Can Natural Resources Promote Industrialization? Firms, Competition, and Spillovers from an Industrial Policy

1 Introduction

Industrial policy is an intensely debated topic in economics. Critics point to numerous instances of failure in governments picking winners or protecting domestic industries (e.g., Krueger (1990)). Proponents highlight success stories of government intervention in countries such as South Korea and China (Cherif and Hasanov, 2019). In practice, industrial policies are widely used across developed and developing countries, but empirical evidence on their impact is thin (Lane, 2020). Getting these policies right could have large implications for economic growth and poverty reduction.

One important mechanism underlying successful industrial policy may be competition. Aghion et al. (2015) find that policies fostering sectoral competition increase firm productivity growth in China. Competition may induce productivity growth directly (e.g., by increasing managerial effort, innovation, or investment), or indirectly by reallocating market share to more productive firms (Backus, 2020). Another oft-discussed feature of industrial policies is their capacity to generate spillovers, either in space (Cerqua and Pellegrini, 2017) or along supply chains (Du et al., 2014). Lane (2021) documents that South Korea's active promotion of heavy industry in the 1970s generated positive effects on downstream sectors and negative effects on upstream sectors.

Interest in industrial policies is especially acute in countries dependent on natural resources, where diversification away from agriculture and resource extraction is a policy priority (Signé, 2018). Natural resources introduce development challenges, including volatility, rent-seeking, and Dutch Disease (van der Ploeg and Poelhekke, 2009; Mehlum et al., 2006). On the other hand, resource sectors can generate upstream demand for inputs and stimulate downstream processing (Allcott and Keniston, 2018; Smith, 2016). Countries ranging from Indonesia to Norway have introduced resource-based industrial policies to internalize value-addition along commodity chains and develop upstream and downstream industries (Guadagno, 2015). A better understanding of resource-based industrial policies may help governments leverage resources for development and avoid the resource curse (Venables, 2016). This, in turn, could improve the economic wellbeing of the nearly 3.4 billion people living in 72 countries identified as "resource-dependent" by the United Nations (Roe and Dodd, 2016).

One widely used industrial policy is a local content requirement (LCR), which mandates that firms (often multinationals) in a specific sector source a proportion of their inputs from domestic suppliers. The goal of such policies is to provide infant industry protection and stimulus to local firms, allowing learning-by-doing and scale economies. But LCRs are not costless. These policies reduce competitive pressures for beneficiaries, potentially enabling rent-seeking and higher markups.

I analyze the firm-level impacts of a local content requirement imposed on the oil sector in Brazil. Brazil is a resource-rich country with a history of active industrial policies and, more recently, deindustrialization (De Paula, 2016; McMillan et al., 2014). Brazil's LCR for the oil sector was created in 1997 but strengthened significantly in 2003 by requiring oil companies to source a fixed percentage of inputs from Brazilian firms. In 2005 the LCR was further strengthened by shifting from "global percentages," under which oil companies had to achieve a minimum local content share but had discretion in how they satisfied this share over their procurement portfolio, to "item percentages," under which oil companies had to satisfy minimum local content shares in each of 16 categories of goods and services (Rocha, 2018). The LCR may have stimulated firm growth and entry in targeted sectors, but may also have protected inefficient firms. Oil companies complained that the Brazilian LCR raised costs and resulted in long wait times for key inputs; it was relaxed after 2015 (Bispo and Giserman, 2020).

