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De-risking private power in Bangladesh: How financing design can stop collusive contracting

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ABSTRACT

Collusive contracting with private power plants in Bangladesh has resulted in high power prices that cost the taxpayer around U$1 billion in subsidies. The main driver of collusive contracting is the unwillingness of politically unconnected firms to engage in a high-risk environment. To attract investment, the government has adopted a targeted risk absorption strategy that negotiates mark-ups with interested firms. We argue that this strategy cannot discover the minimum mark-up that would induce investment. Moreover, because only politically connected investors are likely to be bidding and negotiating, this approach encourages investors to set high mark-ups. An alternative strategy is competitive risk-mitigation that provides *contestable subsidies* from development finance institutions (DFIs), such as preferential finance and partial risk guarantees. Contestable subsidies work by reducing risks of unconnected investors, encouraging their participation to make collusion more difficult, and constraining mark-ups. To test our hypothesis, we collect a dataset on plant-level DFI support and prices from 58 private power plants in Bangladesh from 2004 to 2017. Our empirical analysis finds that financing instruments with contestable subsidies from DFIs are associated with a 26% reduction in plant-level prices controlling for plant capacity, size, and fuel type.

1. Introduction

Over the last several decades, developing countries have increasingly used power purchase agreements (PPAs) with private providers to meet their rapidly growing energy demands. Since 2000, private investments in developing-country energy projects have totaled $867 billion across 4,900 projects (World Bank, 2020). Private participation has helped many countries successfully increase their generation capacity and expand electricity access to millions of people every year. However, developing countries have higher country-specific and contract enforcement risks that deter investors, and limited competition can allow significant overpricing of contracts (Dye, 2020; Eberhard et al., 2017).

Power projects involve large upfront investments with profits recovered over long periods. This requires credible contracts that are effective over time. To attract investors in high-risk contexts, one option is for governments to adopt a *targeted risk absorption strategy*. Under this strategy, negotiations are conducted with individual investors, and agreements incorporate high mark-ups to mitigate firms' risks. Targeted strategies are prevalent in high-risk environments. Since 2000, 55% of private energy investments in developing countries have been awarded through 'unsolicited bids' (World Bank, 2020). However, negotiations are unlikely to reveal the minimum mark-ups that firms would have accepted. Moreover, due to credible commitment problems in contexts of weak contract enforcement, firms without close connections to government generally stay away, leaving the field to politically connected firms. Under these conditions, mark-ups are likely to be further raised by collusion and shared between the parties.

To make power affordable under a targeted strategy, a typical response is for the public power purchaser to sell power to consumers at a lower price and have their losses covered by transfers from government. In the case of Bangladesh, collusive contracting with private plants has cost the government up to $1 billion per year in these subsidies (Ministry of Finance of Bangladesh, 2021). Additionally, collusive contracting has contributed to sectoral corruption including more expensive plants in Bangladesh receiving dispatch orders *before* lower-cost firms, preferential supply of fuel, and preferential renewals of contracts (Nikolakakis et al., 2017; Zhang, 2019).

The most effective way of discovering the lowest prices and risk-adjusted mark-ups is to make bids or negotiations genuinely

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competitive by attracting unconnected investors. But these investors are unlikely to engage unless their exposure to future contract violations can be reduced. In earlier qualitative research on the political economy of risks, mark-ups and pricing in the power sector as part of a World Bank mission to Bangladesh in 2010–11, we found that investors treated future payments that final consumers were able to pay differently from any part that had to be covered by government transfers (Khan et al., 2012). The latter triggered higher risk perceptions for unconnected investors as connections are often required to ensure timely and ongoing transfers over time. An effective approach is therefore to adopt a *competitive de-risking strategy* that reduces risks for all investors regardless of their connections by offering support that lowers generation costs to a level close to what final consumers can sustainably pay. This study focuses on two instruments used by development finance institutions (DFIs), *preferential finance* and *partial risk guarantees,* that have characteristics that can support competitive de-risking. Preferential finance provides financing at below-market rates, and risk guarantees protect investors from losses caused by non-commercial risks such as breach of contract, regulatory changes, and political violence. The subsidies implicit in these instruments can reduce the exposure of investors to future payment risks. But participation is only enhanced if the instrument is not targeted to a specific investor.

Competitive de-risking strategies can trigger interest or scrutiny from a broader range of investors, creating effective horizontal checks on the bidding process. Horizontal monitoring by competitors with the interest and capability to create real pressure is often effective in reducing collusion and corruption when formal rule enforcement is weak (Khan and Roy, 2022*)*. A targeted risk absorption strategy can attract investors, but the cost of power is likely to be much higher because competitive checks on negotiated mark-ups are much weaker.

To test the effect of contestable subsidies from DFIs on the price of electricity, we collect a novel dataset on the amount and price of power purchased from 58 private power plants in Bangladesh from 2004 to 2017. Our analysis finds that contestable subsidies were on average associated with a 26% reduction in plant-level prices controlling for government land leases (another form of subsidy), plant fuel type, plant capacity, and age. This effect is much larger than can be explained by the direct effect of these subsidies. To address possible selection bias, we also employ multivariate distance matching analysis, which matches treated and control plants based on the distance between their covariates. The findings of the matching analysis are consistent with our primary regression results in both effect size and statistical significance. We also find that when support is targeted to specific investors (and not contestable) the price effect disappears. Targeted subsidies include preferential government land leases for some power plants. The contestable nature of de-risking subsidies is therefore crucial for reducing contracted prices.

This study contributes to recent literature on corruption in the power sector in developing countries (Ahmad et al., 2022; Imam et al., 2019; Junxia, 2019, Kotikalapudi, 2016; Rimšaitė, 2019; Ryan, 2020). The study also indirectly supports recent calls for an increased role of DFIs in supporting private energy projects (Eberhard et al., 2017; Kenny, 2020). It is important to note that to have a competitive effect, DFI financing instruments have to be priced to reduce investment risk sufficiently and cannot be targeted to specific investors. The study also contributes to the related literatures on the role of DFIs in financing the transition to sustainable energy (Christianson et al., 2017; Matthaus and Mehlin, 2020; Steffen et al., 2020; Venugopal et al., 2012) and in de-risking renewable energy investments (Schmidt, 2014; Sweerts et al., 2019; Waissbein et al., 2013). De-risking strategies to mobilize private finance will be critical for expanding renewable and cleaner energy in developing countries. Our research highlights the role that development banks and climate funds can play in designing appropriate financing instruments to reduce collusion by opening up the bidding market.

