ASIAN INFRASTRUCTURE
INVESTMENT BANK

ASIAN INFRASTRUCTURE FINANCE 2022

MOONSHOTS FOR THE EMERGING WORLD

Building State Capacity and Mobilizing the Private Sector Toward Net Zero

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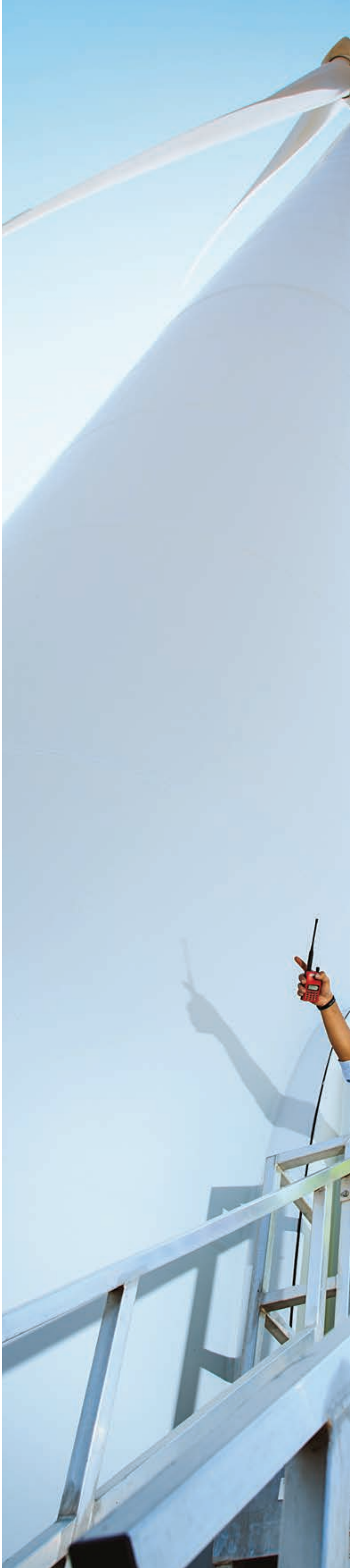

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ABBREVIATIONS

AIIB	Asian Infrastructure Investment Bank
BOO	build-own-operate
BOT	build-operate-transfer
bps	basis points
CCS	carbon capture and storage
COVID-19	coronavirus disease
EMDE	emerging and developing economy
ESG	environmental, social, and governance
ETS	emission trading system
FDI	foreign direct investment
GDP	gross domestic product
GFC	Global Financial Crisis
GHG	greenhouse gas
GVC	global value chain
ICT	information and communication technology
IEA	International Energy Agency
IMF	International Monetary Fund
IPP	independent power producer
MDB	multilateral development bank
MOF	Ministry of Finance
MSME	micro, small, and medium-sized enterprise
NDB	national development bank
OECD	Organisation for Economic Co-operation and Development
PPA	power purchasing agreement
PPI	Private Participation in Infrastructure
PPP	public-private partnership
PV	photovoltaic
R&D	research and development
SOB	state-owned bank
SOE	state-owned enterprise
SOFI	state-owned financial institution
SOHC	state-owned holding company
SWF	sovereign wealth fund
UK	United Kingdom
US	United States

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FOREWORD

Today's economic challenges are many. A lingering pandemic, high commodity prices, disrupted energy markets, stressed supply chains, and geopolitical tensions, to name a few. Furthermore, in 2022, the development challenges experienced by our members are increasingly being shaped by the impacts of climate change and natural disasters. Rolling heat waves, droughts, and floods across our globe serve as a stern warning that climate change is not slow-moving, as it used to be erroneously assumed. The environmental disasters of 2022 paint a grim preview of what's to come unless we act decisively to transform our global economy into a net-zero reality.

