Thresholds in natural resource rents and state owned enterprise profitability: Cross country evidence

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Abstract

In this paper we contribute to the resource curse literature by examining the association between state owned enterprises (SOE) profitability and natural resource rents. We use data on $91,094$ firms across 36 industries in 101 countries to show that although SOEs are inherently less productive compared to privately owned enterprises (POEs), there exists a threshold value of natural resource rents windfall above which SOEs would outperform POEs profitability. This threshold value of natural resource windfall we find to be between 138.6% and 192.3% above the long-term median value of resource rents. We argue that this threshold may exist because of: (i) at the country level, higher level of natural resource rents allocation that is reinvested domestically in the form of SOE capital investments; and (ii) at the industry level, SOEs experience higher scale economies through production linkages to the natural resource sector.

JEL Classification Numbers: L25, L32, L33, M21, O25

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1 Introduction

There is a large literature that examines the impact of natural resource dependence on economic development. Since Auty (1993) coined the term "natural resource curse" to refer to the observed negative relationship between natural resource dependence and economic growth, the literature has exploded in this regard. These studies are mainly macroeconomic in nature and have either focussed on the impact of natural resource dependence on economic growth or institutional factors such as human capital, good governance, investment, and savings (see Frankel (2011) and Badeeb et al. (2017) for a summary). In this paper we provide microeconomic evidence on the relationship between natural resource dependence and economic performance at the firm level. We examine the performance of state-owned enterprises (SOE) and their relative profitability against the privately owned enterprises (POEs).

There are many reasons to explore the impact of natural resource dependence on firms, looking at SOEs and their relative performance against the POEs. Chief among these reasons is the fact that SOEs are financed wholly or partially through government expenditure and so are dependent on the extent to which natural resource rents finance these expenditures (Chang, 2007; Frankel, 2011; Kojima et al., 2010; Lundgren et al., 2013; Victor et al., 2014). At the firm level in a resource-dependent economy, any underperformance of SOEs would provide a micro-counterpart to the resource curse observed at an aggregate level. Unfortunately, empirical evidence on resource rents-financed SOEs remain scarce, and there is a continuous debate about the efficacy of resource rents management towards SOE performance.

Based on macroeconomic evidence, many studies in the resource curse literature have identified poor resource rents management to be a determinant of economic underperformance at the aggregate level. Given that SOEs are often perceived as outlets for leakages of resource rents, their reputation in national economies is not positive. In many cases they are seen as corrupt bureaucratic leviathans. This is increasingly being recognised as an outmoded perception because more SOEs have performed well in recent years due to improved corporate governance models.[1] Efficient re-investment of resource rents back to the SOEs can be seen as one logical mechanism towards improved performance in resource-dependent economies.

[1]Once considered a relic of the past, SOEs have rebounded to account for approximately 10% of global production (Bruton et al., 2015), USD2 trillion worth of equity market capitalisation, and more than 6 million employees (Christiansen, 2011; Kowalski et al., 2013).

Bernstein et al. (2013) and Halland et al. (2016) argue that one example of how such progression can be made is via resource rents-financed strategic investment funds (SIFs).[2]

In the context of the natural resource curse, these proponents of SIFs argue that such direct capital investments into domestic SOEs is efficient and minimizes the risk of growth retarding corruption. This may result in an efficient transmission mechanism from resource extraction to SOEs' productivity and therefore towards improved value creation in the domestic economy. Although SOE's and POE's relative productivity has been widely studied (see Cheng et al. (2021) as an example), the general connection with natural resource dependence, especially in the context of SOEs across different industries in a developing economy, remains underexplored.

We try to fill this gap by focussing on the behaviour of SOEs as well as their relative performance against POEs. Even though we do not explicitly introduce a SIF as a separate entity, à la Lim and Zhang (2021), its efficient capital investment function is implicitly modelled by a government who invests resource rents into the SOE's capital stock. This, coupled with SOEs' production linkages to the national resource sector, means the profit of a typical SOE would be a positive, non-linear function of resource rents. This non-linearity allows us to show that there exists an upside risk to resource rents above which SOEs can outperform POEs.

To examine this, we provide the broadest cross-country microeconomic evidence on the topic and empirically assess the differential profitability impact by using data on $91,094$ firms across 36 industries in 101 countries during the period 2008-18. This dataset is built by combining the World Bank Enterprise Surveys (WBES) and macroeconomic data from the World Development Indicators (WDI) compiled by the World Bank. We use the World Bank's (real) estimates of aggregate natural resource rents (which covers oil, natural gas, coal, mineral, and forest rents) at the country level to proxy for resource dependence. The natural resource rents in question therefore includes both renewable and non-renewable resources.[3]

Our show that although SOEs are inherently less productive compared to POEs (an observation that is consistent with the resource curse at the aggregate level), there

[2]As suggested by the headline of an article in The Economist (2017), "*Sovereign-wealth funds catch on in Africa*", the model of sovereign resource wealth funded SOEs is expected to be increasingly adopted by up-and-coming developing economies with newfound resource wealth.

[3]We recognize that financial researchers and practitioners alike would be more interested in the impact of individual resource prices, such as oil prices, coal prices, etc. but data restrictions do not allow this disaggregation.

exists a threshold value of resource windfall above which SOEs would outperform POEs profitability. We estimate this threshold to be between 138.6% and 192.3% above the long-term median value of resource rents. It is worth noting that firms are not randomly privatized, and eight industries have no SOEs which limits a causal interpretation of our results, although causation is not the main aim of our analysis. Our empirical analysis merely captures an association between SOE profitability and resource rents, allowing us to identify a threshold beyond which SOEs perform better than POEs. The windfall threshold that we find is achievable in the data and may not only be possible from new discoveries but also price fluctuations. As an example, according to World Bank data, the real long run median for crude oil is USD32.94 per barrel between the years 1980 and 2010. Therefore, a price jump above USD78.39 would satisfy the lower bound of our computed threshold. Although never above the threshold before the year 2000 and rarely between the year 2000 and 2010, since 2010, the real price of crude oil jumped above this price five times. Interestingly, these were also in the final years of the commodities super cycle from 2000 to 2015.

As such, our study provides complementary firm-level evidence to the existing resource curse literature, which suggests that resource curse, while remarkably difficult to break, is transitory in nature and "breakable" during period of high resource prices, if there exists efficient reinvestment of resource rents into the SOE sector. This confirms the mediating impact of resource rents when comparing performance in SOEs and POEs. Specifically, it confirms that SOEs can be very profitable during the period when resource windfall received by the government is high. This we speculate happens through a combination of: (i) at the country level, higher level of rents allocation reinvested domestically in the form of SOE capital investments; and (ii) at the industry level, SOEs experience higher scale economies through production linkages to the natural resource sector.

The remainders of the article are as follows. Section 2 reviews the resource curse literature and makes clear the connection with SOEs. Section 3 presents a simple conceptual framework to examine analytically the impact of natural resource rents on SOEs' profitability. Section 4 discusses the data and methodologies. Section 5 evaluates the empirical results and analyses them in the context of the propositions. Section 6 concludes the article and identifies the main limitations of our paper.

2 The Natural Resource Curse

This paper contributes additional evidence to the contentious arguments about resource curse – the observation that countries rich in natural resources, such as oil and natural gas, tend to perform badly economically. Although not totally conclusive, the literature mainly shows that natural resource dependence has robust relationships with economic growth and development. For instance, Sala-i-Martin (1997) and Doppelhofer et al. (2000) argue that natural resources are one of the ten most robust determinant of economic growth. Many studies documented a negative relationship, and studies such as Sachs and Warner (1995, 1999) go as far as arguing for the permanent existence of a resource curse.

Badeeb et al. (2017) describe several potential casual mechanisms to explain this phenomenon, ranging from the early "Dutch disease" literature, commodity price volatility, to institutional factors such as economic mismanagement, rent seeking, and political corruption. Some recent studies have focused on economic mismanagement, corruption, and poor institutional quality, all of which are believed to exacerbate the natural resource curse. As examples, Iimi (2007) argue that economic mismanagement is an important factor as resource rents can provide policymakers with a false sense of economic security. By thinking that the public finance is in a good position, the government will tend to de-emphasize the importance of continuous investment in both public utilities and human development, which then may result in the citizens' lack of incentive in accumulating human capital (Gylfason et al., 1999; Gylfason, 2001). Similarly, Badeeb et al. (2016) show that oil curse can also affect private investment. Lower human and physical capital could then lead to the creation of inefficient firms—be it SOEs or POEs—in the domestic economy, the fundamental symptom of the resource curse.

In addition, it is also argued that rent-seeking and corruption are potential determinants of resource curse at the macro level. The sheer value of resource rents is massive, and this can create adverse incentives for policymakers to misappropriate these funds, which then lead to a gradual erosion of institutional quality and state stability (Arezki and Brückner, 2011; Hodler, 2006). If political interference is rampant, SOEs can turn out to be inefficient bureaucratic leviathans that register persistent losses (Iimi, 2007). Moreover, there is also evidence that short-term spike in resource income windfalls could limit government democratic accountability (Tsui, 2011). That said, the aggregate evidence of the impact of institutions on resource curse remain inconclusive, even at the macroeconomic level. While the presence of resource rents does create potential incentive for corruption, the rent in itself does not cause the curse. Other recent empirical evidence finds either no evidence of a resource curse or positive effect on GDP growth (see Brunnschweiler and Bulte, 2008; Cavalcanti et al., 2011; James, 2015; among others). As pointed out by Mehlum et al. (2006), "natural resource-abundant countries constitute both growth losers and growth winners, and the main difference between the success cases and the cases of failure lies in the quality of institutions". In fact, even for measurable factors like financial institutions, it is argued in studies such as Ang and Fredriksson (2018) that there are opposing forces associated with the accumulated statehood and bureaucracy in influencing its development. With such inconclusive evidence, and the fact state-owned enterprises appear to be here to stay (as many developing States' preference of industrial drivers), it reaffirms the need to examine firm-level evidence, controlling for country and industry fixed effects.

More pertinent to our study are those papers focusing on commodity price volatility as a potential determinant of the resource curse. In a review, Davis and Tilton (2005) point out that commodity price volatility can cause pro-cyclical fluctuations in government revenues and spending, which then translates to output fluctuation. For example, Van der Ploeg and Poelhekke (2009) present evidence that per capita output growth is negatively related to volatility of unanticipated output growth, which is caused by highly volatile world resource prices in resource-dependent countries. Similarly, Kim and Lin (2017) argue that the resource curse may be due to the volatile nature of natural resource prices in global markets.

