SUMMARY

CLIMATE POLICY INITIATIVE
NÚCLEO DE AVALIAÇÃO
DE POLÍTICAS CLIMÁTICAS
PUC-Rio

CHALLENGES AND OPPORTUNITIES OF ENERGY EFFICIENCY: A LOOK AT BRAZILIAN INDUSTRY

OVERVIEW

Brazil has not had the same success as nations around the world in promoting energy efficiency (EE). As presented by the American Council for an Energy-Efficient Economy, Brazil ranked 20th among 25 of the world's top energy-consuming countries in the Council's analysis that examines efficiency policies and performance.[1] Brazil has a tremendous opportunity to encourage economic growth and to reduce greenhouse gas emissions from investment in EE. To date, however, the country has barely pursued this tool for achieving sustainable growth, especially in industry, and little is known about the relationship between energy efficiency and productive efficiency (the value added by a worker).

This brief introduces an analysis of energy efficiency and productivity in Brazilian industry. Climate Policy Initiative (CPI/PUC-Rio) researchers show that, energy efficiency and productive efficiency in the Brazilian industry are related. Because of that, challenges in promoting energy efficiency align with broader issues regarding sectoral productivity.

The analysis uses a series of economic exercises to determine how energy efficiency relates to productivity in Brazilian industrial firms and assesses its effects on aggregate product. It develops indicators to assess efficiency in the use of inputs and the potential for productivity gains. Annual data at the level of the industrial firm are used, covering 106 sectors of extractive and processing industries from 2003 through 2015.

CPI researchers conclude that the energy efficiency and the productive efficiency of industrial sectors are stable during the study period. To shed further light onto this, efficiency measures are separated into two factors: **the efficiency of the typical firm,** which characterizes efficiency in the use of resources within the firm; and **the Allocation Quality Indicator (AQI),** which measures efficiency of resource allocation among firms in the same sector.

For the first indicator, the results show that energy and productive efficiencies of the typical firm tend to grow during the study period, suggesting an improvement in the use of resources within firms. Nevertheless, for the second

1 American Council for an Energy-Efficient Economy (ACEEE). 2018. The 2018 International Energy Efficiency Scorecard. See: http://aceee.org/research-report/i1801

MAIN RESULTS

- Brazil's efforts targeted at promoting energy efficiency have occurred in response to specific episodes of energy shortages and focused on residential consumption.
- There is a relationship between energy and productive efficiencies in the Brazilian industry.
- Energy efficiency and productive efficiency of industrial sectors were stable from 2003 through 2015. This is because the economic environment favors greater efficiency in the use of resources within the firm, but it reduces the market share of the most efficient firms.
- Resource reallocation (capital, labor, and electricity) across firms generates gains in total factor productivity of 81% in 2015; improvements in capital allocation generated higher productivity gains than improvements in energy efficiency.

indicator, there was an increase in market share of less efficient firms from both energy and productive perspectives (reduction in AQIs). **Thus, although the economic environment favors greater efficiency of typical firms, it reduces the market share of the most efficient firms.**

The analysis also evaluates alternative scenarios for improving resource allocation and their impact on productivity. Resource reallocation (capital, labor, and electricity) across firms in the same sector generates gains in total factor productivity of 81% in 2015. The researchers show that better capital allocation generates higher productivity gains than improvements in energy efficiency.