This issue of the Asian Infrastructure Investment Bank's (AIIB) Asian Infrastructure Finance (AIF) report is about the net-zero transition. It surfaces today's uncomfortable realities, details the outstanding gaps that must be overcome to reach net zero, and identifies opportunities available for doing so. For the globe to reach carbon neutrality, governments must use every tool at their disposal including, critically, effective engagement with the private sector. This year's AIF report offers some of the data, concepts, and policy ideas required to accelerate the net-zero transition for all. The sustainability of our global economy depends on an unswerving commitment from all members of the international community

Ultimately, governance is key to achieving a net-zero transition. At AIIB, we attach great importance to high standards of governance and adherence to our core values. From day one, AIIB has been committed to transparency, integrity, and accountability. Our governance model was designed to enable our ambitious aspirations. We have learned from other multilateral development banks (MDBs) and introduced innovative governance practices that allow us to operate as a modern 21st century MDB.

AIIB was conceived in a new era. This is in an era where countries and international organizations are reexamining what they must do to secure humanity's future before planetary systems destabilize beyond a tipping point. Making this challenge harder, this is also an era where global economic integration, despite driving unprecedented growth in living standards, is now suffering regular setbacks. The unequal distribution of globalization's benefits has polarized high-income and lower-income countries, complicating critical global cooperation.

The old playbook is no longer relevant. Global economic institutions must focus on getting fit. This new era demands the muscular reshaping of systems and policies that originally led to the global inequity we see today. At AIIB, this means we are exploring new ways to raise the bar for environmental and social governance while preserving the positive institutional features that have lifted millions out of poverty.

The development experiences of emerging and developing countries matter. This year's report highlights just some of the unique policy insights and strategic approaches that offered by a closer examination of emerging and developing countries. It is for this reason that developing countries deserve representation in international organizations more commensurate with their rising economic weight. Not only is this the just thing to do, it enriches global governance with new development paradigms. It is for this reason that AIIB's governance was structured to give developing members a larger voice. With the planetary stakes so high for humanity, all ideas that help achieve sustainable development—no matter how unconventional for some—should be food for thought and digestion. The novel practices identified in this year's report should be carefully assessed for inclusion in the climate change mitigation and adaptation toolkit.

We at AIIB embrace fresh ideas and diverse concepts. Resolving the tension between contradictory views provides greater insight into the true nature of an issue. This better enables us to formulate policies and strategies that support members' efforts to realize their net-zero pathways. Emerging and developing economies deserve more than just access to necessary financial and technical support to address the legacies of environmental injustice. They also deserve more attention, as their experience offers policy lessons that can help the global collective to realize our moonshot toward net zero.

In today's era, improving debt sustainability is all the rage, but it cannot be just a passing fad. Any debt overhang should be addressed with the long term in mind and new money should be provided. For many developing countries, debt financing remains an effective method to fund the critical infrastructure required for economic and social development. Creditors and debtors in both the public and private sectors must work in close collaboration to help highly indebted countries navigate out of the economic woods. As ever, sustainable growth remains the most assured long-term pathway away from indebtedness. However, help must be offered to highly indebted countries to ease their debt service burden today so as to protect their investment in infrastructure for tomorrow. In this regard, it is incumbent upon all of us—AIIB and its members—to ensure fiscal policies allow space for remedies when government borrowing unfortuitously misaligns with national economic cycles.

As a member of the MDB community, AIIB will continue to play its part to deal with the past, managing the present, and most importantly, building the future. Like many other peer institutions, AIIB lost no time in providing urgently needed finance to help safeguard our members' economies and livelihoods in the face of COVID-19. In our uncertain era, one of the lingering pandemic disruptions and rising geopolitical tensions, we remain prepared to respond swiftly to help members who may fall prey to the volatile global economic conditions ahead. Our institution's message is clear: we are here with you, and we will not fail you. We offer our unqualified commitment to stand with our members as we support their efforts to build green infrastructure for tomorrow—the world's realization of a net-zero future depends on it.

Jin Liqun
President and Chair of the Board of Directors
Asian Infrastructure Investment Bank

PREFACE

Putting global development on a path that respects planetary boundaries —and yet allows citizens in emerging and developing economies to realize their potential—is the challenge of our generation and those to come. It involves dealing with many interrelated stresses at once: rising global temperatures, rapidly declining biodiversity, falling water tables, increasing soil erosion, and escalating risks of zoonotic diseases, among others. The longer we postpone this adjustment, the tougher the task for our children and grandchildren.