Despite the potential role of commodity price volatility as a potential determinant of resource curse on aggregate, in the modern era—when futures and option contracts can easily be utilized—there is a significant difference between the upside variance to resource prices from the downside, the latter of which can be hedged while the benefits associated with the former is reaped. As pointed out by Bonet-Morón et al. (2020), in a recent study of oil shocks on subnational public investment in Colombia, this is indeed the case as periods of high oil prices is observed to lead to higher public investment, and that there is no evidence of unproductive spending despite the under-developed institutions. In addition, in Phan et al. (2020), which examine the importance of managerial ability on the crude oil price uncertainty-firm performance relationship in the U.S., they found managerial ability to be significant in reducing the negative impact of oil price uncertainty on firms' performance. Given that they also stress the significance of firm- and sector-level heterogeneity, as well as firm-level studies being scarce in the literature, this underlines that the impact of resource prices, and by extension resource rents, on firms' performance is not as straightforward as commonly thought.

Indeed, as much as resource price volatility is a potential determinant of the resource curse, the period of upswing in resource prices would create opportunities for SOE outperformance, whose operations are closely linked to the national resource sector. Granted, this is conditional on efficient investment of resource rents to capital investment in the SOE sector, which is precisely the SIF mechanism proposed by Halland et al. (2016). Insofar as SOEs are able to capitalize on the period of resource price upswing, then there exists an optimal allocation of resource rents to SOEs and by extension, potential SOE outperformance over POEs.

Empirically there seems to be some evidence in support of this line of thought. Specifically, as seen in Figure 1 there appears to be a positive relationship between natural resource rents and capital investment of SOEs, which one can speculate may translate to improved profitability. In fact, Lim and Zhang (2021) identify the presence of an optimal reinvestment rate of resource rents to SOEs in their paper, which is motivated by the anecdotal evidence from Malaysia's Government Linked Companies (GLCs). Specifically, they point out that as at the progress review in 2012 when oil prices were above USD 100 per barrel (as a proxy for the overall outlook of resource prices), SOEs' performances were remarkably well and rivalled those of top-performing private enterprises. However, towards the end of the programme, SOEs' profitability declined and not coincidentally, it was also the end of the global resources market boom. Therefore, in a SOE-dominant economy, this might translate to a potential "out" for an economy entrapped in a resource curse. At a minimum, it will at least show that resource curse is not permanent, but of a transitory nature.

3 Conceptual Framework

To provide a theoretical basis for our empirical investigation of whether an efficient SIF, that fully reinvests resource rents back to the domestic economy via its subsidiaries of SOEs, would provide a way to break the natural resource curse, we develop a stylized theoretical model focusing solely on firms like studies such as Brambilla (2009), Melitz (2003). This model is explicitly presented in Appendix A. Specifically, utilizing the fact that commodity price volatility in itself is asymmetric in nature (where upside risk to price changes is good for SOE performance, as documented in Lim and Zhang, 2021), based on the theoretical basis of the model, we derive formal derivation of analytical propositions pertinent solely on resource rent changes to be isolated and empirically tested, therefore avoiding any mix-up with other elements (political institutions, market power) not explained/captured by the model. The working mechanisms of the model are illustrated in Figure 2, and its full mathematical set-up is presented in Appendix A. Based on this theoretical model, we derive three empirically testable propositions.[4] These are as follows:

Proposition 1: *For two firms with the same physical capital stock and facing the same capital rental cost, a typical SOE is relatively productive inefficient compared to a typical POE.*

Proposition 2: *The profits of a typical SOE is strictly increasing with respect to the natural resource rents collected by the government.*

Proposition 3: *On average and in any given sector j, in a period of high resource prices, a typical SOE would make higher profits compared to a POE if the total resource rents generated by the government, which are used to finance SOE investments, are above a threshold value Υ_t^C.*

Proposition 2 is consistent with the "resource rents-managing" SIF framework proposed by Halland et al. (2014, 2016), whereas Proposition 3 is the key novel contribution of this article. Specifically, by examining whether the threshold exists empirically and therefore by extension from Proposition 2, we can then infer that there exists a potential role to be played by SIFs in overcoming a persistent resource curse: if there exist an empirical threshold to resource rents or prices above which SOEs can outperform POEs, then the nature of the resource curse would be one that is transitory and not permanent in nature.

4 Data, Empirical Specification, and Exploratory Analysis

To evaluate the theoretical propositions shown in Appendix A, we use the cross-country survey data from the WBES, which contains data on accounting information such as sales, inputs, labour, stock of capital, investment, costs, broad

[4]Proofs for all three propositions are in the online Appendix A.

cost-of-doing business indicators, and most importantly, government ownership ownership.[5] Our sample consists of cross-sectional observations of $91,094$ firms across 36 industries (based on ISIC code 3.1 definition) in 101 countries during the periods of 2008-18. This information is summarized in Appendix B. Due to the different country-specific waves of the WBES being implemented by the World Bank across different years, the country-specific data are asymmetric and uneven. This precludes a panel data-based dynamic analysis; hence our main focus is on examining (and estimating) the *level* effects (and associated thresholds) of natural resource rents on SOEs' profitability (for Proposition 3, the relative profitability against the POEs) based on the cross-sectional evidence of all the waves of WBES implemented globally spanning the time period. For the benchmark case, we define a firm as a SOE based on a cut-off value of government ownership of 10 percent and above. This cut-off is standard in the literature, but we vary this cut-off to check for robustness in the subsequent analysis.[6]

Unlike the other two propositions, the evaluation of Proposition 1 does not require any information on resource rents and is usually treated as trivial in the literature. We proceed first with examining it based on firm-level observations. Figure 3 presents an overall kernel density plot of the full-sample firms' labour productivity: one each for the SOEs and POEs. This figure shows that POEs have a more centred distribution, but they have longer tails on both ends of the distribution. The combined Kolmogorov-Smirnov test statistic was 0.11 and is significant at the one percent level. This indicates that there is a statistical difference in productivity between SOEs and POEs.

To empirically evaluate Proposition 1, we require two additional variables: (i) physical capital stock, which is measured as the logarithm of the total real net book value of machines and equipment; and (ii) capital rental cost, which is proxied by a firm's effective capital utilization, as measured by the logarithm of physical capital-to-labour ratio. Controlling also for the precise ownership stakes (to avoid within-type variations among the SOEs, the effects of which ought to be controlled for

[5]The World Bank has been conducting these firm-level surveys since 2000 for the manufacturing and services sectors in every region of the world. In each country, businesses in the cities or regions of major economic activities are interviewed. The WBES surveys formal (registered) companies with five or more employees. See www.enterprisesurveys.org/ for further information.

[6]Even though the legal definition differs across countries, in most economies' entities with an equity stake of 10 percent and above are considered as non-minority/significant shareholders. For instance, see the Companies Act 2006 of the United Kingdom, and the Securities Act 1933, Securities Exchange Act 1934, plus subsequent legal amendments, in the United States.

in establishing the initial baseline, à la Proposition 1), as well as different combination of fixed effects at the country, industry, and year levels, the regression results are summarized in Table 1, which show that labour productivity of SOEs is generally lower when both physical capital stock and capital intensity/utilization (proxy for real rental cost) are controlled for.

The empirical evaluation of Propositions 2 and 3 requires the construction of an integrated dataset that incorporates not just the WBES data, but also cross-country data of measures on natural resource rents. In the absence of precise measures of the natural resource values extracted and the corresponding revenue streams transferred to the government, we use the World Bank's series on real natural resource rents, which are estimated based on the methodologies of World Bank (2011).[7] These are then multiplied by the country-specific real measures of primary commodity price indices (divided by GDP deflators) published by the International Monetary Fund (IMF), to obtain an index measure of national-level natural resource rents. Specifically, for each country IMF publishes 12 different annual commodity price indices, based on different nature of trades (exports, imports, net exports) and weighting methods, the details of which can also be referred to in Appendix B. As built-in robustness checks, we evaluate both Propositions 2 and 3 using all 12 rents measures. Given the relative stability of the real resource rents overtime, any observed variation in the total resource rents at country level would reflect primarily the change in commodity prices (adjusted by GDP deflator).

In addition to the measure of total resource rents at country level, Υ_t^k, for country $k = 1, ..., 101$ (which is sufficient for the evaluation of Proposition 2), to evaluate Proposition 3 would require further construction of a sector-specific variable to proxy the allocation of SOE investments, also known as a sector-specific resource rents measure. Specifically, assuming that SOE investments financed by resource rents are allocated across the different sector j based on the relative size of the SOEs, for a country k, $\upsilon_t^{k,j} = \varsigma_t^j \Upsilon_t^k / N_G^{k,j}$ is the sector-specific allocation of the SOE investments financed by the national resource rents into sector j, where $\varsigma_t^j \in (0, 1)$ is the sector j's share of the total SOE investments in country k, calculated by $\varsigma_t^j = N_{G,t}^j / N_{G,t}$ (see Appendix A). The difference between Υ_t^k at country level and $\upsilon_t^{k,j}$ at industry level is

[7] Specifically, these refer to the unit rents derived after a two-stage procedure: (i) first, nominal rents are estimated as the difference between the value of natural resource production at world prices and total costs of production; (ii) then, the nominal rents are decomposed so that the unit rents (in real terms) are isolated from both the stock and price effects. See World Bank (2011, pp. 52-54) for details.

therefore a measure of the SOE-concentration ratio of the different industries.

For the evaluation of Proposition 2, which is applicable to all the SOEs, the empirical form is specified as:

$$\pi_{n,j,t}^{SOE,k} = \alpha_0 + \alpha_1 \Upsilon_t^k + \sum_{s=1}^{S} \psi_{j,k} X_{jt}^k + \sum_{k=1}^{K-1} \mu_k + \sum_{j=1}^{J-1} \mu_j + \sum_{t=1}^{T-1} \mu_t + \varepsilon_{n,jt}^{SOE,k}, \tag{1}$$

where $\pi_{n,jt}^{SOE,k}$ is the logarithm of the profits of SOE n in industry j of country k, Υ_t^k is the logarithm of the total resource rents of country k, X_{jt}^k are the S number of control variables at the industry level (see the *other variables* in Table 2), μ_k (μ_t) [μ_j] are dummies introduced to capture country- (year-) [industry-] specific fixed effects, and $\varepsilon_{n,jt}^{SOE,k}$ is the random error term. In other words, the empirical evaluation of Proposition 2 concerns the effects of a country-level variable on individual SOEs' profits, after controlling for country-level and industry-level fixed effects.

On the other hand, for Proposition 3, which concerns the average profit difference between SOEs and POEs, a sector-level specification is required. Specifically, the empirical form to be estimated is:

$$\xi_{jt}^k = \beta_0 + \beta_1 \upsilon_t^{k,j} + \sum_{s=1}^{S} \psi_{j,k} X_{jt}^k + \sum_{k=1}^{K-1} \mu_k + \sum_{j=1}^{J-1} \mu_j + \sum_{t=1}^{T-1} \mu_t + \epsilon_{jt}^k, \tag{2}$$

where $\xi_{jt}^k = \bar{\pi}_{jt}^{SOE,k} - \bar{\pi}_{jt}^{POE,k}$ is the sector-specific difference between the logarithm of the average profits of SOEs and the logarithm of average profits of POEs in industry j of country k, $\upsilon_t^{k,j}$ is the (logarithm of) sector rents variable that proxies the SOE investments allocated to industry j and country k, the fixed effects are as defined earlier, and ϵ_{jt}^k is the random error term.