The remainder of this paper is structured as follows. Section 2 discusses the design of targeted and competitive de-risking strategies in the private power sector. Section 3 formalizes the theoretical argument and presents our hypothesis. Section 4 presents the case of Bangladesh's private power sector. Section 5 and 6 present our data and empirical evidence, and the final section discusses implications and concludes.

2. De-risking strategies in the private power sector

Power projects require upfront investments with profits recovered over long periods. Standard contracts protect investors from variations in consumer willingness to pay and fluctuations in demand by implicitly matching any gaps with government transfers. Investors are therefore likely to perceive high levels of risk in contexts with weak contract enforcement. In principle, policy reforms could be targeted to improve overall governance conditions and contract enforcement. Indeed, much effort has been expended on improving transparency, making procurement processes transparent, and strengthening the rule of law. However, these policy changes have long time horizons (Khan, 2007, 2018).

To attract investors in high-risk contexts in the short- and medium-term, governments can either reduce risks for a targeted investor or for a class of investors. We, therefore, distinguish between *targeted risk absorption strategies* and *competitive de-risking strategies.* A targeted risk absorption strategy is based on negotiated risk-adjusted mark-ups with individual investors and *indirect subsidies* to absorb these mark-ups and make power affordable to consumers. In contrast, competitive de-risking strategies focus on increasing competition during the project bidding stage by offering *contestable subsidies*, such as preferential finance and partial risk guarantees, that lower production costs and are available to all potential bidders.

The most common response of governments to attract investors in high-risk contexts has been to adopt targeted risk absorption strategies. Under this strategy, governments attract investors by negotiating 'sufficiently high' risk premia into their mark-ups. The strategy is 'targeted' because the government selects one or more investors with whom to conduct negotiations. Negotiations determine prices with high mark-ups and additional targeted subsidies to induce investors to invest. Targeted subsidies can be financial or in-kind incentives. In Bangladesh, targeted subsidies have included leases of government land for the project, which reduce the direct and transaction costs of land acquisition. In addition, as the high prices contracted by government in these tenders may be much higher than what final consumers are able and willing to pay, the strategy requires that the government absorb the difference in the form of an indirect subsidy. In practice, the power purchaser combines payments from consumers with this indirect subsidy from the exchequer to pay the plant these high prices.

A central problem with a targeted risk absorption strategy in the context of a weak rule of law is that the credibility of contract enforcement with these high prices is dependent on investors' ongoing access to the government. A targeted risk absorption strategy increases the dependence of investors on the government as these high prices are unlikely to be fully paid by consumers in developing countries. Additionally, if there is a risk of a future government challenging these agreements, investors will set prices high enough to recover the investment before that happens. Thus, this strategy is only likely to attract investors who are politically connected, sometimes a single bidder in 'unsolicited' tenders. These negotiations generally result in excessively high mark-ups, particularly because collusion may allow a sharing of the rents across parties.

A more desirable alternative is a *competitive de-risking strategy* that reduces risks for all interested investors to a level where multiple investors start engaging in the market with competitive bids. A competitive de-risking strategy aims to increase competition during the bidding stage by offering forms of support that reduce specific production costs (such as financing costs) and allow plants to bid prices closer to what final consumers are willing to pay. In a context of weak governance, the economic credibility of payment is more important than contractual guarantees. Reducing the cost of capital and the risk of payment default lowers investor risk, particularly for unconnected investors. The result may be an enhanced investment flow, lower prices, and the ability to set higher technological and environmental standards.

We describe forms of support utilized in competitive de-risking strategies as *contestable subsidies.* Contestable subsidies should have three essential characteristics. First, they should reduce power generation costs and, therefore, future payment risks. Second, the form of support should be such that governments cannot easily change or withdraw the support later. Finally, and most importantly, the support should be potentially available to any competent bidder at the bidding stage and not just targeted to a preferred bidder. In the following section, we develop a model that demonstrates that contestable subsidies can plausibly attract the interest of unconnected investors, reduce collusion in setting mark-ups, and significantly reduce the true economic cost of power generation: the full cost after accounting for all forms of subsidies and support.

Two instruments used by DFIs, preferential finance and partial risk guarantees, have characteristics of contestable subsidies and support competitive de-risking. Preferential finance provides financing at below-market rates, and risk guarantees protect investors from losses caused by non-commercial risks such as breach of contract, regulatory changes, and political violence. These contestable subsidies work by attracting unconnected investors and creating incentives for information revelation. In principle, any unconnected investor anywhere in the world can now look into the tender and make an assessment. As a result, even connected investors with access to DFI funding are likely to offer lower prices in these projects to pre-empt unconnected investors challenging the DFIs for supporting overpriced projects that they could have delivered at a lower price.

Fig. 1 summarizes the differences between what we have described as a competitive de-risking strategy and a targeted risk absorption strategy. While both strategies use subsidies to address the market failure caused by high risk, they are not equivalent. The overall fiscal cost of a risk absorption strategy is likely to be much higher than a competitive de-risking strategy because the mark-ups that emerge depend on whether unconnected investors engage or not. Additionally, high collusive mark-ups that emerge with the risk absorption strategy may increase the risk of further rent-sharing arrangements with public officials that drive additional anomalies like the prioritization of dispatch orders to more expensive plants. While the details of subsidy arrangements may vary across countries, we believe the study of how subsidies affect the risks of different types of investors is of general relevance and can be adapted to apply to other high-risk contexts.

3. Subsidies, risks, and power pricing

To show how targeted, contestable, and indirect subsidies affect different types of investors (connected and unconnected), we incorporate these different types of subsidies into typical pricing equations for the power sector. Economic efficiency requires that power is sold at its marginal cost of generation. But with large fixed costs, as is typical in power generation, marginal costs may be lower than average costs, and plants may make losses with marginal cost pricing. Power pricing is therefore typically based on a fixed capacity charge and a variable charge corresponding to marginal costs. It does not matter for efficiency whether the capacity charge is passed on to consumers as a standing charge or paid from general taxation (Ramsey, 1927; Hotelling, 1938, 1939; Rhys, 2018). Prices may additionally be adjusted to account for other market failures.

The social costs of environmental damage may justify the use of taxes to further adjust the price of power upwards. However, in developing countries prices are likely to be already too high because of contracting risks. This may justify price adjustments in the opposite direction. In particular, weak contract enforcement may result in high-risk premia. If the resulting prices are perceived to be too high for final consumers, investors can stay away entirely. In these contexts, subsidies to attract private investments may be justified to improve welfare, in addition to other adjustments including different prices for different types of consumers, fuels, and times of usage (Friedman, 2009; Pikk and Viiding, 2013; Borenstein and Bushnell, 2018).