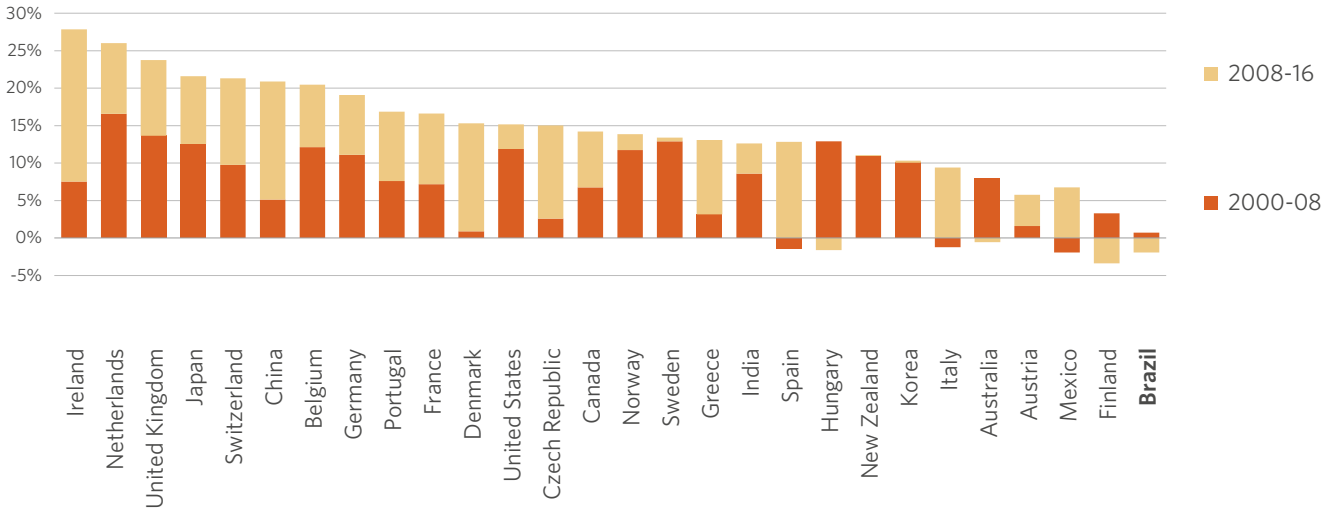
Hence, Brazil must stimulate sectors to move the EE agenda forward, by making gains in energy efficiency. In this sense, Brazilian industry can move closer to long-term sustainability, bringing private and broader social benefits to the nation.

BACKGROUND

Brazil needs to make significant gains in its energy efficiency to advance toward improving the long-term sustainability of its industries and to achieve its Nationally Determined Contribution under the Paris Agreement. Figure 1 shows how the effect of energy efficiency improvements have varied for different countries during two time periods: 2000-2008 and 2008-2016. The figure indicates that Brazil does not follow the same pattern as other countries, exhibiting worse outcomes during the 2008-16 period as compared to 2000-08.

One of the reasons for this poor showing by Brazil is that Brazil's policies and actions to promote EE were not guided by well-structured, long-term planning. Rather, they were implemented as a response to specific episodes when the country had difficulty meeting its energy demand.

Figure 1: Effect of Energy Efficiency Improvements for Selected Countries



Source: *Adapted from International Energy Agency (IEA). 2017. Market Report Series: Energy Efficiency 2017.*

Figure 2 presents key public policies regarding EE in Brazil. Energy efficiency became a relevant theme in public policy with the 1970s international oil shocks and the 1980s external debt crisis. The programs PBE, PROCEL, and CONPET were created during this period. PBE disseminates information about energy efficiency by means of equipment labels, while PROCEL and CONPET aim to promote the rational use of energy resources in the country. These programs focus on the residential sector.

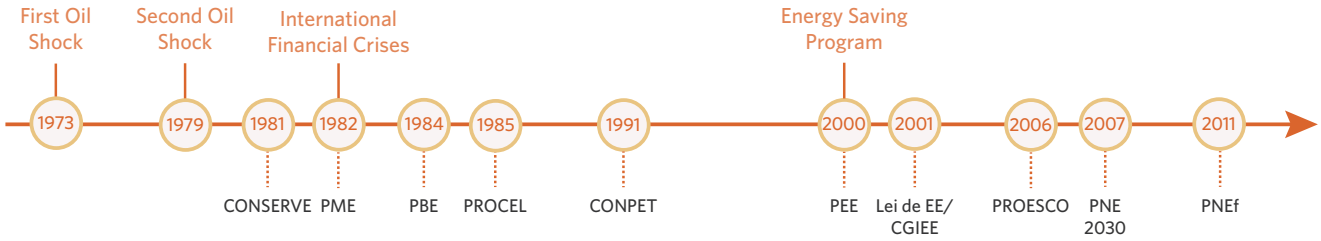
In 2001, due to the electricity rationing, Brazil passed an EE law to establish minimum energy efficiency standards. Over time, EE gradually gained greater attention in governmental energy planning, culminating in the elaboration of the National Energy Efficiency Plan (PNEf) in 2011. However, the PNEf did not translate into further EE actions and policies. One of the obstacles to the implementation of the PNEf guidelines is that the planning and implementation of related EE actions must be distributed across more than a dozen institutions.