Finally, using the above information, we can derive backwards and predict the estimated threshold value (in log form), $\hat{\Upsilon}_t^C$, above which a "*typical SOE would make higher profits compared to a POE*" (when $\hat{\xi}_{jt}^k = 0$, since $\ln 1 = 0$), which would then allow us to derive the corresponding resource windfall (at country level) above which SOEs outperform POEs, $\Delta\Upsilon_t^C = \hat{\Upsilon}_t^C - \bar{\Upsilon}_t$, where $\bar{\Upsilon}_t$ is the logarithm of median resource rents (at country-industry panel level). The summary statistics of these are presented in Table 2. This covers 666 unique country-industry panel (with at least one SOE and POE) that is used to test proposition 3.

From the mean of the sector-specific measure of profit difference between SOEs and

POEs, $\xi_{jt}^{k} = -0.09$, Proposition 1 remains valid in this industry-level data.

5 Results

5.1 SOE profitability and natural resource rents

Table 3 presents the baseline results for the econometric estimation. In Panel A shows estimation results using only SOE firms (based on 10% ownership threshold), whereas Panel B is estimated using the 666 unique country-industry panels, which is a unit appropriate for the average profit differential between SOEs and POEs to be identified and measurable.[8]

From Panel A, irrespective of which country-specific commodity price index is used in constructing the country-level natural resource rents, Υ_t^k, the estimated $\hat{\alpha}_1$ in all 12 models are positive and statistically significant at the 1% level, ranging from $1.83 - 2.25$. Given the log-log estimation, these suggest that, for a one percent increase in the resource rents at the country level, it is estimated that a typical SOE will see an improvement in its profitability of $1.83 - 2.25$ percent—-a small magnitude that appears appropriate for the impact of a country-level variable on firm-level profitability of individual SOEs.

The estimated benchmark results regarding Proposition 3 are presented in Panel B. Again, we can see that the estimated coefficients for $\hat{\beta}_1$ are statistically significant and robust across the 12 different models that use the different sector rents measures. Specifically, $\hat{\beta}_1$ is estimated to range from 0.324 to 0.335, which shows that an increase in the value of the sector rents measure (the proxy for sector-specific allocation of SOE investments) would result in an improved difference between the average SOE profits and POE profits within a sector. To the extent that our sector rents measure is representative of the resource wealth allocated to financing SOEs' operations, this means that for an initial negative ξ_{jt}^{k} (initial average SOE profitability is lower than POEs), the SOEs would close the profitability gap between them and the POEs with additional sovereign resource rents being reinvested into the SOE sector. Specifically, a one percent increase in sovereign resource rents invested into the SOEs is expected to close the profitability gap by $0.324\% - 0.335\%$.

[8]Prior to the estimation of both, we test again for the exogeneity of the key variables $[\Upsilon_t^k,\ v_t^{k,j}]$ against their respective control variables using panel-data exogeneity tests (see Wooldridge, 2010, Section 11.2). In both cases, the test statistics rule out the need of using an instrumental-variable approach.

Further, based on the estimated models, we derive the threshold $\hat{\upsilon}_t^{k,j}$ value that corresponds to $\hat{\xi}_{jt}^k = 0$ [when the ratio of average SOE and POE profits (in level, not log) is one], which in turn would yield the threshold value, $\hat{\Upsilon}_t^C$. More relevant for policy development, the implied required natural resource rents windfall, as measured by $\Delta\Upsilon_t^C$, for SOEs to outperform POEs is estimated at 138.6% to 192.3% above its median value. Intuitively, for an average SOE to benefit enough from both the additional governmental investments and the cost-reduction associated with scale economies to outperform an average POE, ceteris paribus, a significant expansion in natural resource revenue is necessary.

This windfall threshold is seemingly large but not insurmountable. In fact, it is achievable in the data used for this analysis and may not only be possible from new discoveries but also price fluctuations. As an example, according to World Bank data, the real long run median for crude oil is USD32.94 per barrel between the years 1980 and 2010. Therefore, a price jump above USD78.39 would satisfy the lower bound of our computed threshold. Although never above the threshold before the year 2000 and rarely between the year 2000 and 2010, since 2010, the real price of crude oil jumped above this price five times. Interestingly, these were also in the final years of the commodities super cycle from 2000 to 2015.

5.2 Further robustness checks

In addition to the 12 measures of commodity price indices discussed earlier, as a further robustness check, we re-estimate the baseline models based on different cut-off values for the share of government ownership. Specifically, we consider a cut-off value of 0 percent (as in Estrin and Rosevear, 1999), and a higher cut-off value of 20 percent. These are presented in Table 4 and 5 respectively. For Proposition 2, the values of the estimated $\hat{\alpha}_1$ remain largely similar to the benchmark estimates despite the different cut-off values of government ownership. These reaffirm that the profitability of firms with government ownership, irrespective of the actual shareholding percentages, is positively associated with the natural resource rents generated at the country level. Similarly, the estimated results for Proposition 3 are robust to the different government ownership cut-off values for SOEs, implying that the relative profitability of SOEs is significantly dependent on the level of natural resource revenue.

As a further robustness check, in Table 6 we repeat the same testing for both

Propositions 2 and 3 using profit margin (profits/sales) in place of the level of profits. By implication, the dependent variable in Panel B is now average profit margin differential between the SOEs and the POEs at the unique industry-country panel level. We see that our results remain robust, though the statistical significance of estimated coefficients for $\hat{\beta}_1$ is overall slightly weaker than the benchmark results. Nevertheless, this set of results based on profit margin further confirms the robustness of the documented relationship between natural resource rents and SOE profitability, as it rules out the possibility that our benchmark results merely capture the positive association between two level variables.

Finally, given that our dataset covers so many different countries, a sceptic of our results may argue that our results may be biased because of cross-country variations that elude the use of country fixed effects in the regressions. This may be especially true for high income countries (Christiansen, 2011). In this vein, we removed the countries in our sample that the World Bank classifies as high-income countries and re-estimated the baseline model. These results are presented in Table 7. Based on these results, for Proposition 2, the values of the estimated $\hat{\alpha}_1$ are positive, statistically significant and remain relatively similar to the benchmark results presented above. Similarly, as shown in Panel B, the estimated results for Proposition 3 are all robust to this change in the sample.

Overall, this evidence clearly shows that our baseline results are robust to several methodological modifications, hence providing empirical support for the three propositions shown above.

6 Policy Remarks and Conclusion

Contrary to most of the existing literature, in this paper we contribute to the resource curse literature by examining the association between SOE profitability and nominal resource rents. Our results show that although SOEs are inherently less productive compared to POEs (an observation that is consistent with the resource curse at the aggregate level), there exists a threshold value of resource rents windfall above which SOEs would outperform POEs profitability. We estimate this threshold to be between 138.6% and 192.3% above the long-term median value of resource rents. It is worth noting that firms are not randomly privatized, and eight industries in our dataset have no SOEs which limits a causal interpretation of our results, although causation is not the main aim of our analysis. Importantly, our empirical analysis merely captures an association between SOE profitability and resource rents, allowing us to identify a threshold beyond which SOEs perform better than POEs. The resource rents windfall threshold that we find is achievable in the data and may not only be possible from new discoveries but also price fluctuations.

As illustrated in the conceptual framework, we infer that this threshold effect is taking place through a combination of: (i) at the country level, higher level of rents allocation that is reinvested domestically in the form of SOE capital investments, and (ii) at the industry level, SOEs experience higher scale economies through the production linkages to the natural resource sector, SOEs' average profitability would outperform those of POEs.

Although we do not present a causal analysis in the paper, in this context, our findings reaffirm the increasing need for developing country governments' industrial planning horizon to take fully into account the outlook of resource prices. In addition, during the constant recalibration of industrial policies, the results also suggest the investment and adoption of a real-time aggregate resources price monitoring and forecasting regime to support national industrial development authorities. With this, then the *ex-ante* implementation of industrial policies, notably in terms of the funding focus on the different industrial sectors of the economy, can be on a rotational basis based on robust forecast of resources prices and therefore the SOE profits. Specifically, during periods with expected high resource prices and hence increased SOE competitiveness, the SOEs 'sector' can be the main target of industrial policy; during period with expected low resource prices then the funding incentives should be more targeted at private firms-driven industries. Lastly, due to data limitations and the fact that privatization decision is not random we welcome future research that examines the causal effect of randomization in this context.

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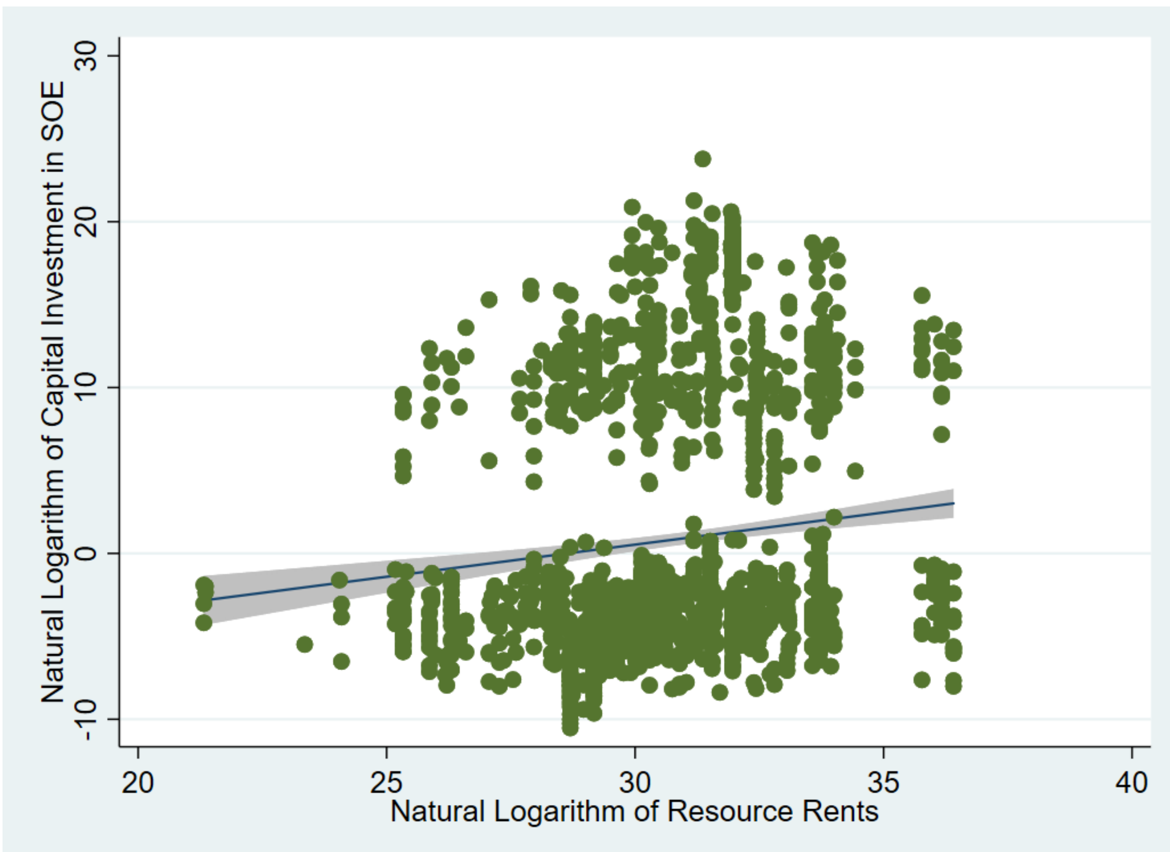
Figure 1: Natural Resource Rents and Capital Investment in SOEs



Note: This figure shows a positive correlation between natural resource rents and capital investment of SOEs. The correlation coefficient is 0.19 and significant at the 1% level.