Contracts with power plants specify a combination of a fixed charge for capacity, a variable charge for energy purchase, and supplemental charges for additional specified costs like number of start-ups per month (Jones et al., 2008). Given the contracted quantity of power that the plant has to supply, this gives a more or less narrow range of fluctuation for the average price per unit of power from that plant. In Bangladesh, each type of fuel is supplied to all plants requiring it at the same subsidized price, so variations in prices across plants using the same fuel are largely due to differences in technical efficiency and mark-ups.

Risk raises the minimum mark-up acceptable to investors, but politically connected and unconnected investors face different risks. Politically connected investors face lower payment risks as they are likely to be prioritized if there are fiscal delays, but they can also negotiate higher mark-ups by informally sharing rents with public officials. Unconnected investors face higher payment risks, are less able to negotiate higher mark-ups, and are therefore unlikely to bid at all unless their risks are reduced in some way. This is of course a simplification as the degree of access is likely to vary across a spectrum of investors. For any particular generation technology (specified by fuel used, rated capacity, and the age of the plant as a proxy for time-specific factors

Fig. 1. Competitive de-risking versus targeted risk absorption strategies.

determining pricing), an investor i will bid a generation price P_i^g given by equation (1).

$$P_i^g = C_i + M - CS_i - \lambda_i TS_i \tag{1}$$

where C_i is the average generation cost for the plant, including both fixed and variable costs; M is the mark-up per unit of power; CS_i is the value of any contestable subsidy per unit; $\lambda_i \in [0, 1]$ is the quality of political connections with 1 being the most politically connected bidder and 0 an unconnected bidder, and TS_i the value of any targeted subsidy. We assume two types of investors: unconnected investors, $i = u$, and politically connected investors, $i = c$.

We assume that contestable subsidies are equally accessible to all investors if they satisfy technical and commercial conditions. In contrast, access to targeted subsidies, such as access to government land through preferential leasing arrangements, depends on investors' level of political connections. As λ_i increases, the probability of accessing targeted subsidies also increases. Mark-ups are the most important variable determining price and the mark-up level in a project depends on whether unconnected investors are participating in the bid (or may potentially enter), or not. Hence, the mark-up M in equation (1) does not have a subscript specific to the investor, it depends on the likelihood of unconnected investors participating in the competition for the project. In tenders with no likelihood of unconnected bidders entering, connected bidders collude with officials in closed negotiations to set high mark-ups. If there is a likelihood that unconnected investors may enter, competitive pressure and scrutiny by capable peers can be expected to reduce mark-ups. Equation (2) shows the mark-up achieved in a project as a decreasing convex function of the number of actual or potential unconnected investors in the bid, $n_{i=u}$, and project-specific risks R. Policy can influence the interest of unconnected bidders, but in the short term, project-specific risks in the country are largely exogenous for policy.

$$M = f(n_{i=u}, R) \tag{2}$$

If there are no unconnected investors, the project mark-up M is equal to M_{high}. If unconnected investors enter, this exerts downward competitive pressure on mark-ups. As the number of unconnected investors interested in a project increases, the project M decreases towards M_{low}. In practice, the potential entry of more than one unconnected investor may be required to significantly reduce mark-ups, but we believe that a small number of potential unconnected entrants or even only one is sufficient to constrain mark-ups in many contexts.

When mark-ups are high, the resulting high prices may have to be absorbed by indirect subsidies to the public power purchaser and through it to the relevant investors. In Bangladesh, the public power purchaser buys from private producers at plant-specific prices P_i^g, but sells on to distribution companies at a policy-determined price P^s, which may be lower than P^g for high-cost plants. When it is lower, the power purchaser makes a loss on the transaction, which is covered by government transfers to it, which constitute an indirect subsidy IS_i to each high-priced generator.

$$IS_i = P_i^g - P^s \tag{3}$$

The entry of unconnected investors is therefore the variable that breaks down collusion and reduces mark-ups (equation (2)), but this can only be achieved if unconnected investor risks $r_{i=u}$ can be sufficiently reduced. An important determinant of $r_{i=u}$ is the extent to which investors are dependent on ongoing transfers from government and this depends on the gap between the price $P_{i=u}^g$ at which unconnected investors can generate power relative to the sustainable selling price P^{ss} they believe consumers are able to pay. The sustainable selling price, P^{ss}, is not the same as the policy-determined selling price P^s at which power is actually sold; it may be higher or lower. Investors are more concerned with what consumers in that market can sustainably pay, which depends on their real purchasing power. For instance, the policy-determined price may have to be adjusted downwards in the future if effective demand collapses or there are political pressures from struggling consumers. The distinction between P^{ss} and P^s also clarifies that the problem does not disappear if governments raise the policy-determined selling price P^s to the average cost of generation as this does not guarantee that consumers can actually pay. Investors may still not be paid without government transfers.

If $\frac{P_{i=u}^g}{P^{ss}}$ is much higher than 1, the unconnected investor is open to the risk of non-payment by customers, making them dependent on indirect subsidies. Without political and administrative connections, they are likely to be at the back of the queue in case of any payment problems. While there are other project-specific risks R, this component of risk can be reduced with policy. Given that P^{ss} is a subjective estimate that can be equal to or different from P^s, $r_{i=u}$ is only likely to be reduced by reducing $P_{i=u}^g$, the price at which the unconnected investor can generate power.

$$r_{i=u} = f\left(\frac{P_{i=u}^g}{P^{ss}}, R\right) \tag{4}$$

By contrast, for politically connected investors, the risk of non-payment is not sensitive to the gap between their generation price and what consumers can pay, because, depending on their connections, they can ensure that indirect subsidies will be released and bills paid on time. Indeed, they prefer to set the highest mark-ups that government will accept so that their investments are relatively rapidly recovered. Their risk depends on the quality of their connections, λ_i, and on context and project-specific factors R.[1]

$$r_{i=c} = g(\lambda_i, R) \tag{5}$$

Taken together, these relationships imply that even small contestable subsidies can reduce risk perceptions of unconnected investors sufficiently to enable them to participate, resulting in significantly lower mark-ups and prices. The relationships are summarized in the following figures. First, Fig. 2 shows how contestable subsidies reduce risks for unconnected investors. Contestable subsidies reduce the price $P_{i=u}^g$ at which unconnected investors can generate power (in equation (1)), and this reduces their risk perception $r_{i=u}$ (in equation (4)). The figure shows $r_{i=u}$ as a non-linear decreasing function of $\frac{P_{i=u}^g}{P^{ss}}$. The risk perceptions $r_{i=c}$ of connected investors are not sensitive to contestable subsidies (equation (5)) but is plausibly lower than risks facing unconnected investors. If the