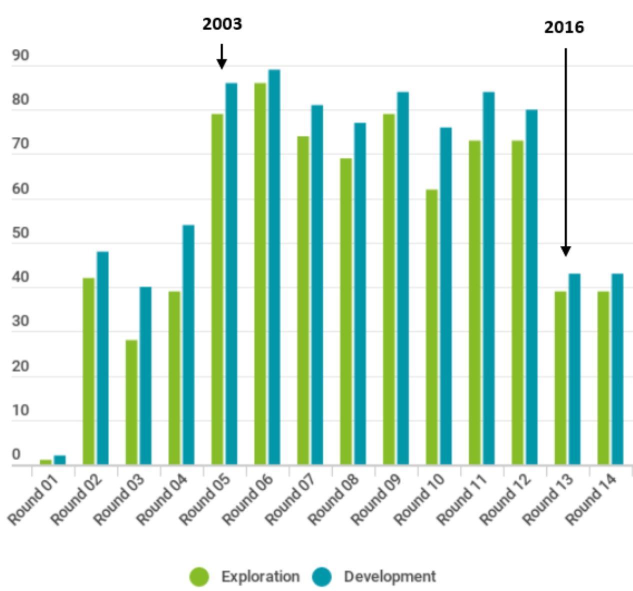
I propose innovative uses of Brazil's rich administrative datasets to explore the mechanics of industrial policy along three dimensions. First, how did growth and performance in upstream oil-input supplying firms that benefited from the LCR program evolve relative to comparable firms that did not? Second, within the pool of beneficiary firms, how did performance vary across subsectors with differing levels of initial market concentration? By excluding international competition, item-specific local content percentages guaranteed domestic market share for some subsectors that were competitive within Brazil, and others in which production was highly concentrated. Did firm performance improve less in subsectors with less domestic competition? Third, did firms benefiting from Brazil's LCR generate spatial or supply-chain spillovers onto neighboring firms? The possibility of agglomeration externalities such as knowledge diffusion is a major motivation for LCRs, but the possibility of crowding out is also real. By exploiting Brazil's Input-Output Matrices and data on the geolocation of manufacturing firms, I will assess whether linkages to beneficiary firms affect non-beneficiary firm outcomes.

My findings will contribute to economists' understanding of the relationship between competition and firm productivity, the nature of agglomeration externalities and spillovers, and the role of natural resources in fostering or hindering industrialization. Findings will also provide quantitative evidence on the efficacy and welfare implications of local content requirements, potentially improving the design of industrial policies around the world.

2 Context and Literature Review

Brazil's LCR for oil companies began with deregulation of the sector in 1997, but obligatory minimum percentages were only set by the National Oil Agency (ANP in Portuguese) in 2003. Oil companies participating in auctions for rights to offshore fields included local content commitments as part of their bids. As shown in **Figure 1**, this 2003 rule change resulted in a significant increase in the local content percentage committed to by oil companies in winning bids. In turn, higher local content commitments translated into increased demand for domestic upstream input suppliers (e.g. producers of ships, pipes, generators, drilling equipment, etc.). In 2005, government regulators strengthened the policy further by imposing item-specific local content requirements, which were intended to force oil companies to source sophisticated inputs locally (Rocha, 2018).

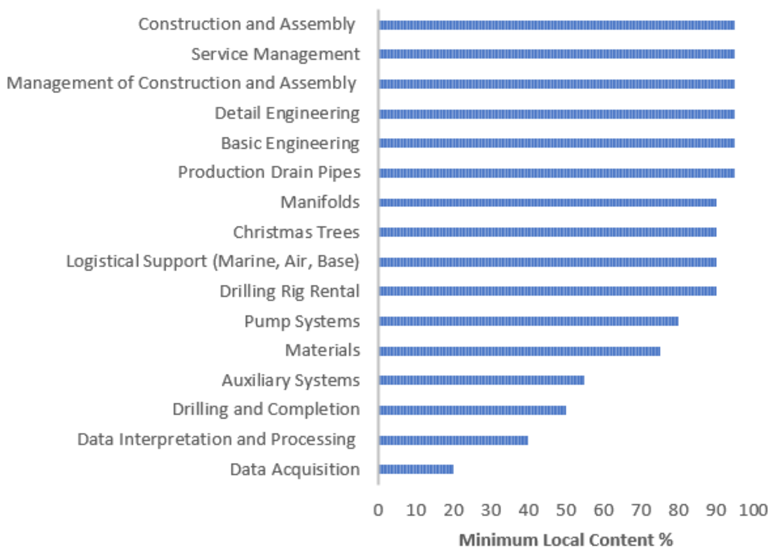
Figure 1: Local content commitments by oil companies (1999-2017)



Source: ANP (2020)

Item-specific requirements imposed in 2005 restricted oil companies' ability to allocate procurement between domestic and foreign suppliers in accordance with the feasibility and costs of production in Brazil. While some sectors, such as construction, contained numerous competitive firms within Brazil, other sectors, such as generator manufacturing, were highly concentrated and often dominated by local branches of multinational firms (Clavijo Vitto, 2016). **Figure 2** reports minimum local content requirements defined for each subsector in 2005. The 2005 requirement thus introduced subsector-level variation in competition. Whether or not the LCR was successful in promoting domestic firm growth and upgrading, oil companies complained that Brazilian input suppliers were slow, higher cost, and lower quality than international options. Consequently, the local content requirement was relaxed after 2015, resulting in the sharp decrease in local content commitments observed after 2015 in Figure 1.