The 2022 Asian Infrastructure Finance report is about the climate dimension of this challenge—the net-zero transition—to achieve zero net emissions of greenhouse gases globally by 2060. State capacity and private sector resources will be tested everywhere, but most of all in countries where they are most scarce. These are also the countries most likely to suffer from climate change. The challenge includes building resilience for what could potentially be a chaotic transition with very unequal outcomes within and across countries.

With emerging and developing economies facing strong headwinds from rising debt levels and increasing costs of borrowing, the net-zero transition will only gain traction with a convincing economic logic and a strong social foundation. As in many advanced economies, the net zero transition should be conceived of as a moonshot—with inspirational once-in-a-generation projects based on mission-driven approaches to addressing fundamental societal challenges. The rich countries which created the problem in the first place should live up to their commitments to help finance these projects.

Rather than pitting economic development against climate change mitigation and adaptation, the net-zero transition strengthens the arguments for traditional development efforts to build state capacity, foster private sector development and strengthen technology adoption, now driven by the need to decarbonize the economy. The rapid emergence and dissemination of new green technologies offer exciting opportunities to reskill workers, change land use and repurpose organizations, but to be supported at the outset and sustained over time this transformation must be perceived as just.

Governments must leverage all the instruments at their disposal—state-owned enterprises (SOEs), state-owned financial institutions (SOFIs), and contracts with the private sector. They will need to reduce the carbon footprints of the SOEs and SOFIs and encourage them to invest in renewables and new technologies. Sovereign wealth funds and national development banks will have to help crowd in private investment in green infrastructure and stimulate green innovation.

Net zero cannot be achieved without active private sector participation. Partnerships with private companies can allow the state to benefit from their skills, capital and dynamism. Exactly how these contracts should be structured and managed will depend on the local context, but transparency and proper governance are essential. These partnerships require state capacity to function well, but over time they can also help the state increase its ability to implement complex projects

In some areas, coordination above the level of an individual company will be necessary, not least when it comes to shaping infrastructure investment. Take, for instance, the electric vehicle industry where energy and transport infrastructure come together. Decisions are strongly interconnected, between makers of batteries, power utilities and car producers, and interacting with government regulations and infrastructure provisions (e.g., charging network).

The net-zero transformation will also require mission-driven, "moonshot" industrial policies for the broader economy. There are many useful examples to study. Singapore, for example, is building an intricate ecosystem where many dedicated government entities are working in close coordination with state-sponsored financial institutions and the private sector to achieve the net-zero target. We can learn from the sense of common purpose that permeates these institutions.

But it is such coordination efforts that place the greatest demand on state capacity. They often involve prioritization across sectors and technologies, inherently difficult choices for governments to make and very vulnerable to outside influence and political capture. Working with development partners on so-called country platforms, as discussed in the report, could provide one important way to build state capacity and support countries in their transition to net zero.

The report points to numerous opportunities for multilateral development banks (MDBs) to help reduce the carbon footprint of SOEs and encourage investment in renewables and other technologies that promote the transition. Similarly, MDBs can work with SOFIs to lower climate risk in their portfolios and identify opportunities to decarbonize investee companies. They can also help balance public-private partnerships and other forms of contracting between the state and private sector.

Finally—and this presents the most difficult but also the greatest potential—MDBs can help catalyze and support higher-level coordination within and across economies to encourage green innovation and reduce greenhouse gas emissions. Ultimately, of course, the net-zero transformation must be backed up by global cooperation. The MDB community has a huge responsibility to make sure that we continue building from the achievements in Paris and Glasgow. We will need several "moonshots" to protect the planet and the species under our care, but the net-zero transformation is the most immediate one that we must now all embark on together.

Erik Berglof
Chief Economist
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EXECUTIVE SUMMARY

The net-zero transition is increasingly characterized as a "moonshot," a once-in-a-lifetime inspirational project requiring a mission-driven industrial policy with coordination across all parts of the economy, and in the end globally. However, many emerging and developing economies (EMDEs) are at risk of being left behind. It is not only about access to finance and appropriate technologies to address problems they did little to cause, but also about the ability to absorb these resources. Reaching net zero in time will be the greatest challenge for state capacity to date for these economies. This report is about how to deploy existing and build new state capacity, often in conjunction with the private sector, to accelerate green innovation and the transfer of technologies—and ensuring as smooth and as fair a transition as possible.