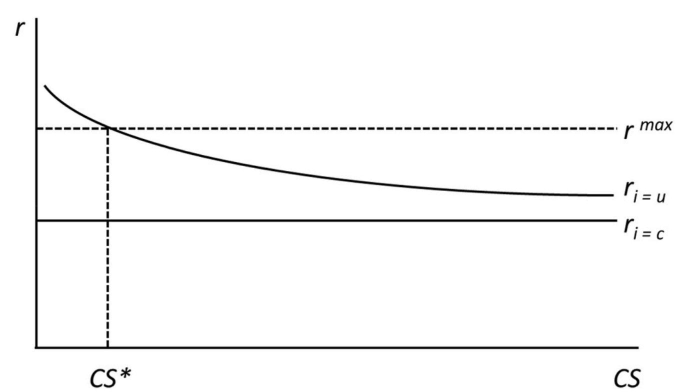

Fig. 2. Contestable subsidies and investor risk.

[1] We model the risk functions of unconnected and connected firms separately in equations (4) and (5) to guide the reader through the theoretical differences in risk for the two investor types. The two equations can be simplified as $r_i = f\left[(1 - \lambda_i)\frac{P_i^g}{P^{ss}}, R\right]$. We thank an anonymous reviewer for making this suggestion.

maximum risk any investor is willing to accept is r^{max} in Fig. 2, contestable subsidies above the level *CS** allow unconnected investors to participate. If contestable subsidies are absent or below *CS**, only connected investors participate. The level of contestable subsidies required to break collusion is therefore not necessarily very high and can itself be discovered in practice by offering higher levels of financing support till unconnected participation is triggered and the prices that are bid or negotiated are much lower.

Secondly, Fig. 3 shows that the potential entry of unconnected investors constrains the mark-ups of *all* investors (equation (2)). Lower mark-ups result in lower generation prices for *both* types of investors (i = c and i = u) and therefore lower prices. Projects with contestable subsidies higher than some minimum level *CS** should therefore have significantly lower prices regardless of the type of investor who wins the contract.

Finally, the effect of contestable subsidies on power prices is *not* just the arithmetic effect of the subsidy being passed on in lower prices, but also an additional effect due to mark-ups being reduced through an anti-collusion effect. Subsidies can be provided in different ways to power producers and the true economic cost of power is the generation cost plus all of these subsidies. Our analysis shows that how subsidies are structured has a significant impact on their true cost. Power generators may get a combination of contestable and targeted subsidies (*CS* and *TS* in equation (1)) and additional indirect subsidies *IS* through the power purchaser (equation (3)) when their generation prices are higher than the prices at which power is sold to consumers. To see the interdependence of these three types of subsidies, Fig. 4 shows what happens to *IS* when either *CS* or *TS* increase. If the last two subsidies had no effect on mark-ups, an increase in either would result in an equivalent reduction in generation prices (equation (1)) and therefore an equivalent reduction in indirect subsidies *IS* passed on through the power purchaser (equation (3)). The equivalence or constant mark-up hypothesis is shown as the 45-degree line in Fig. 4. In this world, subsidies do not affect the true economic cost but shift the burden across consumers, taxpayers, and different types of power producers.

In reality, the type of subsidy can have a large effect on mark-ups. If the subsidy is targeted and only goes to a privileged investor, the latter is also likely to be able to negotiate prices that absorb most or all of the subsidy in higher mark-ups. In this case, the flat line in Fig. 4 shows how increases in *TS* may simply increase mark-ups, leaving prices and *IS* unchanged. Increasing targeted subsidies, therefore, results in a higher overall subsidy burden. Moreover, the full economic cost of power is likely to be much higher than required to attract the investment as the mark-up is not minimized. We described this as the targeted risk absorption strategy. In contrast, relatively small contestable subsidies of *CS** could trigger new participation by unconnected investors, reduce mark-ups, and result in a more than equivalent decline in prices and *IS*. Contestable subsidies can therefore *reduce* the full economic cost of power and the overall fiscal burden of subsidies. We described this as the

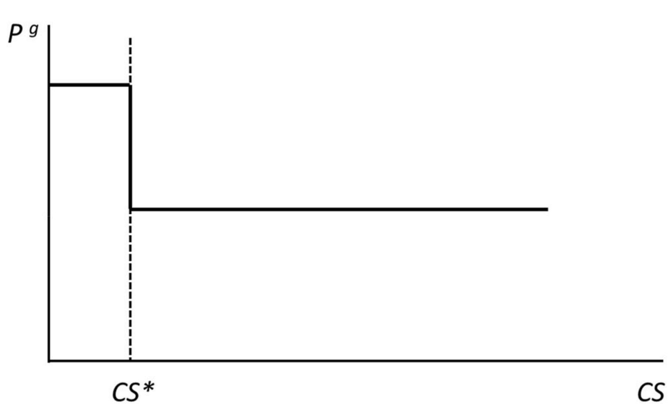

Fig. 3. Effects of contestable subsidies on generation prices.

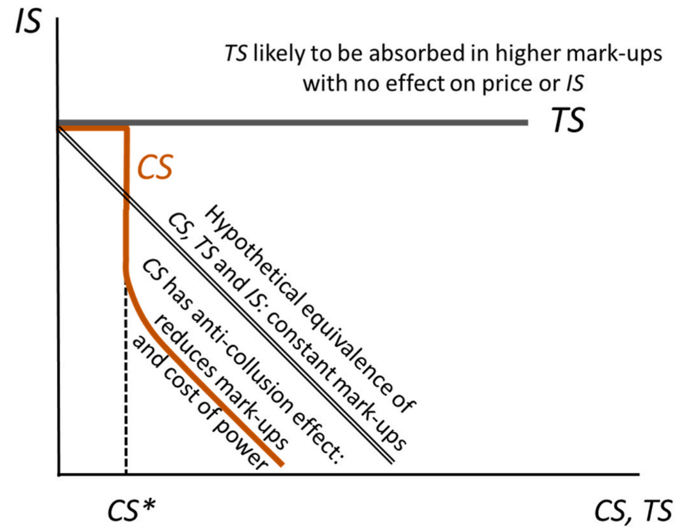

Fig. 4. The competitive effect of contestable subsidies.

competitive de-risking strategy.