Figure 2: Minimum local content percentages for subsectors (defined in 2005)



Source: Clavijo Vitto (2016)

Holmes and Schmitz (2010) note that the question of whether and how competition affects firm productivity has long been central to economics. Many studies focus on careful description of specific industries, and take advantage of exogenous market or policy changes that increase competition, such as trade reforms (e.g. Dunne et al. (2008); De Loecker (2009)). Of primary interest are the mechanisms through which increased competition leads to growth in firm productivity: within-firm improvements deriving from increased investment, innovation, or managerial effort, or reallocation of production from inefficient to more efficient firms. Backus (2020) studies the ready-mix concrete industry and finds that greater exposure to competition increases productivity, where gains are made not through reallocation between firms, but from within-firm specialization and management. My study focuses on a policy change that *reduced* competitive pressures to different degrees across industrial subsectors. This case provides an opportunity to study whether robust domestic competition can make up for restrictions on foreign competition imposed by an industrial policy.

Turning to the effects of international trade on competition, Melitz (2003) develops a dynamic industry model with heterogeneous firms. The model predicts that greater exposure to international competition will lead firms at the top of the domestic productivity distribution to export, while less-productive firms supply the domestic market and the least productive firms exit. The Melitz model would predict that Brazil's LCR, by reducing exposure to international competition, would allow less productive firms to persist in the market, reducing aggregate sectoral productivity. This is, however, a static prediction, and dynamic or long-run outcomes could differ.

Models of agglomeration economies, which allow for knowledge spillovers, learning-by-doing, and economies of scale, might predict that channeling demand from the oil sector to domestic firms could help entrants overcome fixed costs and realize dynamic within-firm productivity gains (Duranton and Puga, 2003). Greenstone et al. (2010) finds that the opening of large plants leads to significant increases in TFP in neighboring firms, especially those that participate in similar factor markets. Furthermore, in the presence of market imperfections, Liu (2019) demonstrates that targeting subsidies to upstream sectors may bring social benefits. Thus, the overall effects of Brazil's LCR on firm entry/exit, growth, and productivity are theoretically ambiguous. The LCR targeted benefits to upstream input-suppliers, but did so by means of trade restrictions rather than subsidies. While this is cheaper for a fiscally constrained government, it may also reduce competition. In sum, effects of the Brazilian LCR may depend on prevailing levels of domestic competition and strength of linkages between oil-input supplying firms and other manufacturers.

My study contributes to the growing firm-level literature on the natural resource curse. Moshiri et al. (2019) and Cust et al. (2019) use firm-level data from Canada and Indonesia, respectively, to examine heterogeneity in firm-level responses to oil booms. The latter find that oil windfalls increase nearby firms' wages, labor productivity, and employment, with low productivity firms exiting and survivors increasing productivity and output. Allcott and Keniston (2018) use manufacturing census microdata from the United States to study the effects of oil booms on local economies. They find that manufacturing activity increases with oil production, especially in upstream and locally traded sectors. This suggests that resource booms can stimulate at least some forms of upstream manufacturing.

Finally, my study fills an important gap in the renascent literature on industrial policies by using firm-level microdata to empirically evaluate an LCR. The existing literature on LCRs consists largely of theoretical models (e.g., Richardson (2017); Macatangay (2016); Grossman (1981)) and qualitative case studies (e.g., Kolstad and Kinyondo (2017); Kalyuzhnova et al. (2016); Ovadia (2016)). Recent review papers by Cherif and Hasanov (2019) and Lane (2020) document widespread application of industrial policies in practice and call for more empirical evidence of their effects. I respond to this call by taking advantage of Brazil's rich, firm-level administrative datasets, which make possible careful empirical analyses that were not previously feasible. My findings will provide a better understanding of when and how industrial policies work, including the mechanisms connecting competition to productivity and the nature of spillovers along supply chains.

3 Empirical Research Design

3.1 Data

My proposed empirical strategy draws on the merger of three administrative datasets. The first is RAIS, a matched employer-employee dataset containing information on the location, size, sector, ownership structure, average employee wage and education levels, and R&D share of employment for the universe of formal firms in Brazil. The RAIS dataset contains annual observations of approximately four to eight million firms; firm ID numbers allow these observations to be linked into a panel for years 2000-2019.

