrated public monopolies to distinguish generation, transmission, distribution and trader companies (Landi, 2006). In order to address the economic balance of the profit motive of the companies on the one hand and the need to provide moderate tariffs to final consumers on the other hand, the ANEEL introduced an incentive regulation program through the adoption of a price-cap[5] regime.

The price-cap regime simulates elements of a competitive market. An upper bound tariff to be charged by distribution companies is settled in the privatization contracts, based on the initial finance balance of the companies. This tariff is supposed to be adjusted yearly using a national price index minus a productivity index (*X-Factor*). In addition, a tariff review process is accomplished every 4 years to redefine the productivity index in a way to transfer productivity gains from distribution companies to final consumers. The higher the productivity, the higher is the *X-Factor* and lower is the yearly tariff adjustment. In the period before and after the tariff review process, electric power utility companies have incentives to become more productive, because they might internalize the productivity gains and increase their returns.

The main element of new tariff policy is the redefinition of the *X-Factor* by the regulatory agency during the tariff review process. The ANEEL carried out two review processes; the first in the 2003/2004 and the second in 2007/2008. Before 2003, the *X-Factor* was set to zero. To revise the *X-Factor*, usually the regulator grounds this variable in the studies concerning Total Factor Productivity (TFP) and efficiency of electric power companies. In a recent econometric study, Ramos-Real et al. (2009) showed that only after 2004 did electric power distributors start to present satisfactory productivity indexes and positive rates of return. The same study also shows that companies with a smaller rate of electric power supply by kilometer (kWh/km) of distribution networks tend to present weak performance compared to those with a larger rate. In addition, Tovar et al. (2009) also showed that the size of the companies is an important element to determine the evolution of productivity. In summary, there might be evidence that market and company sizes determine the tariff gap among the Brazilian regions, triggered by the transference of productivity gains to final consumers.

Fig. 1 shows evolution of electric power real average tariff in Brazil. From 1995 to 2008, the tariff increased by 360.6%. It was at R$ 57.12/kWh in 1995 and increased to R$ 263.22/kWh in 2008. In the same period, the inflation rate increased 184.6%. The tariff increases above the inflation rate affects the rate of return for the electric power sector and thus should stimulate new private investments in

[3] Tigawatts/hour.
[4] Law no. 8.987/1995
[5] See Littlechild (1983).