Figure 2: Summary of the Theoretical Framework

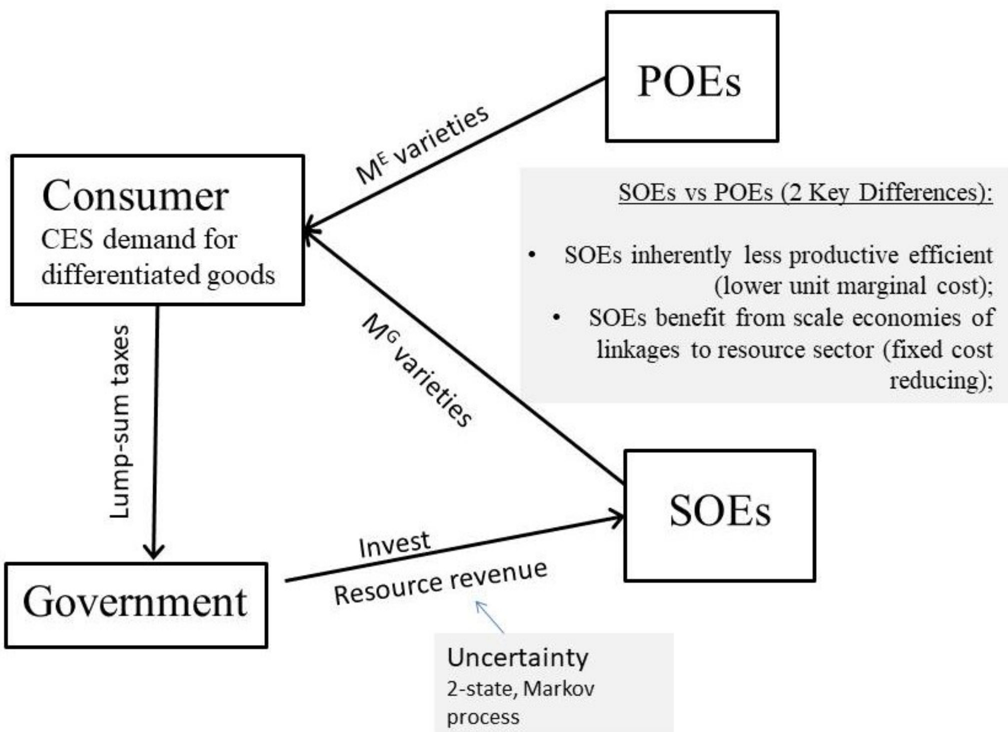
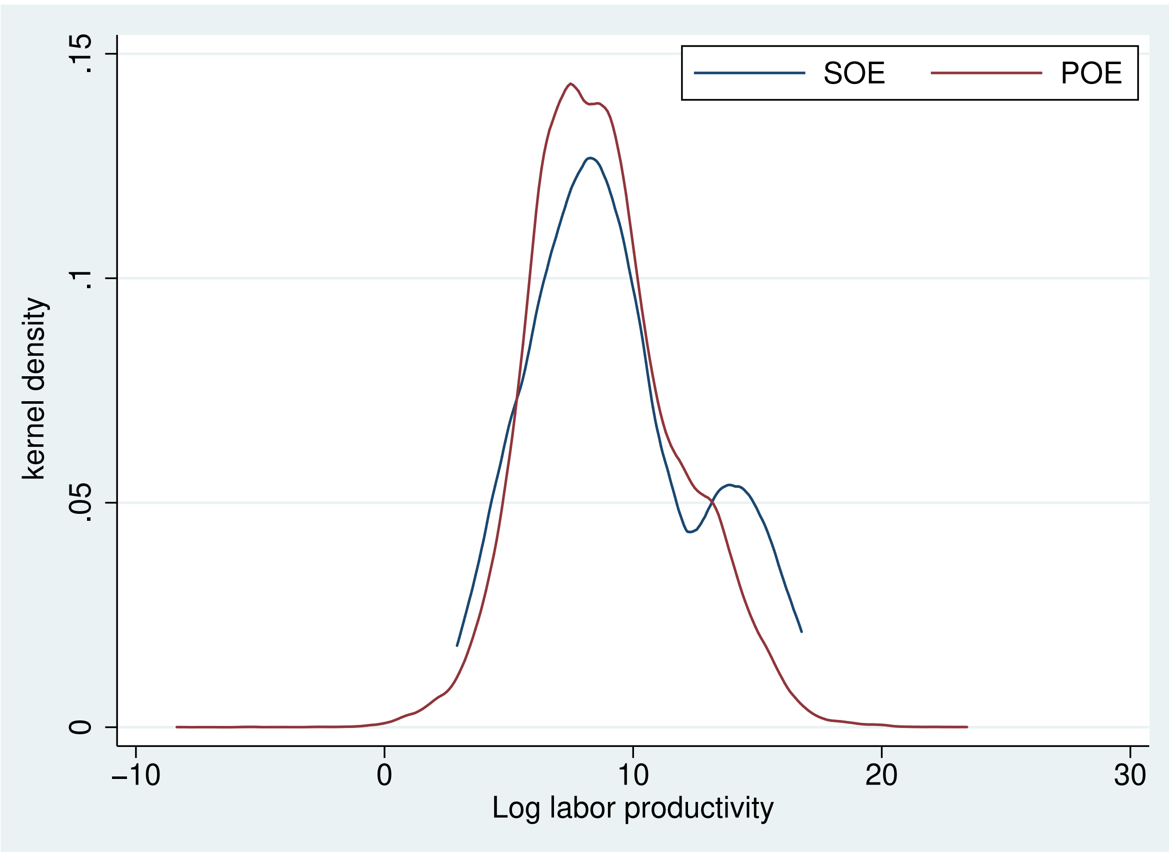


Figure 3: Kernel Density Plot of Labour Productivity



Note: This figure shows a kernel density plot for SOEs and POEs. POEs have a more centred labour productivity distribution but they have longer tails on both ends of the distribution. The combined Kolmogorov-Smirnov test statistic was 0.11 and significant at the 1% level, showing there is a statistical difference between SOEs and POEs.

Table 1: Testing of Proposition 1

Dep. var: Labour Productivity	(1)	(2)	(3)
SOE	-0.347*	-0.367**	-0.153*
	(0.195)	(0.183)	(0.090)
Capital	0.161***	0.243***	0.137***
	(0.008)	(0.008)	(0.005)
Capital Utilization	-0.078***	-0.132***	-0.117***
	(0.008)	(0.008)	(0.004)
Labour	-0.000	-0.000**	-0.000***
	(0.000)	(0.000)	(0.000)
Gov. Own. Share	0.014***	0.014***	0.002
	(0.004)	(0.004)	(0.002)
Year FE	No	Yes	Yes
Industry FE	No	Yes	Yes
Country FE	No	No	Yes
N	91094	91094	91094
R^2	0.043	0.109	0.716
F	774.491	310.382	1359.696

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Standard errors in parentheses are robust.

Table 2: Summary Statistics for Country-Industry Panels used to Test Proposition 3

	Obs	Mean	Std. Dev.	Min	Max
Main Variables					
Log Average Sector Profit of SOEs	666	16.59	3.28	8.97	25.10
Sector Log Profit Difference: SOEs-POEs	666	-0.09	3.07	-12.06	10.80
Sector Rent 1	666	28.58	2.44	20.66	34.70
Sector Rent 2	666	28.58	2.44	20.66	34.70
Sector Rent 3	666	28.51	2.43	20.69	34.74
Sector Rent 4	666	28.50	2.43	20.69	34.73
Sector Rent 5	666	28.58	2.45	20.63	34.70
Sector Rent 6	666	28.58	2.45	20.62	34.69
Sector Rent 7	666	28.46	2.44	20.42	34.82
Sector Rent 8	666	28.44	2.44	20.35	34.81
Sector Rent 9	666	28.59	2.44	20.69	34.70
Sector Rent 10	666	28.59	2.44	20.71	34.70
Sector Rent 11	666	28.60	2.43	20.89	34.72
Sector Rent 12	666	28.62	2.43	20.96	34.72
Control Variables					
Sector Share of Credit Constrained Firms	666	0.08	0.12	0	1
Sector Share of Loan Applications	666	0.08	0.12	0	1
Sector Share of Exporters	666	0.08	0.14	0	1
Sector Share of Corruption Incidence	666	0.08	0.12	0	1
Sector Share of Innovators	666	0.05	0.08	0	1
Sector Labour Share	666	0.08	0.12	0	1
Average Labour Growth	666	1.01	0.44	0	2.71
Skilled Labour Sector Share	666	0.90	0.13	0.36	1
Log Average Sector Capital	666	1.90	6.03	-7.95	19.96
Log Average Sector Sales	666	1.02	0.09	-0.02	1.34

Notes: based on authors computation using data from WBES, WDI and IMF WEO. These are summary statistics for the unique country-industry panels used in the testing of Proposition 3, the main thrust of the paper.