The net-zero transition will require a major step up in state capacity to transform state institutions, to enable and crowd in private companies and institutional investors, and to coordinate across the net-zero value chains. This report examines the main "tools" available to the state-owned enterprises (SOEs), state-owned financial institutions (SOFIs) and private-public partnerships (PPPs)—and their potential to drive the net-zero transition. It also tries to better understand patterns of green innovation, in particular the scope for enhancing innovation and technology adoption in EMDEs. This report further discusses the net-zero context for three large economies in Asia—China, India and Indonesia—without which a successful global net-zero transition cannot succeed.

State-owned institutions must go from laggards to leaders in the net-zero transition. This report shows that SOEs and SOFIs today have a heavily oversized carbon footprint. These institutions remain critical in the development paths of many EMDEs. Hence, governments must enhance the governance and net-zero mandates of these institutions, to accelerate phasing out of fossil fuel assets, invest in green infrastructure with their advantageous financial capacity, and actively foster green innovation as well as green technology adoption across the value chains. The alternative is for these institutions to be locked out from key markets and being saddled with stranded assets no longer commercially viable due to changes in price of greenhouse gas emissions.

State capacity should be viewed as a form of societal infrastructure needed to support the reform of SOEs and SOFIs as well as to implement the wider policy framework necessary to achieve carbon neutrality. Stronger state leadership can also help catalyze the net-zero transition of the private sector which can contribute much more with the right conditions. The report shows that PPPs can bring the skills and dynamism of the private sector, even reinforce state capacity. The PPP experience differs by country contexts and the report identifies key conditions for their success. In the energy market for example, improved regulations have brought about more PPP investments in renewable energy. Nevertheless, there have also been disappointments caused by inconsistent policy frameworks.

Green innovation and technology adoption is at the center of the net-zero transition. Innovation will be needed to scale up existing technologies and take new technologies to underserved markets. For EMDEs adaptation and imitation are often the cheapest and most effective way of increasing efficiency and decarbonizing the economy—what matters is the cost of greenhouse gas emissions in the country. The report analyzes patent data to understand present trends for green innovation. There is much more that EMDEs can do to innovate and acquire the technologies required for green production, but also what the global community can contribute by making these technologies available and providing financial support for the acquisition and absorption.

A meaningful carbon price (beginning with the removal of subsidies to fossil fuels) will be a litmus test of commitment to the net-zero transition. It is a key to solving the twin externalities—one to reduce production and consumption of fossil fuels, and to ensure sufficient incentives for innovation and research and development investments. It will ensure that what comes out of various policy interventions will continue to be economically viable and consistent with net zero. A carbon price will not be sufficient on its own—additional mission-driven coordination within and across sectors will be necessary. Such industrial policies will be particularly challenging in economies where state capacity is in short supply. Efforts to finance technology transfer and green innovation must be combined with efforts to build state capacity using both top-down reforms and bottom-up initiatives.

The net-zero transition faces key dilemmas in the short term. Geopolitical tensions, with their impact on energy prices, has given new urgency to addressing energy access and security. There is a risk of a "beggar thy neighbor" energy policies. Global coordination must ensure that green technology, finance, and raw materials are availed or traded equitably, and must be combined with targeted support for the poorest and most vulnerable. This will be important for global consensus, especially for a just transition. Even more so than for the pandemic, the effects of climate change are truly global and cross-border in nature. Unless the whole world is collectively successful, no country can avoid the heat. Global cooperation will be transformative for the fight against climate change.

CHAPTER 1

OVERVIEW: TRANSFORMING FOR NET ZERO

No growth is sustainable unless consistent with net-zero greenhouse gas (GHG) emissions. Human activity is threatening the health of many of the Earth's critical ecosystems and the capacity of the biosphere. The global community is thus facing its biggest challenge to date in bringing down the concentration of GHGs in the atmosphere to a sustainable level. The current speed and forcefulness of action will not be sufficient to hold the increase in the global average temperature even below 2°C above pre-industrial levels set out in the Paris Agreement. There is the possibility of passing systemic tipping points with potential catastrophic impacts.