The second dataset is the Annual Industrial Survey (PIA in Portuguese, which I refer to as the Manufacturing Census), a census of all Brazilian manufacturing firms with more than 30 employees and a representative sample of smaller firms. Access to this dataset is obtained by submitting a proposal to the Brazilian Institute of Geography and Statistics (IBGE). After approval of the proposal, researchers can work with the Manufacturing Census data in a secure data room in Rio de Janeiro. The Manufacturing Census dataset contains information on each firm's profits, output, investment, exports and imports, and product portfolios, allowing estimation of labor productivity and TFP. Data from this census are available annually between 2000-2019. In the secure room it is possible to merge the Manufacturing Census with RAIS, as well as with a recently released registry of firms affected by the LCR. This registry consists of 127,435 certifications obtained by 3,324 firms, documenting the percentage of local content embodied in their goods. Each certification details the type of good, the firm's ID number, and date of certification. By merging these datasets, I can identify each firm that participated in the LCR and construct a rich panel of outcomes for these firms, as well as their neighbors and matched counterfactuals, over a twenty-year period spanning from three years prior to initial strengthening of the LCR policy in 2003, to three years after relaxation of the policy in 2016.

3.2 Outcomes

Drawing on matched employer-employee administrative data, manufacturing census data, and the registry of local content beneficiary firms recently released by ANP, I will construct key outcome variables to analyze effects of the LCR at the firm level. From matched employer-employee registries, I can track each firm's entry and exit from the formal sector. I can also calculate total employment, average wage and education levels of employees, and monthly hiring and layoffs. From the manufacturing census, I will construct measures of total output, profits, labor productivity, and capital investment. I estimate total factor productivity (TFP) following Ackerberg et al. (2015). To explore firm-level innovation, I follow methodologies proposed by De Araújo et al. (2009) and Bustos et al. (2020) to calculate the fraction of a firm's workers in R&D-related occupations, thus obtaining a measure of R&D intensity. I also observe firms' export participation, as well as their product portfolio each year, allowing me to detect when firms introduce new product lines.

3.3 Empirical Strategies

How did application of the LCR contribute to development of Brazil's manufacturing sector? In a counterfactual world where the policy was not implemented, how would beneficiary firms and their non-beneficiary neighbors have fared? Did heterogeneity in pre-policy market structure lead to differential trends in firm productivity growth across subsectors? I separate these questions into three empirical strategies and discuss causal inference for each in turn. First, I propose an event study framework, taking advantage of large policy changes in 2003 and 2016, to estimate first-order effects of the LCR policy on beneficiary firms relative to closely matched controls. Second, I focus within the subsample of LCR beneficiaries to measure how pre-policy levels of market concentration affected subsequent rates of firm entry and performance. Finally, I propose a network linkages strategy, following Lane (2021), to estimate effects of backward and forward supply chain linkages to LCR beneficiaries on firm outcomes. I estimate spatial spillovers using the spillover robust difference-in-differences approach proposed by Clarke (2017).

3.3.1 First-Order Treatment Effects of the LCR

I estimate dynamic treatment effects of the LCR policy on beneficiary firms using an event study framework (Callaway and Sant'Anna, 2020; Borusyak and Jaravel, 2017). I can alternately define the event of interest to be the strengthening of the LCR in 2003, or relaxation of the policy in 2016. For firm f in year t, let $K_{ft} = t - 2003$ be the number of years before or after the policy change (alternatively, 2016). I regress outcome Y_{ft} on $1(K_{ft} = t)$ relative year indicators for the fully saturated set of indicators going from 2000 to 2019. I control for two-way fixed effects at the firm and year level (δ_f and γ_t, respectively):

$$Y_{ft} = \delta_f + \gamma_t + \sum_{t \neq 2002} [\mathbb{1}(K_{ft} = t)]\beta_t + \epsilon_{ft} \quad (1)$$

Firms self-select into participation in the LCR. As with many industrial policies, the Brazilian LCR was developed in dialogue with industry groups and was likely not entirely unanticipated or exogenous to industry pressures. To reduce concerns over selection, I will implement a coarsened exact matching strategy (Iacus et al., 2012) on the rich set of observables in the merged dataset, including municipality, 5-digit sector, number of employees, average wage and education of employees, R&D and investment intensity, ownership type, export-orientation, founding date, and TFP. For time-varying variables that could themselves be outcomes of LCR participation, I will use pre-policy levels. The millions of firms in the dataset make it feasible to find common support under rigorous coarsened exact matches. Firm fixed effects control for time-invariant firm-level unobservables, such as a fixed ability parameter.