Putting these observations together, we have the following hypotheses:

H1. Contestable subsides, such as preferential finance and risk guarantees from DFIs, reduce generation prices of private power plants.

H2. The reduction in prices associated with contestable subsidies is greater than the value of the subsidies.

H3. Targeted subsidies (like subsidized access to land) do not have an equivalent effect on generation prices.

4. Private power generation in Bangladesh

Bangladesh was an early adopter of private investments in the power sector in the late 1990s. In the early 2000s, the first two private power projects came on stream and achieved some of the lowest independent power prices in South Asia (Pargal, 2017). These were the 450-MW Meghnaghat and 360-MW Haripur gas-powered plants. Both projects received preferential financing and partial risk guarantees from DFIs. Both contracts were won by the American company AES Corporation, but ownership changed hands several times since then, without affecting the prices specified in the initial contract.

Based on calculations published by the World Bank, the direct effect of the subsidized finance in the first two projects could account for a reduction in the unit cost of power of around 5 percentage points. The direct effect depends on the proportion of the project cost covered by the loan and the rate differential with market interest rates. A benchmark calculation for Bangladeshi power plants prepared by AT Capital Research for the World Bank (World Bank, 2010) shows that if as much as 70% of the project cost of a plant of the size of Mehgnaghat or Haripur was covered over 15 years at an interest rate 5% lower than the market alternative, the average price per kilowatt-hour (kWh) would be reduced by around 16% (World Bank, 2010, 165). In comparison, the Meghnaghat plant received only 16.7% of its project finance as a loan from the ADB at a LIBOR + spread interest rate that was around 5% below the local market rate. It also received 26.7% of its capital from the Infrastructure Development Company Limited (IDCOL), a local non-bank financier, but at terms close to market rates. Thus, less than 44% of total project financing (rather than 70%) came from DFIs and the average interest rate advantage was only around 2–3%. The Haripur project had a direct loan from the IFC for only 22% of the project value and an IFC syndicated loan for 8% of project value at international market rates that were around 4–5% lower than local market rates. Once again, the overall support was much lower than the benchmark calculation by AT Capital Partners. Partial risk guarantees through DFIs may have a further small effect on the terms achievable for other financing. Compared to the 16% estimate in the benchmark calculation, DFI support in the Meghnaghat and Haripur projects would arithmetically reduce the cost of generation by around 5–7 percent at best. The real effect of the support was rather to reduce the risk for investors, attracting politically unconnected investors to bid. It also opened up potential competition, and the constraint on mark-ups had a much greater effect on pricing than the direct effect.

The role that subsidized financing played in these projects was not recognized. On the contrary, as the first two tenders achieved very low prices, this was interpreted by the World Bank and others as evidence that preferential DFI financing was not required for private power. Contestable subsidies in DFI financing instruments were largely withdrawn in the 2000s and only available on a smaller scale in the 2010s from the IFC, the Multilateral Investment Guarantee Agency (MIGA) (both part of the World Bank Group), and German and Dutch development banks. Bidders in subsequent power projects had to arrange market financing to a much greater extent. The withdrawal of these instruments was associated with the exit of most politically unconnected bidders in the mid-to-late 2000s.

The withdrawal of preferential credit by DFIs was followed by a drying up of investor interest in the mid-2000s, resulting in a severe power crisis. Generation capacity flatlined from 2004 to 2008, coinciding with a period of rapid economic growth. The only interest in new private projects came from politically connected companies, and conflicts between them frequently blocked or delayed contracts. Frequent power cuts and shortages contributed to a political crisis. An emergency caretaker government took over from 2007 to 2009 and introduced short-term rental power contracts as a crisis measure. These attractive contracts absorbed risk by offering investors high prices and targeted subsidies, often in unsolicited bids. Investors in small power projects could recover their investments in two to five years through enhanced capacity charges paid as rentals. However, even these measures were insufficient to address the scale of the problem. The new government elected in 2009 went further by abandoning competitive tendering altogether in the *Speedy Supply of Power and Energy Act* in 2010. This institutionalized a risk absorption strategy by creating a legal framework allowing one-to-one negotiations between government and investors to set prices and conditions that were sufficiently attractive for investors. The problem was that these negotiated prices were very likely to be collusive, with high mark-ups and sharing of rents. Yet even in this environment, a few projects continued to get small amounts of preferential financing from DFIs and we can test the effect of these small contestable subsidies.

The *Speedy Power Act* increased private power production at the cost of much higher prices. There was a rapid growth in the number of private power plants. Initially, these were rental and small Independent Power Producer (IPP) projects, which grew from 17 to 36 from 2010 to 2018. Larger IPP projects began to come on stream after 2014, with 34 projects by 2018. From 2010 to 2018, installed private capacity grew from 1,878 to 6,196 MW, increasing from 33.6% to 41.2% of Bangladesh's total capacity. Peak private power generation also grew after the *Speedy Act* from 1,301 MW to 2,846 over the same period. However, the increase in generation capacity was also driven by a significant increase in the number of plants utilizing dirtier fuels such as furnace oil and diesel. From 2010 to 2018, the percent of power generated from furnace oil increased from 12% to 34% and diesel from 4% to 10%. In contrast, the percent of private power generated from gas, the cleaner alternative, decreased from 84% to 56%.

Fig. 5 shows the rapid growth in average purchase prices of the Bangladesh Power Development Board (BPDB) from private plants from 2008 to 2018 (BPDB, 2018). This is the average of plant level P^g discussed in section 3. The BPDB is the public purchaser buying power from private producers and selling on to distributors at wholesale rates. The

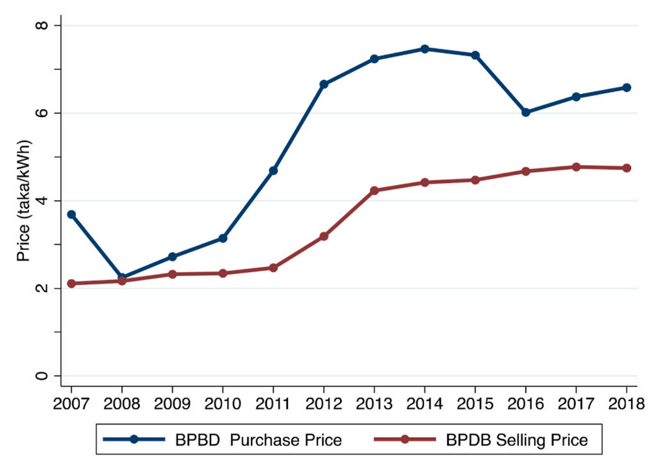

Fig. 5. Power Purchaser's (BPDB) buying and selling prices for private plants, 2007–18.

average price of private electricity generation more than doubled from 2010 to 2018. Despite a steady increase in BPDB's selling prices, the policy-determined price P^s could not be raised as fast as the rapidly rising prices emerging from the targeted risk absorption strategy. The gap between the lines in Fig. 5 shows the growing losses of the BPDB that were covered by indirect subsidies to pay the plants. The annual deficit of the BPDB grew from around \$87 million in 2008 to more than \$1 billion in 2015 and 2019 driven by increases both in the quantity of power purchased and the deficit per unit of power (Ministry of Finance of Bangladesh, 2021).