It is important to reiterate that climate change mitigation is a global public good where every contribution adds up and in equal measure! [see Sandler (2005), Buchholz & Sandler (2021)]. This is thus a collective effort and an individual country's responsibility. Each country will undoubtedly approach the net-zero transition in its own way, starting from where it is today and using the tools at its disposal. But as a global community, all will have to achieve net zero within a few decades.

This will test the ability of economies to transform themselves to operate within planetary boundaries, requiring unprecedented mobilization of state and private sector resources. Infrastructure and innovation will be at the heart of this transformation. Imagine this: Mostly electric vehicles (EVs) on roads in a few decades, and a vast network of charging infrastructure will replace petrol stations. All fossil-fuel infrastructure—production platforms, pipes, and power plants—will be either mothballed or retrofitted to work with renewables, batteries and clean hydrogen. Understanding this capacity to change, what this report terms transformational capacity, goes to the very heart of the ability of economies to sustain growth and development over time.

Many countries, including those in Asia, have undergone dramatic transformations throughout their economic development. Infrastructure is often at the center of it (Asian Infrastructure Investment Bank, 2020). There is evidence that countries that grow more rapidly at lower levels of income also tend to grow faster at higher levels of income, suggesting that they have different transformational capacities (Bulman, Maya, & Ha, 2017). This capacity, which includes the ability of the state to develop and work in partnership with the private sector, is part of a wider notion of state capacity.

1.1 The Transformation Challenge and Role of Infrastructure

The structural transformation challenge for an economy involves moving from where it currently finds itself to the world institutional frontier in terms of technology and how they organize production, like legal capabilities, organizational structures and support for markets. In the process, there is a shift from investment as the source of growth to innovation becoming the main driver. Emerging and developing economies (EMDEs) are, by definition, some distance away from the frontier.

The challenge for today's EMDEs involves shifting to the global frontier both in terms of technology—from adoption to genuine innovation —and the organization of production. Doing so requires changing economic structures and the accompanying institutions while staying within environmental and social constraints.

Consistent with net zero, green infrastructure is the cornerstone of all sustainable production and economic activity. Here, EMDEs have the notional advantage of building sustainable infrastructure from the onset instead of dealing with legacy infrastructure that can be hard to retrofit. Conversely, addressing today's infrastructure gaps with investments in unsustainable technologies will be no development shortcut but a "long cut" with more difficult adjustments ahead.

The case of infrastructure investment is particularly interesting because it is a sector that straddles the state and the private sector. At one end of the spectrum are models of concentrated state ownership directing infrastructure investments. At the other end are market economies that shifted away from regulation investment towards price regulation - an approach that is now being rethought in the face of the climate challenge.

In advanced economies, the credo of the 1980s and 1990s was "privatize, privatize, privatize." In retrospect, this simplistic messaging addressed obvious inefficiencies in public infrastructure but was not, in the final analysis, sufficient to create the optimal conditions for infrastructure development. Infrastructure quality in many advanced economies has started to degrade as a result. This inefficiency is even more acute in the context of net zero, given the large local and global externalities which require state involvement.

Can state actors alone be trusted to advance the net-zero transformation? Experience in many EMDEs shows states or state-owned enterprises (SOEs) are playing leading development roles but often with mixed or poor results. Furthermore, this report (like others) finds that SOEs are still investing in fossil fuel infrastructure significantly, often supported by state-linked finance. The heightened concerns around geopolitical risks, energy security, and the need to sustain economic recovery post-pandemic will likely accentuate this in the short run. Unless emissions are fully captured and stored, fossil-fuel infrastructure must be dramatically phased-out over the medium term.

Most economies operate somewhere between pure market or pure state-led infrastructure development. Experience differs greatly, particularly across EMDEs. Many transition economies, for example, started with almost exclusive state ownership of infrastructure but today have a range of public and private contracting arrangements. The private sector also plays a significant role especially when it comes to credibly meeting contractual commitments on project development, innovation and the operation of assets.

1.2 State Capacity as a Driver for Change

State capacity is based on two essential features. The first is fiscal capacity. While governments worldwide have improved and increased their ability to raise taxes, many EMDEs face unsustainable debts partly because the state cannot raise resources or enforce fiscal rules.