Table 3: Baseline Results with SOE Threshold, $c >= 10\%$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Panel A												
Υ_t^k	2.203***	2.216***	1.834***	1.830***	2.252***	2.253***	1.937***	1.893***	2.201***	2.213***	1.963***	2.044***
	(0.222)	(0.219)	(0.199)	(0.197)	(0.219)	(0.218)	(0.191)	(0.191)	(0.229)	(0.226)	(0.236)	(0.230)
R-Sq	0.678	0.679	0.677	0.677	0.679	0.679	0.680	0.679	0.677	0.677	0.672	0.675
N	1402	1402	1402	1402	1402	1402	1402	1402	1402	1402	1402	1402
Panel B												
$\upsilon_t^{k,j}$	0.333***	0.333***	0.326***	0.328***	0.334***	0.335***	0.334***	0.335***	0.333***	0.332***	0.327***	0.324***
	(0.096)	(0.096)	(0.096)	(0.096)	(0.095)	(0.095)	(0.096)	(0.095)	(0.096)	(0.096)	(0.096)	(0.097)
R-Sq	0.301	0.301	0.300	0.301	0.301	0.301	0.301	0.302	0.301	0.301	0.301	0.300
N	666	666	666	666	666	666	666	666	666	666	666	666
$\Delta\Upsilon_t^C$	1.722	1.923	1.870	1.859	1.726	1.731	1.758	1.803	1.734	1.75	1.386	1.386
Control Vars.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The control variables can be separated into two groups (share of the industry in the specific country (industry size) and the average of the variable in that industry). In particular, we control for the total industry share of: bank credit, bank loan, exports, corruption, innovation, labour; and the mean industry: assets, labour growth, capital and skill. These controls are included in all regressions. Results for models (1) - (12) are from different regressions. Resource rents is the sector specific allocation of total country level natural resource production profits each year as estimated by the World Bank. The differences in the models are due to differences in the calculation of country level natural resource rents as shown in Appendix B. All regressions include a battery of control variables. Standard errors shown in parenthesis are clustered at the industry level. * Significant at 10%, ** significant at 5%, *** significant at 1%.

Table 4: Robustness Check with SOE Threshold, $c > 0\%$

Panel A												
Υ_t^k	2.060***	2.077***	1.732***	1.734***	2.108***	2.111***	1.826***	1.784***	2.048***	2.062***	1.836***	1.916***
	(0.222)	(0.218)	(0.196)	(0.194)	(0.219)	(0.218)	(0.189)	(0.189)	(0.229)	(0.227)	(0.232)	(0.227)
R-Sq	0.677	0.678	0.677	0.677	0.678	0.679	0.679	0.678	0.676	0.676	0.672	0.674
N	1524	1524	1524	1524	1524	1524	1524	1524	1524	1524	1524	1524
Panel B												
$\upsilon_t^{k,j}$	0.281***	0.281***	0.274***	0.277***	0.282***	0.283***	0.283***	0.285***	0.280***	0.279***	0.275***	0.272***
	(0.095)	(0.095)	(0.095)	(0.095)	(0.094)	(0.094)	(0.095)	(0.095)	(0.095)	(0.095)	(0.095)	(0.096)
R-Sq	0.283	0.283	0.282	0.282	0.283	0.283	0.283	0.283	0.283	0.282	0.282	0.282
N	716	716	716	716	716	716	716	716	716	716	716	716
Control Vars.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The control variables can be separated into two groups (share of the industry in the specific country (industry size) and the average of the variable in that industry). In particular we control for the total industry share of: bank credit, bank loan, exports, corruption, innovation, labour; and the mean industry: assets, labour growth, capital and skill. These controls are included in all regressions. Results for models (1) - (12) are from different regressions. Resource rents is the sector specific allocation of total country level natural resource production profits each year as estimated by the World Bank. The differences in the models are due differences in the calculation of country level natural resource rents. For these results, a firm is characterized as state owned if the government owns any share in the firm. All regressions include a battery of control variables as highlighted in the Data section of the paper. Standard errors shown in parenthesis are clustered at the industry level. * Significant at 10%, ** significant at 5%, *** significant at 1%.

Table 5: Robustness Check with SOE Threshold, $c >= 20\%$

Panel A												
Υ_t^k	2.382***	2.389***	1.977***	1.951***	2.434***	2.432***	2.067***	2.017***	2.387***	2.397***	2.133***	2.205***
	(0.248)	(0.243)	(0.223)	(0.220)	(0.243)	(0.242)	(0.212)	(0.213)	(0.256)	(0.253)	(0.269)	(0.260)
R-Sq	0.691	0.692	0.690	0.690	0.693	0.693	0.693	0.692	0.690	0.690	0.684	0.687
N	1134	1134	1134	1134	1134	1134	1134	1134	1134	1134	1134	1134
Panel B												
$\upsilon_t^{k,j}$	0.458**	0.458**	0.447**	0.445**	0.464**	0.464**	0.460**	0.454**	0.456**	0.457**	0.438**	0.442**
	(0.211)	(0.210)	(0.209)	(0.208)	(0.210)	(0.210)	(0.209)	(0.209)	(0.211)	(0.211)	(0.211)	(0.210)
R-Sq	0.392	0.393	0.392	0.392	0.393	0.393	0.393	0.392	0.392	0.392	0.392	0.392
N	654	654	654	654	654	654	654	654	654	654	654	654
Control Vars.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The control variables can be separated into two groups (share of the industry in the specific country (industry size) and the average of the variable in that industry). In particular we control for the total industry share of: bank credit, bank loan, exports, corruption, innovation, labour; and the mean industry: assets, labour growth, capital and skill. These controls are included in all regressions. Results for models (1) - (12) are from different regressions. Resource rents is the sector specific allocation of total country level natural resource production profits each year as estimated by the World Bank. The differences in the models are due differences in the calculation of country level natural resource rents. For these results, a firm is characterized as state owned if the government has at least 20% share in its ownership. All regressions include a battery of control variables as highlighted in the Data section of the paper. Standard errors shown in parenthesis are clustered at the industry level. * Significant at 10%, ** significant at 5%, *** significant at 1%.

Table 6: Robustness Check using Profit Margin

Panel A												
Υ_t^k	0.651***	0.652***	0.518***	0.523***	0.664***	0.661***	0.567***	0.546***	0.657***	0.661***	0.579***	0.607***
	(0.080)	(0.078)	(0.068)	(0.067)	(0.079)	(0.079)	(0.067)	(0.067)	(0.082)	(0.081)	(0.082)	(0.079)
R-Sq	0.673	0.674	0.671	0.672	0.674	0.674	0.674	0.673	0.673	0.673	0.669	0.671
N	1402	1402	1402	1402	1402	1402	1402	1402	1402	1402	1402	1402
Panel B												
$\upsilon_t^{k,j}$	0.083**	0.083**	0.081*	0.081*	0.083**	0.083**	0.084**	0.082**	0.083**	0.083**	0.082*	0.083**
	(0.042)	(0.042)	(0.042)	(0.042)	(0.042)	(0.042)	(0.042)	(0.042)	(0.042)	(0.042)	(0.042)	(0.042)
R-Sq	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223	0.223
N	666	666	666	666	666	666	666	666	666	666	666	666
Control Vars.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The dependent variable in this regression is profit margin (profit/sales). The control variables can be separated into two groups (share of the industry in the specific country (industry size) and the average of the variable in that industry). In particular we control for the total industry share of: bank credit, bank loan, exports, corruption, innovation, labour; and the mean industry: assets, labour growth, capital and skill. These controls are included in all regressions. Results for models (1) - (12) are from different regressions. Resource rents is the sector specific allocation of total country level natural resource production profits each year as estimated by the World Bank. The differences in the models are due differences in the calculation of country level natural resource rents. For these results, a firm is characterized as state owned if the government has at least 10% share in its ownership. All regressions include a battery of control variables as highlighted in the Data section of the paper. Standard errors shown in parenthesis are clustered at the industry level. * Significant at 10%, ** significant at 5%, *** significant at 1%.

Table 7: Robustness Check without High Income Countries

Panel A												
Υ_t^k	2.283***	2.295***	1.904***	1.893***	2.334***	2.335***	2.007***	1.964***	2.283***	2.293***	2.036***	2.110***
	(0.225)	(0.221)	(0.202)	(0.200)	(0.221)	(0.220)	(0.194)	(0.194)	(0.231)	(0.229)	(0.239)	(0.232)
R-Sq	0.680	0.681	0.679	0.679	0.681	0.681	0.681	0.681	0.678	0.679	0.674	0.676
N	1336	1336	1336	1336	1336	1336	1336	1336	1336	1336	1336	1336
Panel B												
$\upsilon_t^{k,j}$	0.792***	0.790***	0.773***	0.772***	0.795***	0.795***	0.788***	0.792***	0.793***	0.791***	0.779***	0.772***
	(0.180)	(0.180)	(0.179)	(0.179)	(0.179)	(0.179)	(0.179)	(0.178)	(0.181)	(0.180)	(0.182)	(0.181)
R-Sq	0.353	0.353	0.352	0.352	0.353	0.353	0.353	0.353	0.353	0.353	0.352	0.352
N	612	612	612	612	612	612	612	612	612	612	612	612
Control Vars.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The control variables can be separated into two groups (share of the industry in the specific country (industry size) and the average of the variable in that industry). In particular we control for the total industry share of: bank credit, bank loan, exports, corruption, innovation, labour; and the mean industry: assets, labour growth, capital and skill. These controls are included in all regressions. Results for models (1) - (12) are from different regressions. Resource rents is the sector specific allocation of total country level natural resource production profits each year as estimated by the World Bank. The differences in the models are due differences in the calculation of country level natural resource rents. For these results, a firm is characterized as state owned if the government has at least 10% share in its ownership. All regressions include a battery of control variables as highlighted in the Data section of the paper. Standard errors shown in parenthesis are clustered at the industry level. * Significant at 10%, ** significant at 5%, *** significant at 1%.

Online Appendix A;
Not part of main manuscript.

Appendix A - Technical Notes for: Natural Resource Rents Threshold and State-Owned Enterprise Profitability: Cross Country Evidence

King Yoong Lim and Diego Morris

Abstract

This presents the mathematical model underpinning the empirical set up, as well as subsequent derivations of the Propositions.

1 Theoretical Model

1.1 Consumer Demands

There are two types of firms in the economy: the POEs and the SOEs.[1] The economy is populated by identical consumers and their preferences are represented by a CES utility function over differentiated products along two different continuum of $[0, M^E]$ and $[0, M^G]$ for POEs- and SOEs-produced products respectively. In the context of our empirical analysis, each products are represented by a different sector. If every sector has both SOEs and POEs' participation, then $M^E = M^G$.