The new high-priced plants used their excess profits in rent-seeking strategies to capture even more rents. Nikolakakis et al. (2017) found that more expensive gas-fired plants received *more* orders than cheaper ones. Merit order dispatching would normally mean ordering from the cheapest plants first, then sequentially from more expensive ones, with the most expensive supplying peak loads. Nikolakakis et al. estimate that dispatching by merit order would have saved the government \$1.4 billion or 63% of the payment to gas-fired plants. A misallocation of this magnitude is unlikely to be an accident. More likely it represents the ability of more expensive plants to use some of their excess profits to influence the allocation of orders and enhance profits further. Higher-priced plants were also allocated subsidized fuel in preference to cheaper plants whenever there were shortages. Zhang (2019) estimates that a 1% increase in a private plant's fuel efficiency resulted in a 1.2% *decrease* in its probability of getting gas controlling for plant age and capacity.

These systematic anomalies show that overpriced contracts generated rents that were used to influence further distortions and generate more rents. The \$1.4 billion estimate of unnecessary overpayments for gas-based power is just part of the annual cost of collusion because it only covers gas-powered plants. Other anomalies were also observed. Contracts with high-cost rental power plants often stipulated that if they were not given orders for power, they would still be paid for 60% of the power they could have produced. These large capacity charges created incentives for interested parties to arrange for orders *not* to go to these plants as profits were larger by not producing. These attractive terms were repeatedly renewed for some companies while others like the British company Aggreko had their contracts renewed with 'no power, no payment' clauses, showing that plants without political connections were treated differently (Byron and Rahman, 2014). Finally, public-sector plants that could generate cheaper power appeared to remain out of commission for suspiciously long periods, requiring base loads to be supplied by expensive private plants (Pargal, 2017).

The *Speedy Power Act* did have some justification as an emergency response that was intended to last for no more than two years. However, even if the government had wanted to, going back to open tendering required persuading unconnected investors to participate. But no appropriate strategy was in place. The Act was therefore repeatedly renewed and is currently being extended until 2025. Legislation makes it illegal to subject decisions under the Act to legal challenges. The rents that emerged have clearly created interests within government, bureaucracy, and investors to prolong these arrangements.

5. Data

To test our hypotheses, we examine the effect of contestable subsidies on plant-level power prices adjusting for fuel type, generation capacity, and time-dependent characteristics. We collected data on the price and quantity of power purchased from 58 private power plants in Bangladesh from 2004 to 2017 from annual reports of the BPDB. Based on this data, we calculated the average plant-level purchase price per kilowatt-hour over this period. The average plant-level price per kWh was 9.30 takas, ranging from 1.41 to 24.81 takas across plants. From the annual reports, we also collected control data for each plant including its date of commissioning, installed capacity, and the type of fuel used. The average age of plants is 7.3 years, and the average generation capacity is 75 MW, 45% are gas-based, 43% use furnace oil, and the remaining 12% use high-speed diesel (HSD).

To measure our independent variable, we conducted a survey with the Bangladesh Independent Power Producers' Association to identify plants that had received financing from DFIs with characteristics of implicit contestable subsidies. We supplemented the survey data with interviews with power-sector specialists at the World Bank in Dhaka and independent power sector consultants. Preferential financing and/or partial risk guarantees from DFIs were counted as instruments with built-in contestable subsidies. However, all forms of DFI support do not provide contestable subsidies. For example, we exclude support from the World Bank's Investment Promotion and Financing Facility (IPFF). The IPFF provides interest-free loans to the Bangladesh Bank, which then provides credit to commercial banks, which in turn lend to power projects. As the loans are ultimately made by local banks at standard commercial rates, there is no subsidy element in these loans. Similarly, we exclude lower-interest credit provided by export credit agencies (ECAs), because the risk mitigation benefit is restricted to a particular supplier from the exporting country and their importing partner and so is not contestable.

DFIs and other financial institutions providing financing with characteristics we define as contestable subsidies include the International Development Association (IDA), IFC, ADB, MIGA, IDCOL, the German Development Finance Institution, and the Netherlands Development Finance Company. As discussed further below, the availability of financing with contestable subsidy characteristics varies across projects for reasons that appear to be related to the internal financing cycles of financial institutions and not to types of technologies or the characteristics of investors. Finally, as interest rates and breakdowns of project financing are commercially sensitive data, we cannot estimate the value of the contestable subsidy for each plant. Instead, we use a binary variable to indicate the presence or absence of such support in each plant. Of the 58 private plants in our sample, 13 plants, or 20%, had access to financing satisfying our conditions. The contestable subsidy implicit in DFI financing was less generous in subsequent projects relative to the first two plants discussed earlier. But the level was sufficient to have a significant effect on contracted prices.

Our survey also captured information on government land support. The low-rental leases that some investors received from the government are targeted subsidies. We utilize a binary variable equal to 1 if a plant received a land lease from the government: 27 plants, or 46% of the total, had such leases. A final type of government support comes through fuel subsidies. Fuel for plants is provided by the government at below-market prices. Power purchase contracts in Bangladesh also have a pass-through clause so that most changes in fuel prices do not affect plants. All private plants using the same fuel get it at the same price. There are no variations in this subsidy across plants, so we do not control for fuel subsidies.

Identifying the political connections of current owners is not required for our analysis. We only need to test the effect of instruments that trigger potential competition to affect prices. In our analysis, contestable subsidies lower prices regardless of whether the winning bidder is politically connected or not. Nevertheless, we asked a leading financial journalist to identify the political links of private plant owners. Almost all current owners have *some* political links, but external observation cannot identify the strength of these links and the potential for collusion. Moreover, many plants changed hands several times after commissioning, and it would be difficult to trace these histories. Fortunately, plant-level prices appear to hold to the original contracts even if ownership changes to politically connected parties. All we need to know is whether contestable subsidies were available at the time of contracting.