The second part of state capacity is legal or productive capacity and, more generally, its ability to generate economic growth. Economic growth is desirable because it allows for even more tax extraction. Productive capacity is also obviously essential to realize the full potential of infrastructure investments and innovation [see Besley & Persson (2009), Besley & Persson (2014b)]. An important aspect of state capacity is about anticipating market failures and finding ways to address them successfully with effective regulation while maintaining the benefits from competition.

It Is not surprising, therefore, that economies with lower state capacity will also face greater difficulty in the net-zero transition. The literature on strengthening state capacity is vast, but a key attribute is the common interest that drives the demand for and builds public goods. The fight against climate change is such a common interest, suggesting that the net-zero transition offers an opportunity to build the institutions necessary for the state to deliver on its functions to mobilize domestic resources and increase economic prosperity.

When a state can deliver public goods to large parts of its population, it enlarges the economic pie. Public goods provision creates opportunities to raise revenues further and drive investments in growth-inducing activities. This is all part of building a "common interest society." In short, state transformation depends on building a culture of high-quality public goods provision and a population willing to support these public goods.

In the context of net zero, public support rests on the population being fully aware of the effect of climate change and willing to make short-term sacrifices to build sustainable infrastructure before global disasters strike. Importantly, common interest rests on the net-zero transition being fair—that is, a "just transition," within and across countries. The key features of the net-zero transformation also contribute toward a "common-interest" society globally.

1.3 Risk Sharing and Governance of the Private Sector

State capacity alone would not be sufficient, for so many facets of the economy should rightly be market-driven and in the private sector domain. Many infrastructure sectors cannot do without a competitive marketplace's financial capacity, innovation, and sheer market dynamism to drive their development. The information and communication technology (ICT) and the digital and EV sectors are vivid demonstrations of this. The fast-moving digital infrastructure and application space requires dynamic market players.

Of course, when it comes to transforming infrastructure, the state plays a vital role in planning and creating the enabling conditions. All infrastructure projects require a coherent, long-term vision and policy stability before private sector participation can be viable. EVs can only reach their potential when state infrastructure plays its full part.

Two major risks in infrastructure investment are associated with construction and demand—how long it will take to build and how much it will cost, and what demand there will be for these services. Here state and private sector investment complement each other. However, the largest risk is changes to the policy framework regulating infrastructure. For example, in the energy sector, regulation is critical to the returns from investment. At least until recently, renewables relied heavily on subsidy schemes.

Some areas of infrastructure, like electricity and water, weigh heavily on the budgets of poor households and, for that reason, may become vulnerable to political cycles. All this introduces uncertainty for investors and makes investments harder to finance. As a result, the risk-sharing arrangements between the state and the private sector will have to be perfected, and the solution will necessarily be different in each society.

Beyond risk sharing, the relationship between the state and the private sector in infrastructure also depends heavily on governance. The literature on public-private partnerships (PPPs) is vast. Finding the correct balance of governance involves identifying and internalizing public externality onto private investments. Unfortunately, on many occasions, PPP investments have become very expensive compared to public funding because of pricing risk and other extra costs. This results in increasing costs and deteriorating service due to budget cuts. As a result, more broadly, PPP and infrastructure privatization have earned a bad name, slowing down infrastructure investment despite huge and rapidly growing needs.

To guide the transformations of the state and the private sector to work in tandem, finding new ways of mobilizing capital and sharing risks while keeping in mind the pressures of transformation are key. For example, it is not enough to build hospitals; it is also essential to create pressures to improve how they operate and ensure that broader health policies are conducive to achieving key objectives, like lower child mortality and longer life expectancy for the entire population. For net zero, the ability of PPPs and the private sector to internalize the climate impact of their investments would be critical. An appropriate carbon price, still absent or set at too low a level in many EMDEs, would be a much-needed policy tool to drive this.

1.4 Accelerating Innovations for Transition

As the report highlights, the net-zero transition cannot succeed without massive breakthroughs in innovation and the commercialization of new technologies. To hold the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels, technologies that reduce GHG emissions and those that can take GHGs out of the atmosphere are needed. Some of these are in the market but not yet scalable, while others are not yet market-tested at all. But equally important is the diffusion of these technologies, particularly to emerging and developing economies.