Let q_t^i denotes the total quantity demanded for the aggregate basket of products by the POEs and SOEs ($i = E, G$), the representative utility function is

$$U_t = [\Lambda_E (q_t^E)^{(\eta-1)/\eta} + \Lambda_G (q_t^G)^{(\eta-1)/\eta}]^{\eta/(\eta-1)}, \tag{1}$$

where $\Lambda_E, \Lambda_G \in (0,1)$, $\Lambda_E + \Lambda_G = 1$, and $\eta > 1$ is the elasticity of substitution between the two categories, each defined as

$$q_t^i = \left\{ \int_0^{M^i} [q_{jt}^i]^{(\theta_i-1)/\theta_i} dj \right\}^{\theta_i/(\theta_i-1)}, \quad i = E, G, \tag{2}$$

[1] As reviewed in Djankov and Murrell (2002), there isn't a universally agreed threshold value (in terms of percentage of shares owned by the government) for a firm to be classified as SOEs. In our empirical implementation later, different threshold values are therefore applied to ensure robustness of results.

where q^i_{jt} denotes the quantity of sectoral output j produced by firm category $(i = E, G)$, $\theta_i > 1$ is the elasticity of substitution across the different sectors for the two types of firms.

With sectoral prices being exogenous to the consumers, cost minimization with respect to each categories results in the demand function for each sectoral product j produced by firm type i:

$$q^i_{jt} = (\frac{P^i_{jt}}{P^i_t})^{-\theta_i} q^i_t, \quad i = E, G, \tag{3}$$

where P^i_{jt} is the price of sectoral product j produced by firm type i, and P^E_t and P^G_t are aggregate price indices of the POEs and the SOEs' aggregate production, modelled by the standard form, $P^i_t = \left\{\int_0^{M^i} (P^i_{jt})^{1-\theta_i} dj\right\}^{1/(1-\theta_i)}$, $i = E, G$. This means, for both firm types, $P^i_t q^i_t = \int_0^{M^i} P^i_{jt} q^i_{jt} dj$.

Given an after-tax disposable income of $(1 - \tau_t)Y_t$, which is taken as given when consumers are making their consumption choice, the aggregate demand for the economy-wide baskets of POE- and SOE-produced goods are given by

$$q^E_t = \Lambda^\eta_E (\frac{P^E_t}{P_t})^{-\eta} (1 - \tau_t)Y_t, \; q^G_t = \Lambda^\eta_G (\frac{P^G_t}{P_t})^{-\eta} (1 - \tau_t)Y_t, \tag{4}$$

with P_t denoting the aggregate price index, given by

$$P_t = [\Lambda^\eta_E (P^E_t)^{1-\eta} + \Lambda^\eta_G (P^G_t)^{1-\eta}]^{1/(1-\eta)}. \tag{5}$$

Substituting (4) into (3), we write the series of demand function for each sectoral product j produced by firm type i as:

$$q^i_{jt} = \Lambda^\eta_i (P^i_{jt})^{-\theta_i} (P^i_t)^{\theta_i - \eta} P^\eta_t (1 - \tau_t)Y_t, \quad i = E, G. \tag{6}$$

1.2 Government

There is a government making general consumption (G^O_t) and investing in state-owned enterprises, SOEs (G^{SOE}_t). The government finances its consumption by collecting income taxes from consumers $(\tau_t Y_t)$ and issuing debts (D_t), with the debts issued being repaid in gross term—plus interest, r^G_{t-1}—in the next period. For simplicity, we assume the debts issued are not held by the domestic consumers. Further, in each period t, the government receives royalties/rents from natural resources extraction/production. For analytical tractability (but without losing generality), the resource rents received in each period, Υ_t, is modelled by a two-state stationary Markov process: At a probability ϱ, there is a

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"resource boom" year and Υ_t^B is collected, whereas at a probability $1-\varrho$, $\Upsilon_t^D < \Upsilon_t^B$ amount of resource rents is collected. The expected resource rents to be collected is therefore $\tilde{\Upsilon}_t = E(\Upsilon_t) = \varrho\Upsilon_t^B + (1-\varrho)\Upsilon_t^D$. It is also assumed that the resource rents collected are net of extraction cost.[2]

In each period t, the government's budget constraint is given by

$$\tau_t Y_t + E(\Upsilon_t) + D_t - (1 + r_{t-1}^G)D_{t-1} = G_t^O + G_t^{SOE}. \tag{7}$$

Let the investment into SOEs be a constant fraction of resource rents collected, we have $G_t^{SOE} = \omega_{SOE}\tilde{\Upsilon}_t$, $\omega_{SOE} \in (0,1)$. The remainder, $(1-\omega_{SOE})\tilde{\Upsilon}_t$ is transferred to the budget. Given that the expected resource rents received by the government is $\tilde{\Upsilon}_t$, the fiscal budget in each period t equals:

$$G_t^O - \tau_t Y_t + (1 + r_{t-1}^G)D_{t-1} - D_t = (1-\omega_{SOE})\tilde{\Upsilon}_t. \tag{8}$$

1.3 Firms and Production

There are two categories of firms (POEs, SOEs), with each category i consists of a fixed mass of heterogeneous firms producing and selling sectoral output j, $q_{jt}^{i,n}$, monopolistically competitively in each period. For simplicity, we assume that the entries and exits exactly cancel out, hence there are N_E POEs and N_G SOEs in the economy. Within the same category i, each firm n of type i, $n_i = 1, 2, ..., N_i$, produces a measure $m^i(n_i)$ of sectoral output j. On aggregate, for the POEs and SOEs' total product basket, we therefore have $M^i = \int_0^{N_i} m^i(n_i)dn$, $i = E, G$.

Production involves two steps. In each period t, each firm i learns its production function and cost profiles. The firms then minimize unit marginal cost given the production they face. After that, each firm i chooses prices for the sectoral output j produced, taking the optimized unit cost as given.

The production cost function for each sectoral output j produced by firm n takes the form of

$$C_{j,t}^{i,n}(q_{jt}^{i,n}) = F_{j,t}^{i,n} + c_{j,t}^{i,n}q_{jt}^{i,n}, \tag{9}$$

where $F_{j,t}^{i,n}$ is the fixed cost and $c_{j,t}^{i,n}$ the unit marginal cost incurred by firm n of type i in producing sectoral output j.

[2]Given the empirical emphasis of this article, this specification is therefore vastly simplified in that, resource extraction is treated as an exogenously given process, hence abstracting from intertemporal Hotelling arbitrage considerations explored in studies (Pindyck, 1978; Anderson et al., 2018). The stream of resource rents can therefore be interpreted as net profits/dividend stream influenced by the two-state stochastic process.

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We solve the firms' decision process backward. Taking the optimized unit marginal cost as given, each firm n of type i chooses prices so to maximize variable profits for sectoral product j, $\Pi_{j,t}^{i,n} = (P_{jt}^{i,n} - c_{j,t}^{i,n})q_{jt}^{i,n}$, subject to the demand functions (6). With the CES utility assumption, the first-order maximization problem yields the standard constant markup optimal pricing, $P_{j,t}^{i,n} = \frac{\eta}{\eta-1}c_{j,t}^{i,n}$.

Also, given that each firm is assumed to be small within categories, all firms take the aggregate demand and price indices as given. This means the price of one firm would exert no influence on the market prices in each sector, resulting in $P_{j,t}^{i,n} = P_{j,t}^{i}$. Using (6), the indirect profits of each firm n of type i producing sectoral output j is expressed as

$$\Pi_{j,t}^{i,n} = \frac{(\eta-1)^{\theta_i - 1}}{\eta^{\theta_i}} \Lambda_i^{\eta} (P_t^i)^{\theta_i - \eta} P_t^{\eta} (1-\tau_t) Y_t (c_{j,t}^{i,n})^{1-\theta_i} - F_{j,t}^{i,n}. \tag{10}$$

The core fixed cost of a firm n in type i producing sectoral output j, $F_{j,t}^{i,n}$, is stochastic, in that, firms take draws of $F_{j,t}^{i,n}$ in each period from a distribution $\Phi_1(F_t)$. All firms, regardless of categories and sectoral varieties, are assumed to face the same function Φ_1, though the actual realized core fixed cost will differ across firms. However, as theorized and evidenced in studies such as Bjørnland and Thorsrud (2016), due to production linkages to the natural resource extraction sector, the SOEs can potentially benefit from the synergy of scale economies tied to the overall size of the natural resource production (proxied by the resource rents in each period), at a magnitude $\mu_{jn} > 0$, assumed to be different across SOE-firm n in sector j. In other words, the fixed cost of a SOE can differ across SOE-firm n in the different sector j, due to the different level of linkages across both the different sectors and firms. As such, on average, a POE has the same expected fixed cost, but not for a SOE. Specifically, for a SOE-firm n producing sectoral output j, where $j \in [0, M^G]$,

$$F_{j,t}^{i,n} = \begin{cases} F_t^{E,n} & \text{if } i = E \\ F_t^{G,n}/(\Upsilon_t^B)^{\mu_{jn}} & \text{if } i = G,\ \varrho = 1 \\ F_t^{G,n}/(\Upsilon_t^D)^{\mu_{jn}} & \text{if } i = G,\ \varrho = 0 \end{cases}. \tag{11}$$

Recall that the unit variable cost, $c_{j,t}^{i,n}$, in (9) refers to the optimized unit cost from firms' cost minimization problem. There is both a non-stochastic and a stochastic component. The former refers to the unit cost associated with the effective real rental rate on firm-specific physical capital stock, whereas the latter refers to a 'catch-all' variable cost for all other inputs. Each firm n of type i producing sectoral output j therefore has a variable production cost profile of $(r^{i,n}_{j,t}, \mathbf{c}^{i,n}_{j,t})$, with the latter, $\mathbf{c}^{i,n}_{j,t}$, drawn from a distribution $\Phi^i_2(\mathbf{c}^i_{j,t})$, $i = E, G$.

The effective real rental rate on firm-specific physical capital stock are determined as follows. For each firm n of type i, the production of each sectoral output j, q^i_{jt}, is produced by combining physical capital, $K^{i,n}_{j,t}$, and a composite of all other inputs (denoted as $N^{i,n}_{jt}$), as in $q^{i,n}_{j,t} = q(N^{i,n}_{j,t}, K^{i,n}_{j,t})$, where the production function q assumes standard neoclassical properties of constant returns to scale, diminishing marginal products, and meeting Inada Conditions.

Assuming that all firms face perfectly competitive input markets, the standard first-order conditions would yield the input ratio as a function of the ratio of returns, as in:

$$\frac{K^{i,n}_{j,t}}{N^{i,n}_{j,t}} = \kappa(\frac{\mathbf{c}^n_{j,t}}{r^{i,n}_{j,t}}). \tag{12}$$

Further, assuming symmetry in within-firm physical capital utilization across the production of different sectoral output, $K^{i,n}_{j,t} = K^{i,n}_t$, $r^{i,n}_{j,t} = r^{i,n}_t \ \forall j$, we can then write the optimized unit variable cost as $c^{i,n}_{j,t} = c(r^{i,n}_t, \mathbf{c}^{i,n}_{j,t})$, with $\mathbf{c}^{i,n}_{j,t}$ being the stochastic component and the effective real rate of returns on firm-specific physical capital stock given by

$$r^{i,n}_t = r(\frac{q^{i,n}_{j,t}}{K^{i,n}_t}) \quad \forall j, \tag{13}$$

where for a given $q^{i,n}_{j,t}$, the firm-specific unit capital rental cost, $r^{i,n}_t$, is lower the larger the firm-specific physical capital stock is.