Although many programs and actions (EE law and labelling programs) have shown good results, Brazil has not yet been able to implement effective measures to promote the rational use of energy. Moreover, the EE initiatives focus mainly on making improvements in residential consumption, mostly ignoring the industrial sector. Yet, the industrial sector is the largest energy consumer and accounts for 33% of total national consumption. About 80% of industrial firms use electric power as their main source of energy.[2,3]

2 Empresa de Pesquisa Energética (EPE). 2017. Balanco Energético Nacional 2017: Ano base 2016

3 Confederação Nacional da Industria (CNI). 2013. Sondagem Especial - Industria de Transformação e Extrativa, Ano 3, nº1

Figure 2: Timeline of Key Energy Efficiency Policies and Programs in Brazil



Acronyms

CONPET – National Program of Rationalized Use of Oil By-Products and Natural Gas

CONSERVE – CONSERVE Program

EE Act/CGIEE – Energy Efficiency Act/ Management Committee for Indicators and Energy Efficiency Levels

PBE - Brazil's Labelling Program

PEE - Brazil's Energy Efficiency Programs

PME – Energy Mobilization Program

PNE 2030 - National Energy Plan

PNEf - Energy Efficiency National Plan

PROCEL - Electric Power Preservation National Program

PROESCO - PROESCO/BNDES Energy Efficiency

Source: *Climate Policy Initiative*

As such, policies and efforts aimed at improving efficiency of electricity use in the Brazilian industry have great potential to stimulate economic growth, yield environmental gains, and improve firms' competitiveness. And Brazil should take advantage of the current scenario, which offers an opportunity for recovery following a strong economic recession, to push energy efficiency further up the policy agenda.

ENERGY EFFICIENCY CHALLENGES IN BRAZILIAN INDUSTRY

The researchers conducted an economic analysis aimed at understanding how the efficiency of energy allocation relates to the productivity of firms in the Brazilian industry and its effects on the aggregate product. The methodology follows a branch of recent economic studies that characterize how the efficient allocation of resources affects productivity.

This assessment develops indicators to evaluate efficiency in resource utilization and the potential for productivity gains. The quantitative analysis uses firm-level data covering 106 sectors of extractive and processing industries from 2003 through 2015. Key data are taken from the Annual Survey of Industry (PIA) (*Pesquisa Industrial Anual* - PIA), and the final database is composed of about 30,000 firms per year.

Researchers evaluate two measures of efficiency:

1. Energy efficiency – added value as a share of electricity spending;

2. Productive efficiency – value added by worker.

Results indicate that energy efficiency and productive efficiency in the Brazilian industry are related. This implies that the challenges of promoting efficiency in Brazil align with broader issues regarding sector productivity. In addition, both energy efficiency and productive efficiency do not vary much over time.

In light of this result, researchers split efficiency measures into two components to advance their analysis:

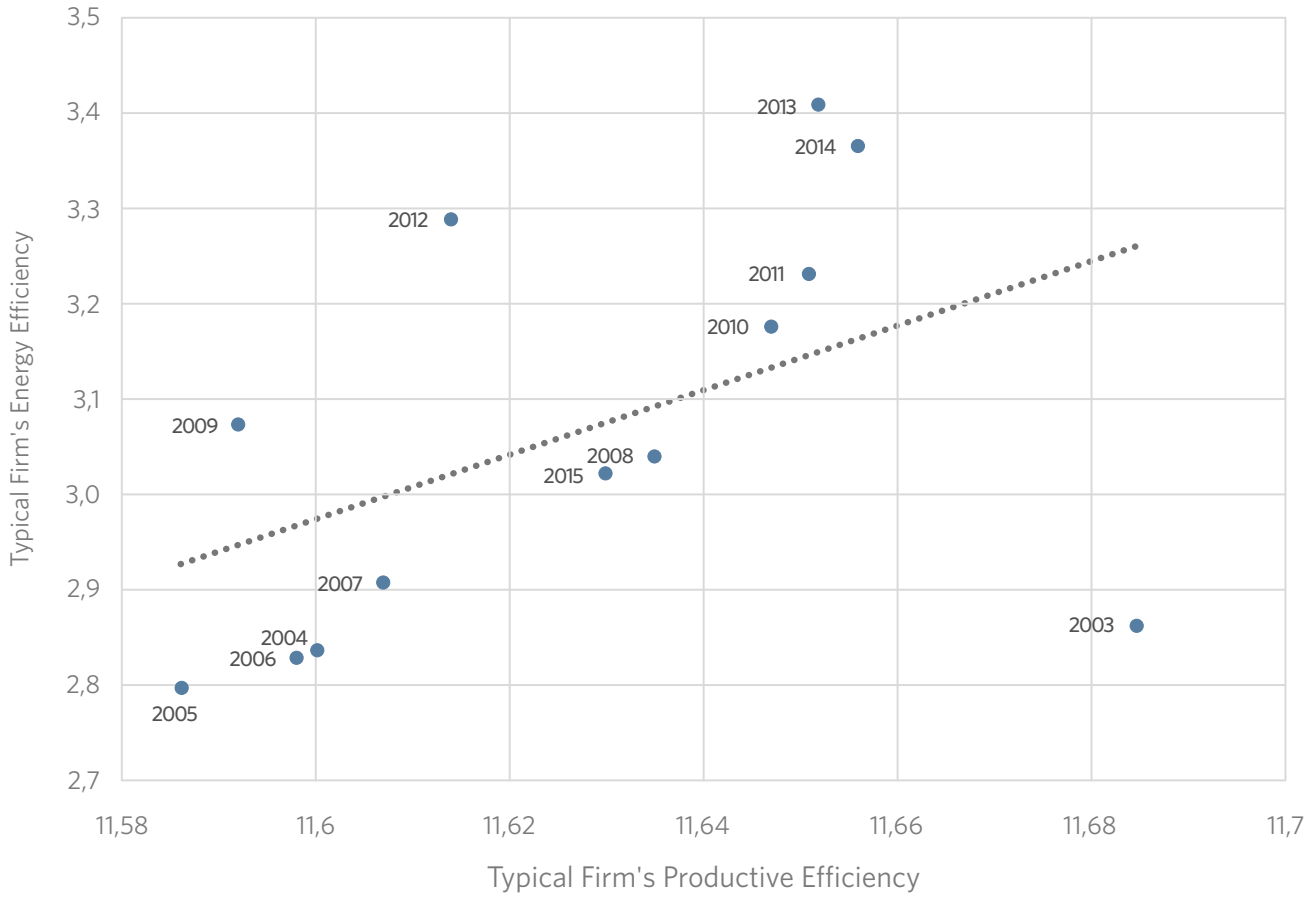
1. Efficiency of a typical firm - characterizes the efficiency in the use of resources within the firm;

2. Allocation Quality Indicator (AQI) - measures the efficiency of resource allocation among firms in the same sector capturing if more efficient firms also have more market share.

Looking at each of these components, the analysis evaluates different aspects of resource allocation efficiency. For example, changes in the conditions of the economic environment (technology, financing, institutions, public policy) can promote greater efficiency via improvement in resource use within the firms (efficiency of the typical firm) or via higher market share of the most efficient firms (AQI).