More broadly, innovation is central to productivity growth because it incorporates imitation, adaptation, and genuine innovation of products, processes, and ways of organizing that are truly sustainable to the global economy. Moreover, innovation helps bring about new technologies that can lead to even more innovation, such as in the fields of intellectual property, research and development (R&D) policy regulation, and competition policy.

Net-zero innovation is essentially like innovation more generally. What generates innovation in economies and individual firms also helps generate green innovation—and what hampers innovation also frustrates the green transition. Government policies and strategic decisions by firms should be guided by the same principles that encourage innovation elsewhere in the economy to move toward net zero.

As noted throughout the report, it is crucial to get right the interplay between the transformational pressures on the state and the mobilization of the private sector. The challenge is also to channel these pressures into green innovation and provide additional incentives for market participants to work with the state on mission-driven industrial policies. Environmental and social constraints should increasingly steer technological development and adoption toward sustainability.

Many policy tools must be used together in a coordinated fashion with state guidance as these are global externalities, not just for individual firms' profits, market shares, or any single country's competitive advantage. Again, a carbon price can help fix this innovation externality by encouraging more innovation in green technology and discouraging innovation in unsustainable sectors. Carbon pricing should also be supplemented by a broad range of policies, including planning, regulation, financial system governance, corporate governance and competition policy, all of which places high demands on state capacity.

1.5 Transforming through Cooperation

This Asian Infrastructure Finance 2022 report has sought to identify the various types of transformational capacity of institutions and structures to spur infrastructure investments and innovation toward the net-zero transition. The report interrogated the sources of this transformational capacity, asking how the state can enable the private sector to develop and, in turn, how to strengthen state capacity. A state's transformational capacity comes largely from its ability to interact with and learn from the private sector.

The successful transformation from investment-led to innovation-led growth, from carbon-intensive to net-zero modes of production, requires systemic shifts involving both the state and the private sector. Such a systemic change will be a "moonshot" that requires cooperation between the public and the private sectors. The ability of an economy to encourage and direct such coordination is at the heart of transformational capacity.

During the pandemic, the development of the vaccines—Operation Warp Speed—demonstrated how the public and the private sectors came together to produce successful vaccines at a record speed. Millions of lives were saved as a result of having viable vaccines. Yet, it was equally true that the vaccine rollout globally was far from successful or equitable, and no doubt many lives were unnecessarily lost. This antecedent holds a key lesson for the net-zero transition—to be truly effective everyone must be brought along and incentivized to contribute fairly.

Geopolitical tensions are intensifying. Concerns over energy security are rising. Competition for renewable energy resources and raw materials to support renewable industries, is increasing. It has to be constantly reinforced that no state can avoid the worst of climate change unless others are equally successful in their net-zero transformation. Even more so than coronavirus disease (COVID-19), climate change is truly global and borderless. A high degree of trust, empathy, and international cooperation will be needed for climate finance to be made available to less-developed economies and for green technologies to be diffused quickly and widely across all economies. Global cooperation will be transformative for the fight against climate change.

CHAPTER 2
STATE CAPACITY AND CLIMATE ACTIONS

This chapter reviews the role of state capacity in promoting green and sustainable development. First, the chapter presents a brief overview of the current climate vulnerability and its relationship with state capacity. Economies vary widely in their current level of climate vulnerability, affecting how exposed they are to the negative consequences of climate change and the appropriate policy responses. State capacity is the ability of governments to increase the range of feasible policies that can be implemented. And this helps increase state effectiveness in promoting development, innovation, and building trust in government to ensure that the government and private sector work together to solve policy challenges.

Second, the chapter links state capacity and climate action. Unfortunately, the most climate-vulnerable economies also suffer from low state capacities, and the lack of capabilities may prevent them from building resilience in critical sectors. Most economies with long-term development strategies to address climate change have high state capacity. Overall, state capacity can be an important limiting factor in addressing the causes and consequences of climate change and preparing a green transition toward low-carbon economic growth. Reforms and capacity building will be needed to address this constraint.

2.1 How Resilient Are Economies to Climate Change Hazards?

The Notre Dame Global Adaptation Initiative (ND-GAIN) Vulnerability Index is a standard indicator that measures a country's exposure to climate change hazards and dependency on major life-support sectors that would be directly impacted by climate change (food, water, health, ecosystem services, human habitat, and infrastructure). The ND-GAIN Index, therefore, captures both ecosystem vulnerability (e.g., flood hazard risks) and the resilience of social structures to respond to it (e.g., water dependency ratio, disaster preparedness).