Another systematic difference between the SOEs and POEs rests in the process of physical capital accumulation. For each private firm n $(i = E)$, a standard equation of motion is given by

$$K^{E,n}_t = (1-\delta)K^{E,n}_{t-1} + I^{E,n}_{t-1}, \tag{14}$$

whereas for a SOE n, the investment from resource rents of the government would have to be accounted for $[\omega_{SOE}\varrho\Upsilon^B_t$ during boom year; $\omega_{SOE}(1-\varrho)\Upsilon^D_t$ during a normal year].[3] Let the sum to be equally divided among the SOEs, and assuming that previous-period profits are reinvested fully into capital accumulation, we have:

$$K^{G,n}_t = (1-\delta)K^{G,n}_{t-1} + \frac{\omega_{SOE}\tilde{\Upsilon}_t}{N^G_t} + \Pi^{G,n}_{t-1}, \tag{15}$$

[3] This general specification allows for the State-financing characteristic of SOEs to be modelled, irrespective of whether one were to interpret it in the context of soft budget constraint, or in the modern corporatized form of equity-financing.

where N_t^G is the total number of SOEs.

The systematic differences across the two categories of firms mainly rest in the production cost aspects. First, in terms of the stochastic component of variable costs, the cumulative distribution function, $\Phi_2^i(c_{j,t}^i)$, $i = E, G$, differs across the two categories. Specifically, $\Phi_2^G(\cdot)$ first-order stochastically dominates $\Phi_2^E(\cdot)$, and $\Phi_2^E(\cdot)$ first-order stochastically dominates $\Phi_2^F(\cdot)$.

2 Mathematical Proof of Propositions

The proof of **Proposition 1** is trivial. The derivations of the **Propositions 2-3** are as follows.

Proposition 1: *For two firms with the same physical capital stock and facing the same capital rental cost, a typical SOE is relatively productive inefficient compared to a typical POE.*

The proof for this proposition is trivial. Based on $c_{j,t}^{i,n} = c(r_t^{i,n}, \mathbf{c}_{j,t}^{i,n})$, if $r_t^{i,n} = \bar{r}_t \; \forall i, \forall n$, given that $\Phi_2^G(\cdot)$ stochastically dominates $\Phi_2^E(\cdot)$, the unit marginal cost of a foreign firm, on average, is lower than a POE, which in turn is lower than that of a SOE.

Proposition 2: *The profits of a typical SOE is strictly increasing with respect to the natural resource rents collected by the government.*

To establish this, we need to show that, for a given expected value of resource rents, $\tilde{\Upsilon}_t$, $\partial(\Pi_t^{G,n})/\partial\tilde{\Upsilon}_t > 0$ always hold for the range of $\omega_{SOE} \in [0, 1]$. Based on (10), and the relevant information from (11)-(15), the profits of firm n within type i in time t can be rewritten as

$$\Pi_{j,t}^{i,n} = \frac{(\eta-1)^{\theta_i - 1}}{\eta^{\theta_i}} \Lambda_i^{\eta} (P_t^i)^{\theta_i - \eta} P_t^{\eta} (1-\tau_t) Y_t \{c[r(\frac{q_{j,t}^{i,n}}{K_t^{i,n}}), \mathbf{c}_{j,t}^{i,n}]\}^{1-\theta_i} - F_{j,t}^{i,n}, \tag{A1}$$

where

$$F_{j,t}^{i,n} = \begin{cases} F_t^{E,n} & \text{if } i = E \\ F_t^{G,n}/(\tilde{\Upsilon}_t)^{\mu_{jn}} & \text{if } i = G \end{cases}, \tag{A2}$$

where $\tilde{\Upsilon}_t = \varrho\Upsilon_t^B + (1-\varrho)\Upsilon_t^D$, and $c(\cdot)$ and $r(\cdot)$ are functions as expressed in $c_{j,t}^{i,n} = c(r_t^{i,n}, \mathbf{c}_{j,t}^{i,n})$ and (13) respectively.

For a typical SOE-firm n producing sectoral output j ($i = G$), differentiate (A1) with respect to the expected value $\tilde{\Upsilon}_t$, we get

$$\frac{\partial(\Pi_{j,t}^{G,n})}{\partial\tilde{\Upsilon}_t} = (1-\tau_t) Y_t \frac{(\eta-1)^{\theta_G - 1}}{\eta^{\theta_G}} \Lambda_G^{\eta} (P_t^G)^{\theta_G - \eta} P_t^{\eta} (1-\theta_G)(c_{j,t}^{G,n})^{-\theta_G} c'(\cdot) r'(\cdot) \frac{\omega_{SOE}}{N_G} + \frac{\mu F_t^{G,n}}{(\tilde{\Upsilon}_t)^{1+\mu_{jn}}}.$$

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By multiplying the numerator and denominator of the first term with $c_{j,t}^{G,n}$, we get

$$\frac{\partial(\Pi_{j,t}^{G,n})}{\partial\tilde{\Upsilon}_t} = [\Pi_{j,t}^{G,n} + \frac{F_{j,t}^{G,n}}{(\tilde{\Upsilon}_t)^{\mu_n}}](1-\theta_G)c_r'(\cdot)r'(\cdot)\frac{\omega_{SOE}}{N_G c_{j,t}^{G,n}} + \frac{\mu F_t^{G,n}}{(\tilde{\Upsilon}_t)^{1+\mu_{jn}}}. \tag{A3}$$

Assuming a standard Cobb-Douglas production functional form, we have $q_{j,t}^{G,n} = (N_{jt}^{G,n})^{1-\alpha}(K_{jt}^{G,n})^{\alpha}$, $\alpha \in (0,1)$. Cost minimization would yield (12) to be $\frac{K_{j,t}^{G,n}}{N_{j,t}^{G,n}} = (\frac{\alpha}{1-\alpha})(\frac{\mathbf{c}_{j,t}^{G,n}}{r_{j,t}^{G,n}})$. Consequently, with the assumed symmetry in within-firm physical capital utilization across the production of different sectoral output, $c_{j,t}^{i,n} = c(r_t^{i,n}, \mathbf{c}_{j,t}^{i,n})$ can be written as:

$$c_{j,t}^{G,n} = (\frac{r_t^{G,n}}{\alpha})^{\alpha}(\frac{\mathbf{c}_{j,t}^{G,n}}{1-\alpha})^{1-\alpha}. \tag{A4}$$

Likewise, (13) is just

$$r_t^{G,n} = \alpha(\frac{q_{j,t}^{G,n}}{K_t^{G,n}}). \tag{A5}$$

Substituting in the partial derivatives of the two expressions, we can write $\partial(\Pi_{j,t}^{G,n})/\partial\tilde{\Upsilon}_t$ as

$$\frac{\partial(\Pi_{j,t}^{G,n})}{\partial\tilde{\Upsilon}_t} = -\left[\Pi_{j,t}^{G,n} + \frac{F_t^{G,n}}{(\tilde{\Upsilon}_t)^{\mu_{jn}}}\right]\frac{(1-\theta_G)}{(r_t^{G,n})^{\alpha-1}}\frac{(\mathbf{c}_{j,t}^{G,n})^{-\alpha}}{(1-\alpha)^{1-\alpha}}\alpha^{2-\alpha}\frac{q_{j,t}^{G,n}}{(K_t^{G,n})^2}(\frac{\omega_{SOE}}{N_G})^2 + \frac{\mu F_t^{G,n}}{(\tilde{\Upsilon}_t)^{1+\mu_{jn}}},$$

or equivalently, since $\theta_G > 1$,

$$\frac{\partial(\Pi_{j,t}^{G,n})}{\partial\tilde{\Upsilon}_t} = \left[\Pi_t^{G,n} + \frac{F_t^{G,n}}{(\tilde{\Upsilon}_t)^{\mu_n}}\right]\frac{(\theta_G-1)}{(r_t^{G,n})^{\alpha-1}}\frac{(\mathbf{c}_{j,t}^{G,n})^{-\alpha}}{(1-\alpha)^{1-\alpha}}\alpha^{2-\alpha}\frac{q_{j,t}^{G,n}}{(K_t^{G,n})^2}(\frac{\omega_{SOE}}{N_G})^2 + \frac{\mu F_t^{G,n}}{(\tilde{\Upsilon}_t)^{1+\mu_{jn}}}, \tag{A6}$$

which is always positive for all the values in the range of $\omega_{SOE} \in [0,1]$.

Proposition 3: *On average and in any given sector j, in a period of high resource prices, a typical SOE would make higher profits compared* *to a POE, if the total resource rents generated by the government, which are used to finance SOE investments, are above a threshold value* Υ_t^C.

Proof: Assuming that $\theta_G = \theta_E = \theta$, $\Lambda_G = \Lambda_E = \Lambda$, we can derive the threshold value of "boom period" ($\varrho = 1$) resource rents as:

$$\Upsilon_t^C > (F_t^{G,n})^{\mu_{jn}^{-1}} \left\{ \begin{array}{c} P_t^\eta(1-\tau_t)Y_t\Lambda^\eta \frac{(\eta-1)^{\theta-1}}{\eta^\theta}[(c_{j,t}^{G,n})^{1-\theta} - (c_{j,t}^{E,n})^{1-\theta}]\left[(P_t^G)^{\theta-\eta} - (P_t^E)^{\theta-\eta}\right] \\ +F_t^{E,n} \end{array} \right\}^{-\mu_{jn}^{-1}}. \tag{16}$$

To derive this, first, note that the indirect profits function in period t for a POE n producing a given sectoral output j is given by

$$\Pi_{j,t}^{E,n} = \frac{(\eta-1)^{\theta_E-1}}{\eta^{\theta_E}}\Lambda_E^\eta(P_t^E)^{\theta_E-\eta}P_t^\eta(1-\tau_t)Y_t(c_{j,t}^{E,n})^{1-\theta_E} - F_t^{E,n}, \tag{A7}$$

and for a SOE firm n producing the same sectoral output,

$$\Pi_{j,t}^{G,n} = \frac{(\eta-1)^{\theta_G-1}}{\eta^{\theta_G}}\Lambda_G^\eta(P_t^G)^{\theta_G-\eta}P_t^\eta(1-\tau_t)Y_t(c_{j,t}^{G,n})^{1-\theta_G} - \frac{F_t^{G,n}}{(\tilde{\Upsilon}_t)^{\mu_{jn}}}. \tag{A8}$$

We also know that the realization of the actual resource rents during a "resource boom" period t (when $\varrho = 1$) is Υ_t^B, whereas during a normal or drought period t (when $\varrho = 0$) is Υ_t^D.