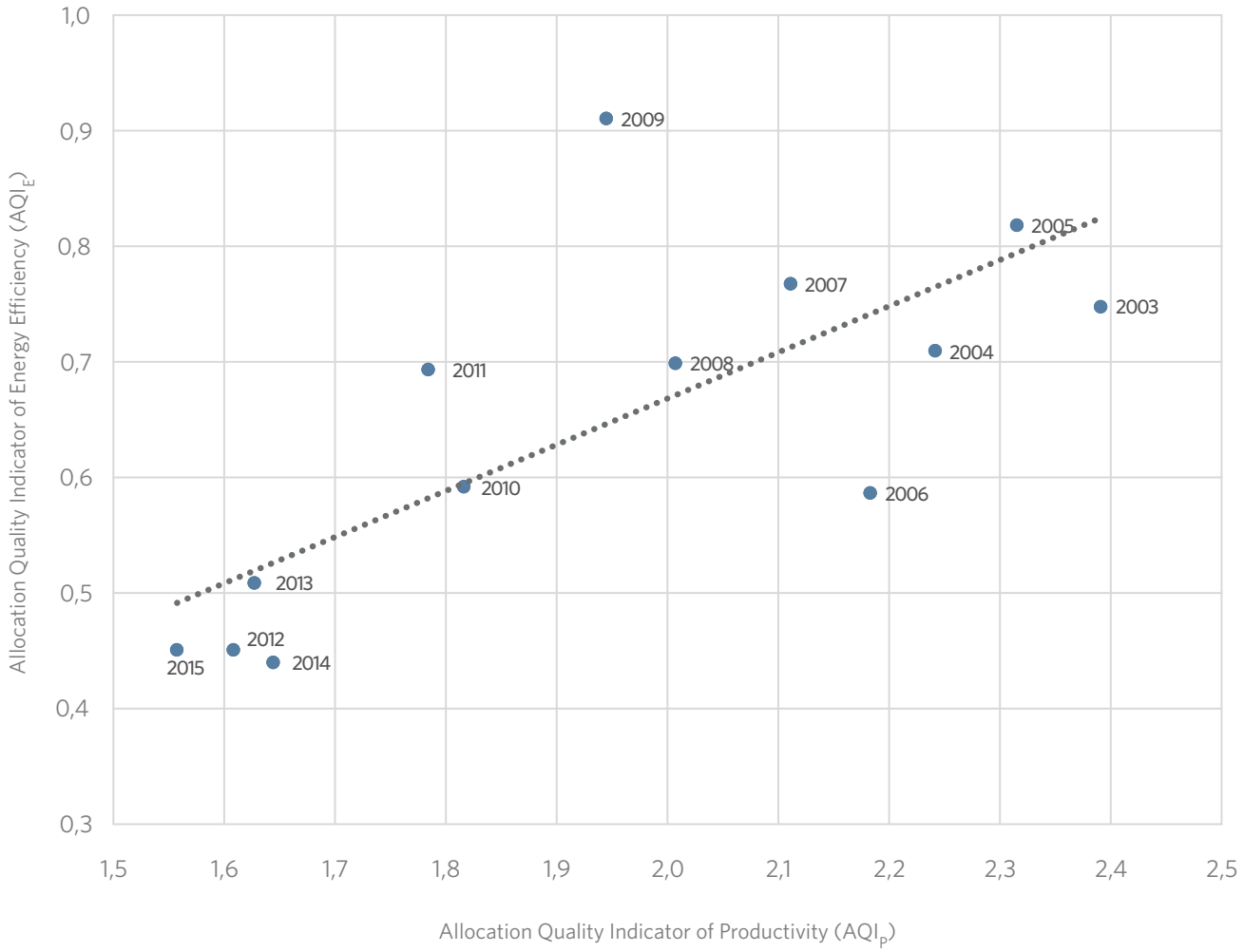
The typical firm's energy and productive efficiencies tend to grow over time, which may be associated with more favorable conditions in the economic environment. Figure 3 shows the positive relationship between the typical firm's energy and productive efficiencies for the aggregate economy, as well as their increase between 2004 and 2014. Nevertheless, Figure 4 indicates that there was an increase in the market share of less efficient firms from both energetic and productive perspectives (fall in AQIs). Thus, although the economic environment is associated with greater efficiency of the typical firms, it reduces the market share of the most efficient firms.

Figure 3: Energy and Productive Efficiencies of a Typical Firm (2001-2015)



Source: *Climate Policy Initiative with data from the Annual Survey of Industry (PIA)*

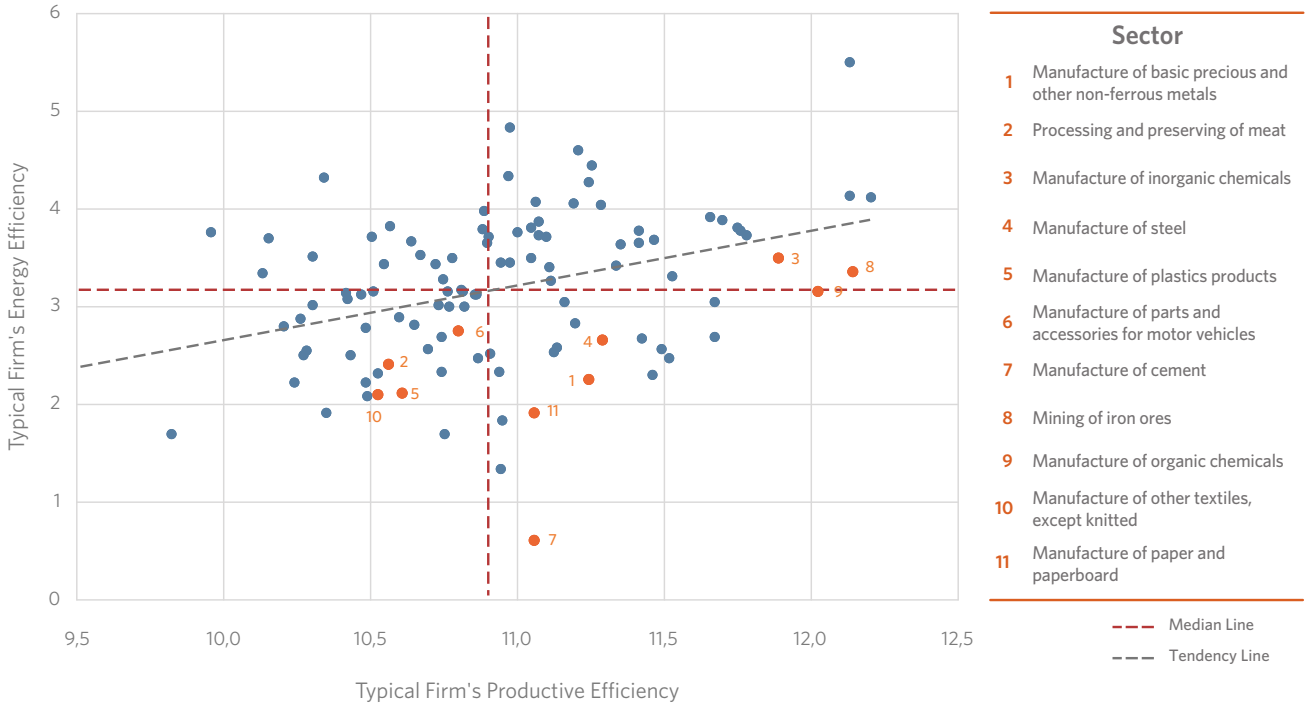
Figure 4: Allocation Quality Indicator (AQIs) of Energy Efficiency and Productivity (2003-2015)