Lastly, our dataset does not indicate that access to contestable subsidies through preferential financing is a function of political connections. There are a small number of players in the Bangladesh power sector, and many of the firms that have received DFI support are known to be politically connected companies. This is important because if DFIs only extended contestable subsidy support to companies without political connections, the lower prices in these projects may simply have reflected a selection bias preventing collusive price-setting. In reality, the same connected companies got DFI support in some projects and not in other similar projects, and their pricing was different across these projects. The factors that determined if one of several financing institutions would provide financing with these characteristics in particular projects appear to be linked to the timing of projects, the funding cycles of agencies, and the initiative of insiders within the funding bodies. The observation that selection was *not* based on the political status of companies allows us to exclude this as a control variable affecting the selection of treatment groups.

6. Results

Our empirical analysis estimates the following model:

$$\textit{Price per kwh}\ (\log)_i = \beta_1 \textit{DFI Support}_i + \beta_2 \textit{Land Support}_i + \lambda w_i + \varepsilon_i \tag{6}$$

where *Price per kwh*$(\log)_i$ is the average logged price per kilowatt-hour for plant i over the study period 2004–2017; *DFI Support$_i$* is a binary variable capturing if a plant received preferential finance or risk guarantees from a DFI that satisfied our contestable subsidy characteristics; *Land Support$_i$* is a binary variable capturing if a plant received a government land lease; w_i is a vector of plant-level controls; and ε_i is the error term. Control variables are included for plant age (to control for time-variant contracting conditions), generation capacity (log), and fuel type. Equation (6) is estimated with ordinary least squares with robust standard errors.

Table 1 reports the regression results. Model 1 includes the primary specification and estimates the average treatment effect of DFI support controlling for land support and plant characteristics. The results find that DFI support has a negative and statistically significant effect on plant-level prices. For an otherwise typical power plant, DFI support is estimated to reduce prices on average by 26%. Because the dependent variable is in log form, the percentage change in prices associated with DFI support is calculated by $\exp(\beta_1) - 1$. This estimated effect size is much higher than any plausible arithmetic effect of DFI support and, thus, consistent with our competitive risk-mitigation mechanism. Recall that across projects lower financing costs and risk guarantees can plausibly explain a lower cost per unit of electricity of around 5% in the plants that received support. Therefore, the much greater reduction in actual plant-level prices has to be explained by competitive pressures on

Table 1
Determinants of private power plant pricing.

	Dependent Variable:	
	Price per kwh (log)	
	(1)	(2)
DFI Support	−0.307***	−0.214*
	(0.108)	(0.123)
Land Lease Support	0.098	0.141
	(0.082)	(0.095)
DFI Support * Land Lease Support		−0.233
		(0.230)
Plant Age	0.001	0.001
	(0.009)	(0.009)
Plant Capacity (log)	0.035	0.065
	(0.071)	(0.080)
Plant Fuel Type		
Gas	−1.906***	−1.883***
	(0.129)	(0.146)
HFO	−0.493***	−0.501***
	(0.120)	(0.133)
Observations	58	58
R-squared	0.882	0.885

Note: *p < 0.10, **p < 0.05, ***p < 0.01. Robust standard errors are reported in parentheses. The excluded fuel type is Diesel.

mark-ups triggered by this instrument.

Turning to the control variables, we do not find that land lease support from the government has a significant effect on private power prices. This is consistent with our hypothesis as land leases are not contestable subsidies that can trigger greater competition. Next, as expected, gas- and HFO-powered plants are estimated to have lower prices relative to diesel-powered plants. Lastly, plant age and capacity are not estimated to have a significant effect on prices after accounting for forms of support and fuel type.

Model 2 interacts DFI support with land lease support to examine if targeted subsidies can mitigate risk if packaged with contestable subsidies. For ease of interpretation, the marginal effects of DFI support with and without land lease support from Model 2 are summarized in Fig. 6. Fig. 7 summarizes the marginal effects of land lease support with and without DFI support. Starting with Fig. 6, the marginal effect of DFI support in projects without land lease support is estimated to be a 19% reduction in prices. For projects with both DFI support and land lease support, the marginal effect is estimated to be a 36% reduction in prices. Both marginal effects are significant at the 10% level.

In Fig. 7, we estimate that the marginal effect of land lease support in projects without DFI support is a 15% *increase* in prices. In projects with DFI support, the marginal effect of land lease support is estimated to be a 9% reduction in prices. However, neither marginal effect is statistically

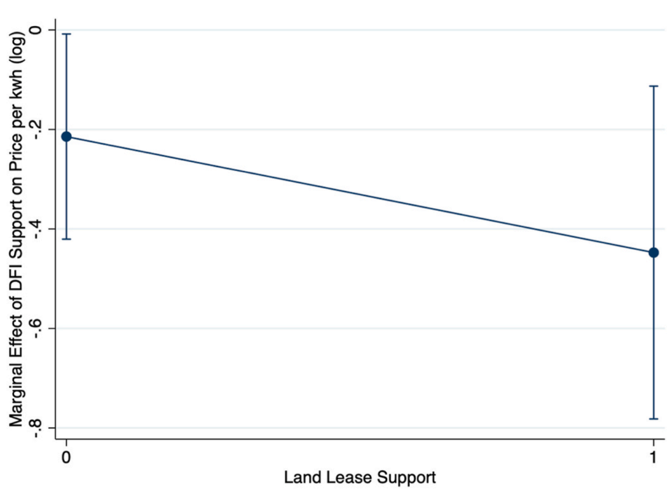

Fig. 6. Marginal Effect of DFI Support on Prices by level of Land Lease Support.

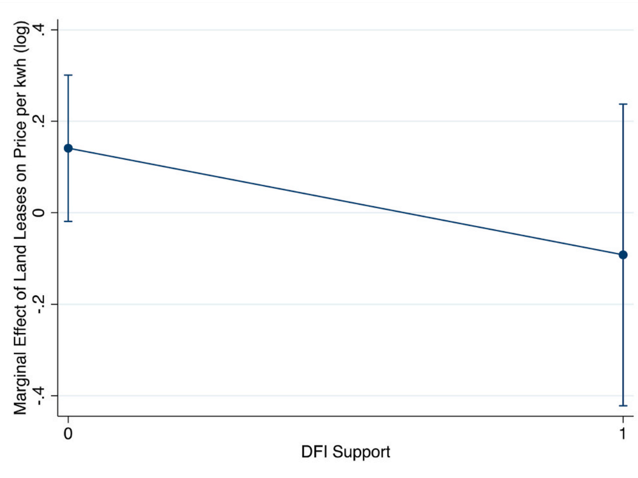

Fig. 7. Marginal Effect of Land Lease Support on Prices by level of DFI Support.

significant. The findings suggest that the use of government land lease support alone is not sufficient to reduce power prices, which is what we expect for a targeted subsidy. Additional research is needed to discern if governments can supplement contestable subsidies from DFIs with land leases to create a package of contestable subsidies that have an even bigger impact in de-risking investments.