In any given sector j, for an SOE n's profits to outperform a POE n during a "resource boom" period t, we need $\Pi_{j,t}^{G,n}/\Pi_{j,t}^{E,n} > 1$. Substituting (A7), (A8), and $\varrho = 1$ into the condition and rearranging,

$$\begin{aligned} &\frac{(\eta-1)^{\theta_G-1}}{\eta^{\theta_G}}\Lambda_G^\eta(P_t^G)^{\theta_G-\eta}P_t^\eta(1-\tau_t)Y_t(c_{j,t}^{G,n})^{1-\theta_G} \\ &-\frac{(\eta-1)^{\theta_E-1}}{\eta^{\theta_E}}\Lambda_E^\eta(P_t^E)^{\theta_E-\eta}P_t^\eta(1-\tau_t)Y_t(c_{j,t}^{E,n})^{1-\theta_E} \\ &> \frac{F_t^{G,n}}{(\Upsilon_t^B)^{\mu_{jn}}} - F_t^{E,n}. \end{aligned} \tag{A9}$$

Further, if we let $\theta_G = \theta_E = \theta$, $\Lambda_G = \Lambda_E = \Lambda$, with algebraic manipulations, we can rewrite (A9) to

$$P_t^\eta(1-\tau_t)Y_t\Lambda^\eta\frac{(\eta-1)^{\theta-1}}{\eta^\theta}[(c_{j,t}^{G,n})^{1-\theta} - (c_{j,t}^{E,n})^{1-\theta_E}]\left[(P_t^G)^{\theta-\eta} - (P_t^E)^{\theta-\eta}\right] + F_t^{E,n} \tag{A10}$$

$$> \frac{F_t^{G,n}}{(\Upsilon_t^B)^{\mu_{jn}}},$$

or equivalently,

$$\Upsilon_t^C > (F_t^{G,n})^{\mu_{jn}^{-1}} \left\{ \begin{array}{c} P_t^\eta(1-\tau_t)Y_t\Lambda^\eta \frac{(\eta-1)^{\theta-1}}{\eta^\theta}[(c_{j,t}^{G,n})^{1-\theta} - (c_{j,t}^{E,n})^{1-\theta}] \left[(P_t^G)^{\theta-\eta} - (P_t^E)^{\theta-\eta}\right] \\ +F_t^{E,n} \end{array} \right\}^{-\mu_{jn}^{-1}}. \tag{A11}$$

Given that $\Phi_2^G(\cdot)$ first-order stochastically dominates $\Phi_2^E(\cdot)$, for constant mark-up pricing $c_{j,t}^{G,n} \geq c_{j,t}^{E,n}$, $P_t^G \geq P_t^E$ for any pair of average firms n. The term, $[(c_{j,t}^{G,n})^{1-\theta} - (c_{j,t}^{E,n})^{1-\theta_E}] \left[(P_t^G)^{\theta-\eta} - (P_t^E)^{\theta-\eta}\right]$, must therefore be positive. Indeed, the RHS is always positive, which means analytically there exists a positive threshold value of boom-period resource rents, Υ_t^C, for any period t considered.

Lastly, for completeness, we also establish for when $\varrho = 0$ (normal/drought period), then the relatively productive efficiency of private firm results in $\Pi_{j,t}^{E,n}/\Pi_{j,t}^{G,n} > 1$ in any given sectoral output j instead. Using (A7), (A8), $\varrho = 0$, and assuming $\theta_G = \theta_E = \theta$, $\Lambda_G = \Lambda_E = \Lambda$ again, it is straightforward to derive:

$$P_t^\eta(1-\tau_t)Y_t\Lambda^\eta \frac{(\eta-1)^{\theta-1}}{\eta^\theta}[(c_{j,t}^{G,n})^{1-\theta} - (c_{j,t}^{E,n})^{1-\theta_E}] \left[(P_t^G)^{\theta-\eta} - (P_t^E)^{\theta-\eta}\right] + F_t^{E,n} \tag{A12}$$

$$< \frac{F_t^{G,n}}{(\Upsilon_t^D)^{\mu_{jn}}}.$$

Matching this to (A10), it can be easily shown that $\Upsilon_t^B > \Upsilon_t^D$ is satisfied.

3 References

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APPENDIX B:

Supplementary Tables

Table B1: Rent Variable Definitions

Sources	Series	Description
International Monetary Fund	Resource price 1	Commodity Export Price Index, with individual commodities fixed-weighted by ratio of exports to GDP
International Monetary Fund	Resource price 2	Commodity Export Price Index, with individual commodities rolling-weighted by ratio of exports to GDP
International Monetary Fund	Resource price 3	Commodity Export Price Index, with individual commodities fixed-weighted by ratio of exports to total commodity exports
International Monetary Fund	Resource price 4	Commodity Export Price Index, with individual commodities rolling-weighted by ratio of exports to total commodity exports
International Monetary Fund	Resource price 5	Commodity Import Price Index, with individual commodities fixed-weighted by ratio of imports to GDP
International Monetary Fund	Resource price 6	Commodity Import Price Index, with individual commodities rolling-weighted by ratio of imports to GDP
International Monetary Fund	Resource price 7	Commodity Import Price Index, with individual commodities fixed-weighted by ratio of imports to total commodity imports
International Monetary Fund	Resource price 8	Commodity Import Price Index, with individual commodities rolling-weighted by ratio of imports to total commodity imports
International Monetary Fund	Resource price 9	Commodity Net Export Price Index, individual commodities fixed-weighted by ratio of net exports to GDP
International Monetary Fund	Resource price 10	Commodity Net Export Price Index, individual commodities rolling-weighted by ratio of net exports to GDP
International Monetary Fund	Resource price 11	Commodity Net Export Price Index, with individual commodities fixed-weighted by ratio of net exports to total commodity trade
International Monetary Fund	Resource price 12	Commodity Net Export Price Index, with individual commodities rolling-weighted by ratio of net exports to total commodity trade
World Bank	Real natural resources rents	Real unit resource rents, estimated based on the decomposition method of World Bank (2011).

Notes: This table contains the definitions of the 12 indicators used in the regression models.

Table B2: Industry Codes

ISIC Rev 3.1 Label	Definitions
16	Tobacco products
17	Textiles
18	Wearing apparel; dressing and dyeing of fur
19	Tanning and dressing of leather; manufacture of luggage,
20	Wood and of products of wood and cork, except furniture;
21	Paper and paper products
22	Publishing, printing and reproduction of recorded media
23	Coke, refined petroleum products and nuclear fuel
24	Chemicals and chemical products
25	Rubber and plastics products
26	Other non-metallic mineral products
27	Basic metals
28	Fabricated metal products, except machinery and equipment
29	Machinery and equipment n.e.c.
31	Electrical machinery and apparatus n.e.c.
32	Radio, television and communication equipment and apparatus
33	Medical, precision and optical instruments, watches and clocks
34	Motor vehicles, trailers and semi-trailers
35	Other transport equipment
36	Furniture; manufacturing n.e.c.
37	Recycling
45	Construction
50	Sale, maintenance and repair of motor vehicles and motorcycles;
51	Wholesale trade and commission trade, except of motor vehicles and motorcycles

Table B2 Cont'd

ISIC Rev 3.1 Label	Definitions
52	Retail trade, except of motor vehicles and motorcycles;
55	Hotels and restaurants
60	Land transport; transport via pipelines
61	Water transport
62	Air transport
63	Supporting and auxiliary transport activities; activities of travel agencies
64	Post and telecommunications
70	Real estate activities
72	Computer and related activities
74	Other business activities
93	Other service activities
95	Activities of private households as employers of domestic staff

Notes: Definitions from the World Bank Enterprise Survey.

Table B3: Detailed country and year information

Country	Year	Country	Year
Angola	2010	Côte d'Ivoire	2008, 2016, 2017
Argentina	2010, 2017	DRC	2010, 2013
Armenia	2008, 2009	Djibouti	2013
Azerbaijan	2008	Dominican Republic	2011
Bahamas	2011	Egypt	2013, 2014, 2016, 2017
Bangladesh	2013	El Salvador	2010
Barbados	2011	Eswatini	2016
Belarus	2008, 2012, 2013, 2018	Ethiopia	2015
Benin	2009, 2016	Gabon	2008
Bhutan	2009, 2015	Georgia	2013
Bolivia	2010, 2017	Ghana	2013
Bosnia and Herzegov..	2008, 2009, 2012, 2013	Greece	2018
Botswana	2010	Guatemala	2010
Bulgaria	2008	Guyana	2011
Burkina Faso	2009	Hungary	2008, 2013
Burundi	2014	India	2013, 2014
Cambodia	2016	Indonesia	2009, 2010, 2015
Cameroon	2009, 2016	Iraq	2011
Cape Verde	2009	Israel	2013, 2014
Central African Repub..	2011	Jamaica	2011
Chad	2009, 2018	Jordan	2013, 2014
Chile	2010	Kazakhstan	2008, 2009, 2013
Colombia	2010, 2017, 2018	Kenya	2013, 2014, 2018
Congo	2008	Kyrgyz Republic	2008, 2009, 2013
Croatia	2013	Lao PDR	2009, 2012, 2016, 2018

Table B3 Cont'd

Country	Year	Country	Year
Latvia	2008, 2013	Rwanda	2011
Lesotho	2008, 2016	Samoa	2009
Liberia	2008	Senegal	2014
Lithuania	2008, 2009, 2013	Serbia	2008, 2013
Madagascar	2008, 2009, 2013, 2014	Sierra Leone	2008
Malawi	2009, 2015	Slovak Republic	2008
Malaysia	2015, 2016	Slovenia	2008, 2009, 2013
Mali	2010, 2016	South Sudan	2014
Mauritania	2014, 2015	SriLanka	2011
Mexico	2011	St Vincent and Grenadi..	2011
Moldova	2008, 2013	Sweden	2014
Mongolia	2009, 2013	Tajikistan	2008, 2013, 2014
Morocco	2013, 2014	Tanzania	2013, 2014
Mozambique	2018	Timor-Leste	2009, 2015
Namibia	2014, 2015	Togo	2009, 2016
Nepal	2009, 2013	Tonga	2009
Nicaragua	2010, 2016	Tunisia	2014
Nigeria	2014, 2015	Turkey	2008, 2013, 2014
North Macedonia	2008, 2012, 2013	Uganda	2013, 2014
Pakistan	2015	Ukraine	2008, 2013
Peru	2010, 2017	Uruguay	2010, 2017
Philippines	2009	Uzbekistan	2008, 2013
Poland	2008, 2009, 2013	Vietnam	2009, 2010, 2014, 2015, 2016
Romania	2008, 2013	Yemen	2010, 2013, 2014
Russia	2008, 2009, 2011, 2012	Zambia	2012, 2013
		Zimbabwe	2011, 2016, 2017