This strategy allows me to explore first-order effects of the LCR on beneficiary firms, i.e., whether these firms grew and upgraded during the program. In some specifications I will restrict the sample to a balanced panel of firms that always operated during the sample period. In other specifications, I will explicitly analyze entry and exit using logit and linear probability models.

3.3.2 Effects of Competition: Heterogeneity in Pre-Policy Market Concentration

I next turn to a controversial feature of Brazil's LCR: item-specific local content percentages imposed in 2005. Following Aghion et al. (2015), I hypothesize that incumbent firms in subsectors with low pre-policy levels of competition may have been able to capture market share without decreasing prices or increasing quality because they had few competitors. Firms in concentrated subsectors may therefore exhibit lower levels of performance growth over the study period when compared to firms in highly competitive subsectors. To test this hypothesis empirically, I compute a Herfindahl-Hirschman Index (HHI) for each of the 16 subsectors detailed in the LCR's item percentage requirements in 2003, prior to the strengthening of the LCR policy. This pre-policy HHI is arguably exogenous to subsequent changes caused by the LCR. For subsector s defined in the item percentages, where $share_f$ is the market share of firm f in 2003:

$$HHI_s^{2003} = \sum_{f=1}^{N} (share_f^{2003})^2 \tag{2}$$

Next, I estimate an augmented version of the event study defined above to explore heterogeneity in dynamic treatment effects along the dimension of pre-policy market concentration, as in the following specification, where θ is a stand-in for concentration cutoffs to be defined:

$$Y_{ft} = \delta_f + \gamma_t + \sum_{t \neq 2002} [\mathbb{1}(K_{ft} = t) \times \mathbb{1}(HHI_s^{2003} > \theta)]\beta_t + \epsilon_{fst} \tag{3}$$

I can also include a sector-specific time trend, μ_{st}, and municipality-year covariates, X'_{mt}, to reduce concerns over omitted variable bias. In this setup, coefficient β_t captures the effect of a sector's pre-policy market concentration on firm outcomes in year t.

3.3.3 Spillovers Along Supply-Chains and Across Space

To assess spillovers, I implement a firm-level version of the network economies method developed in Lane (2021). My primary focus is spillovers propagated through backward and forward linkages along supply chains, but I consider geographical distance to account for spatial relations and transportation costs (Anderson, 2011). For spatial analyses, I geolocate each LCR beneficiary firm and neighboring manufacturing firms using Google API geocoding services, which transform firm addresses reported in RAIS into geocoordinates.

I draw on Brazil's Input-Output Matrix (IBGE, 2010), which disaggregates sectors into 67 activities and 127 products. I calculate the Leontief Inverse matrix and compute total backward linkages (TBL) between industrial sector i and LCR-treated sector j by summing Leontief coefficients l for downstream sectors treated by the LCR policy:

$$Total\ Backward\ Linkage_i = \sum_{j \in LCR} l_{i \to j} \tag{4}$$

Total forward linkages between i and j are calculated in a similar fashion. Since I have data at the firm level and a registry of firms treated by the LCR policy, I can estimate effects on untreated firms with the same industry codes as LCR firms, as well as more distantly related firms. I ascribe the sector-level measure TBL_i to each firm f in sector i, and modify the standard event-study specification to estimate:

$$Y_{ft} = \delta_f + \gamma_t + \sum_{t \neq 2002} [\mathbb{1}(K_{ft} = t) \times TBL_f]\beta_t + \epsilon_{fst} \tag{5}$$

I exclude directly treated firms, such that coefficients β_t show the difference in outcomes between closely linked and more distantly linked untreated firms relative to pre-policy levels. To consider spatial dimensions of spillover strength, I implement additional specifications in which I interact TBL_f (or TFL_f) with distance to nearby LCR beneficiary firms. This accounts for the fact that, in a large country such as Brazil, firms with close supply-chain linkages may not exert strong spillovers if they are geographically distant. Finally, I analyze spatial spillovers directly by implementing the spillover-robust difference-in-differences strategy from Clarke (2017).[1]