Source: *Climate Policy Initiative with data from the Annual Survey of Industry (PIA)*

In some sectors, although the typical firm is more productive than the median industry, it does not consume electricity as efficiently as others. Figure 5 shows the relationship between energy and productive efficiencies of the typical firm as compared to median values in 2015 for the 106 sectors analyzed. It highlights the 11 sectors with greater electricity expenditure, as measured by electricity expenditure of at least 50% of total energy expenditure. Although the measures are positively related, some sectors exhibit low levels of energy efficiency as compared to productivity – examples include manufacture of cement, manufacture of basic precious and other non-ferrous metals, manufacture of steel, and manufacture of paper and paperboard.

Figure 5: Relation between Energy and Productive Efficiencies of the Typical Firm in 2015



Source: *Climate Policy Initiative with data from the Annual Survey of Industry (PIA)*

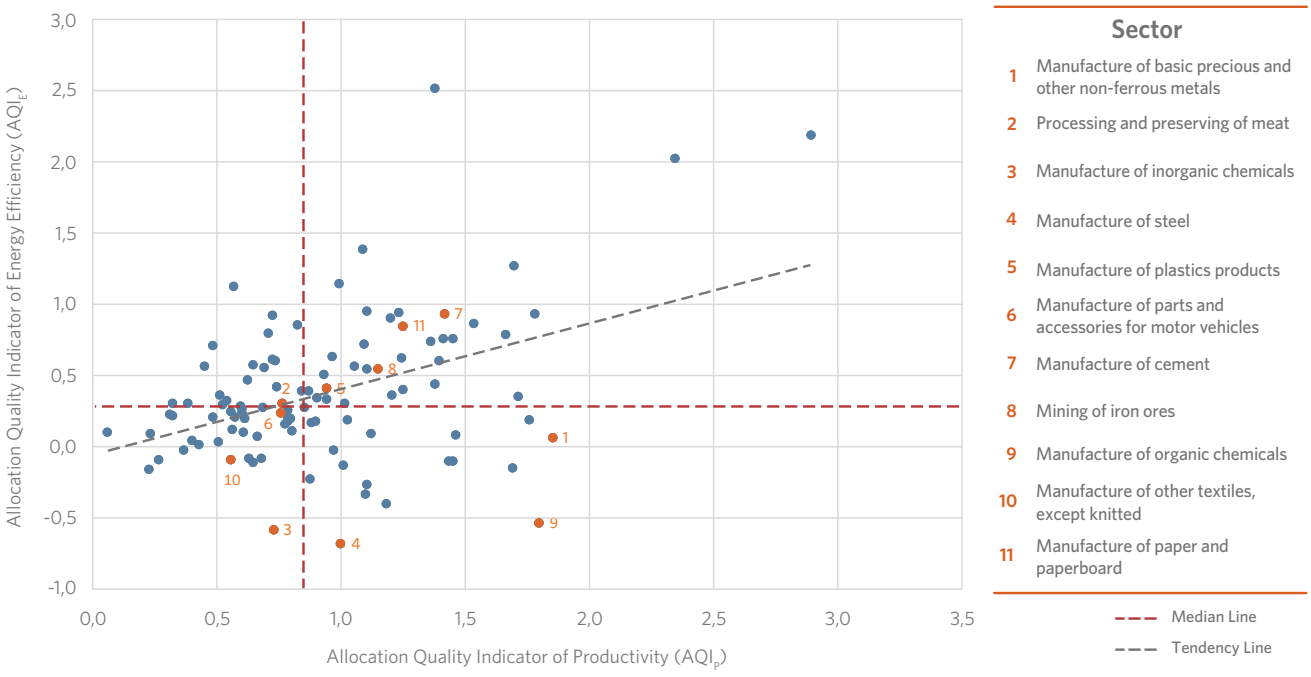
Similarly, Figure 6 shows the relationship between the Allocation Quality Indicator for Energy Efficiency (AQI_E) and Allocation Quality Indicator for Productivity (AQI_P) in 2015, alongside their median values. Sectors exhibiting a low ratio of AQI_E to AQI_P include manufacture of basic precious and other non-ferrous metals, manufacture of steel, and manufacturing of organic chemicals.