Regression analysis cannot satisfactorily adjust for the possible co-determination of our independent and dependent variables. To address this concern, we employ Mahalanobis distance matching (MDM).[2] MDM is a general form of multivariate distance matching that allows for the correction of possible selection bias by creating a multivariate space of covariates and matching treated and controls units based on the distance between observations (Diamond and Sekhon, 2013). In contrast, propensity score matching (PSM) works by pairing units that have similar propensity scores, which measures the probability of treatment assignment (Rosenbaum and Rubin, 1983). Because propensity scores reduce the entire covariate distribution into a single dimension, two plants with similar propensity scores will not necessarily have similar covariate values. In our application, we believe it is vital that treated and control observations are matched based on plant fuel type and generation capacity. Additionally, MDM is considered to be more efficient, have less model dependence, and improve covariate balance relative to PSM (King and Nielsen, 2019). For these reasons, we elected to use Mahalanobis distance matching in our robustness analysis. It is important to note that matching can be only done on the observable characteristics, which might still leave us with selection bias due to unobservable plant characteristics.

Table 2 presents the results using the Mahalanobis distance nearest neighbor matching method with bootstrapped standard errors. Nearest

Table 2
Treatment effects from multivariate-distance matching analysis.

Treatment variable	ATT on plant-level price (log)	Standard error	z-score	% change in price due to treatment
DFI Support	−0.293**	0.146	−2.01	−25%

Note: The treatment effect is estimated using Mahalanobis distance nearest neighbor matching method with bootstrapped standard errors. Control variables include land lease support, plant age, capacity, and fuel type (gas, HFO, and HSD). The dependent variable is the log of plant-level prices. The actual percentage change in prices is calculated by exp(ATT)-1.

[2] We use *kmatch* in Stata. See Jann (2017) for technical details.

neighbor matching involves running through the list of treated units and selecting the closest eligible control unit to be paired with each treated unit. Land lease support, plant age, capacity, and fuel type are used to match treated and untreated units. All 13 treated units in the analysis were matched. Our parameter of interest is the average treatment effect on the treated (ATT). The results confirm that DFI support has a negative and statistically significant effect on plant-level prices. DFI support is estimated to reduce plant-level prices by 25%, compared to 26% estimated in the regression analysis. This estimate of the ATT is significant at the 5% level. Thus, the findings of the matching analysis are consistent with our primary regression results in both effect size and statistical significance and increase confidence in our primary analysis.

7. Conclusion and policy implications

Collusive contracting with private power plants in Bangladesh has resulted in high power prices that cost the taxpayer up to US$1 billion a year in subsidies, as well as the selection of environmentally damaging fuels and technologies. The overpriced plants are also prioritized in dispatch orders and fuel supplies because their high mark-ups allow them to corruptly influence these decisions. The collusion and corruption in the sector can be attributed to many factors, but most of these are not amenable to feasible policy variables. For instance, the collusion could be correctly attributed to the absence of competitive tendering and the enforcement of procurement rules, but this does not identify a feasible policy response in an environment with high risks and weak governance that unconnected investors stay away from.

To identify a feasible policy variable (one that is implementable in the political and economic context and has the desired effect), this study develops a theoretical model of how the design of de-risking strategies impacts the willingness of firms to invest in high-risk environments. Different types of investors, depending on their political connections, perceive the risks associated with payments from a loss-making public purchaser very differently. The more their payments depend on transfers from the government, the greater the risk perceived by unconnected investors. By modeling these differences, we identify a risk-mitigation strategy that can increase the probability that unconnected investors become potential entrants. Risk can be reduced by providing subsidized financing and risk guarantees that any potential investor can access during the bidding phase. By reducing payment risks, potential competition can be enhanced at the bidding phase. This opens up scrutiny by peers who have an interest and ability to monitor, and collusion appears to become less serious as expected. The price reduction in these contracts is more than can be explained by the support provided.

The empirical analysis presented in this study demonstrates that contestable subsidies from DFIs can and do function as competitive risk-mitigating instruments in Bangladesh's private power sector. We find that relatively small contestable subsidies reduced average private power prices in Bangladesh by 26%. Due to their substantial effect on prices, these contestable subsidies could be regarded as public co-investments in power with a high social return rather than subsidies. While the details of subsidy systems can vary across countries, we believe our finding that it is possible to use financing design to reduce risk and attract a broader pool of investors to break down collusion is of more general applicability.

Contestable subsidies are not opposed by powerful players because they involve DFIs, because preferential financing is clearly a 'good thing' and because risk-adjusted mark-ups are still available but are now competitively determined. Many powerful business groups engaged in the sector have both treated and untreated plants in their portfolio. When policy creates a more competitive environment, connected companies are able to deliver better prices, and still make sufficient profits. We find no evidence that the provision of preferential financing and risk guarantees has been strongly opposed by any actors. Instead, broadening the availability of these incentives to cover more projects may work to change the behavior of existing players in a more productive direction, as many connected firms have already demonstrated in particular projects. If widely implemented, the subsidies can significantly reduce costly fiscal transfers to the public power purchaser, which is the most direct measure of the social cost of collusive pricing. In addition, reducing collusive excess profits can also reduce secondary corruption driving further anomalies in dispatch orders, distortions in gas supplies, the choice of inferior technologies, and other decisions that add to the social cost of the collusive power market. Finally, looking beyond the Bangladesh power sector, we believe that the competition-enhancing effects of different types of contestable subsidies should be examined more closely in the post-COP26 world. Private investments have to be competitively attracted in a wide variety of green energy and infrastructure projects in contexts with high contracting risks. Designing appropriate forms of competitive de-risking strategies may be a powerful way of accelerating this process by reducing the overall cost of these projects.

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CRediT authorship contribution statement

Mushtaq Khan: Conceptualization, Investigation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing, Visualization, Project administration, Funding acquisition, Supervision. **Mitchell Watkins:** Conceptualization, Investigation, Methodology, Software, Validation, Writing – review & editing, Visualization. **Iffat Zahan:** Investigation, Resources, Data curation.

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