4 Model and Counterfactual Estimation

To clarify my conceptual framework, generate testable predictions, and estimate counterfactual policies, I will build a structural model of demand and supply for oil inputs. The model will consist of a downstream monopolist (e.g., Petrobras) that purchases inputs from upstream firms that compete in quantities *à la* Cournot. Upstream firms are of two types: domestic and foreign. Each firm gets a draw from a cost distribution, with the domestic cost distribution stochastically dominating the foreign distribution. The solution concept is Subgame Perfect Nash Equilibrium, solved using backward induction. I model the local content requirement as a tax on inputs purchased from foreign input suppliers (since the LCR allows purchases of foreign inputs but applies a fine in these cases). The downstream monopolist responds to global oil prices and upstream input prices to choose quantity of oil produced, quantity of inputs purchased, and share of inputs purchased domestically. Application of the LCR increases the cost of foreign inputs and causes the downstream monopolist to purchase more inputs from domestic firms. One modeling approach is that domestic input suppliers face scale economies or fixed technology adoption costs, such that increased demand from the downstream monopolist increases upstream firm size and productivity. Another modeling approach is that upstream input suppliers face varying levels of domestic competitive pressure, such that prohibition of foreign competition causes upstream market structure to change from perfect competition to, alternately, monopoly, oligopoly, or monopolistic competition. This change in market structure could cause newly monopolistic or oligopolistic firms to increase markups. Using this model, I will estimate counterfactual policy scenarios where the LCR policy was never implemented, or was implemented in a weaker (i.e., lower fines) or stronger form (i.e., absolute ban on foreign inputs).

[1] In this approach, I account for potentially endogenous selection into treatment and location by instrumenting for LCR beneficiaries' employment with an exogenous measure of oil intensity, defined by the interaction of world oil prices with firm distance to the nearest shipyard (the final assembly points for oil inputs). I use this predicted employment to compute R_{ft}, the sum of employees in treated firms within a distance cutoff d of untreated firm $_f$:

$$R\_{ft} = \sum_{T_{ft}=1} (\widehat{employees}_{ft}) \times \mathbb{1}(dist_{f,\_f} < d) \tag{6}$$

This gives a continuous measure of spatial spillover intensity on the untreated firm and allows me to estimate:

$$Y_{ft} = \alpha + \gamma_f + \delta_t + \omega T_{ft} + \tau \widehat{R\_{ft}} X'_{mt}\beta + \epsilon_{fmt} \tag{7}$$

Here, the coefficient of interest is τ, whose estimate gives the spillover effect on neighboring firms.

5 Extension: Rent-Seeking and Campaign Donations

Industrial policies can open windows of opportunity for firms to achieve economies of scale and competitiveness, but can also prop up inefficient or rent-seeking firms. In these latter cases, industrial policies may reinforce inequality by favoring politically connected individuals, as occurred under an LCR for the oil sector in Angola (Ovadia, 2016). Curiously, the Brazilian LCR was phased out in 2016, immediately after the Brazilian Supreme Court banned all campaign donations from firms. I leverage complete registries of political candidates and campaign donations between 2000 and 2016 (made available by Brazil's Supreme Electoral Tribunal) to explore whether campaign contributions or political connections may have influenced (i) firms' access to the oil-input market (e.g., participation in the local content program), and (ii) the continuation of the protectionist LCR policy. To evaluate (i), I will estimate event studies around the time of each firm's accession to the LCR registry, where outcomes are the number or value of campaign contributions made by firms or firm owners to political campaigns. This strategy will provide suggestive evidence of whether firms increase campaign donations to gain access to business from oil companies. To evaluate (ii), I will estimate event studies on firms that participated in the LCR and closely matched controls that did not, where outcomes are again the number or value of campaign contributions. This strategy will measure whether LCR-beneficiary firms donated more than comparable firms during the implementation of the policy. Using qualitative evidence, I will identify which politicians or political parties were most supportive of the LCR during this period, and whether LCR-linked firms disproportionately favored those candidates.

6 Policy Relevance

Globally, the use of local content requirements is widespread, but quantitative evidence on their efficacy is thin. The OECD reports that governments have imposed 145 new LCRs since 2008 (Stone et al., 2015). LCRs are particularly relevant in resource-dependent economies, where diversification away from resource dependence is a major policy goal (Okonjo-Iweala, 2012). The development of productive manufacturing firms is also of widespread interest (Nations, 2019). Seventy-two countries, home to nearly 3.4 billion people (including most of the world's extremely poor people), are dependent on natural resources, and improving the design of LCR policies in these countries could have significant implications for human welfare and poverty reduction (Roe and Dodd, 2016). Following the call from Lane (2020) for more quantitative analyses of industrial policies, my project will fill an important evidence gap, informing debates over industrialization and resource governance. Furthermore, my project has direct policy relevance for Brazil. During interviews I conducted with the directors of Brazil's LCR program, they expressed significant interest in this project, stating that a quantitative evaluation of the LCR is the "million-dollar question" and could directly influence reform of the policy.

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