Some sectors exhibit high values for both for their AQI_E and AQI_P, above the medians. Examples include manufacture of cement, manufacture of paper and paperboard, mining of iron ores, and manufacture of plastics products. In these sectors, firms that are more efficient in the use of electricity and more productive have greater market participation. In contrast, manufacture of inorganic chemicals, manufacture of other textiles except knitted, and manufacture of parts and accessories for motor vehicles energy efficient and productive firms have lower market shares.

In light of the positive relationship between productive efficiency and energy efficiency in industrial sectors, the analysis explores how total factor productivity would react to a reallocation of resources from less to more efficient firms. Reallocating productive inputs (capital, labor, and electricity) between firms generates gains in Brazilian total factor productivity of 81% in 2015.

Although poor electricity allocation has been shown to be positively related to poor resource allocation, capital distortions prove to be even more relevant in explaining the potential gains from reallocation. Researchers find that the reallocation of resources correcting for distortions on electricity yields

Figure 6: Relationship between the Allocation Quality Indicator for Energy Efficiency (AQI_E) and Productivity (AQI_P) in 2015



Source: *Climate Policy Initiative with data from Annual Survey of Industry (PIA)*

a potential gain of 15%, whereas the gain is estimated to be 76% correcting distortions in capital (Table 1).

Overall, results indicate that the poor allocation of capital in the Brazilian industry is the main factor behind low total factor productivity. As such, Brazil must stimulate sectors to move the EE agenda forward, and thereby collect both its private and its broader social benefits.

Table 1: Potential Productivity Gains in 2015 with Different Scenarios

Scenarios	Gains
Correcting for all distortions	81%
Correcting for distortions in electricity	15%
Correcting for distortions in capital	76%

Source: *Climate Policy Initiative with data from Annual Survey of Industry (PIA), 2015*

Conclusion

CPI's institutional analysis about energy efficiency (EE) shows that policies and actions to promote EE in Brazil were implemented in response to specific episodes of difficulty in meeting the demand for energy. Moreover, they largely focused on residential consumption. Yet, it is the industrial sector that most consumes energy, mainly from electricity. Policies and actions that promote electrical efficiency in industrial sectors therefore offer great potential to stimulate economic growth, yield environmental gains, and improve firms' competitiveness.

In light of this, it is crucial to seek greater understanding about how the efficiency of energy allocation related to firm productivity and its effects on the aggregate product. This study emphasizes that energy and productive efficiencies in the Brazilian industry are related and have exhibited stable trends over the past few years. This is because the economic environment favors greater efficiency of typical firms but reduces the market share of the most efficient firms. Moreover, the reallocation of production inputs between firms can generate productivity gains.

Distortions such as lack of information, market frictions, and institutional barriers seem to hinder effective improvement in the rational use of electricity in the Brazilian industry. Additional research efforts are needed to understand the role played by each determinant. In-depth sector-specific studies could also shed light on the topic, as could an evaluation of the effectiveness of existing public policies in mitigating these distortions. Thus, it will be possible to enhance the EE efforts, improving firms' productivity and reducing environmental damages.

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