Economies are unequally affected by climate vulnerability as illustrated by Figure 1, with a higher score indicating higher vulnerability to climate change. While the average vulnerability across all AIIB members is close to the world average of 0.44, scores vary widely across countries. For instance, Malaysia, New Zealand, Türkiye and New Zealand are seen as less vulnerable to climate change hazards than Afghanistan, Bangladesh and Myanmar.

These differences in current climate vulnerability help inform debates about policy actions. More vulnerable countries would strongly benefit from adaptation responses that build resilience in critical sectors most affected by climate change (for instance, by reducing the share of the population impacted by sea level rises). On the contrary, countries with more climate resilience tend to prioritize mitigation strategies that support a low-carbon economy.

Moving from indices like this to climate action is a big step. First, this needs to be done on a case-by-case basis in terms of the specific vulnerabilities faced. Second, there is a need to formulate and execute a clear plan of action. This must be done in the context of a clear understanding of the states' capability to act. In some cases, this is a binding constraint, and meaningful climate action may require investing in state capacities or at least working with institutions capable of supporting and implementing policy change. Either way, understanding state capacities is essential for doing policy reform work.

2.2 What Is State Capacity and Why Does It Matter?

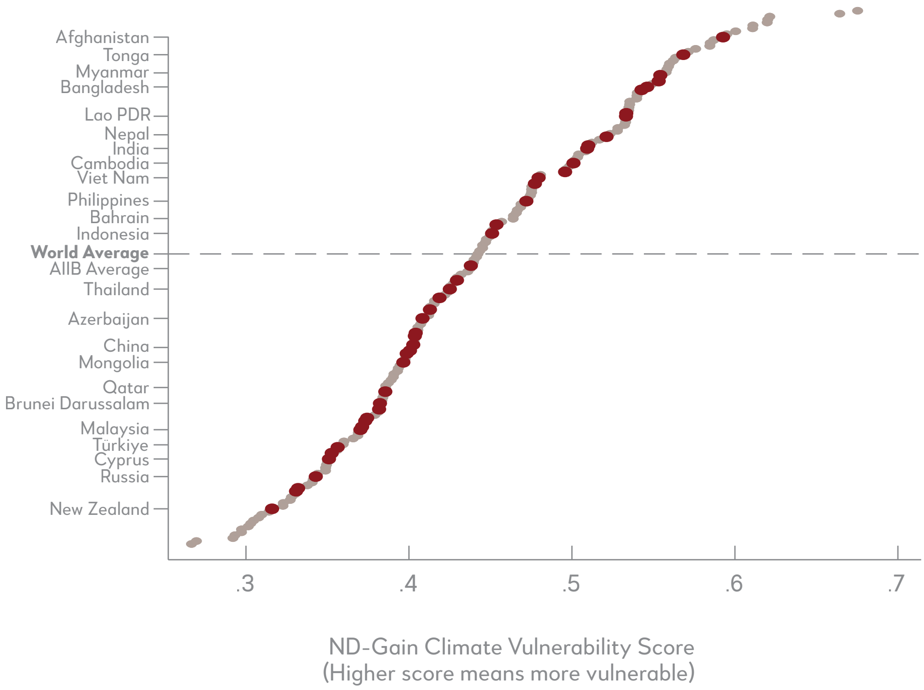
2.2.1 The Dimensions of State Capacity

State capacity is a form of investment but more like investing in "intangible" infrastructure rather than physical assets. It requires improvements in organization, increases in professionalization, and changes in how the state goes about its business, including how parts of government strategize and communicate. Various definitions of state capacity have been put forward for conceptual and measurement purposes (Box A).

These boil down to a focus on a government's ability to (a) increase its range of implementable, feasible policies, and (b) achieve its intended policy goals. The quintessential example is "fiscal capacity," which refers to the ability of the state to increase tax revenues to fund public goods and services for its citizens (Besley & Persson, 2011). The power to tax and raise the revenues needed to make government effective has always lain at the center of state capacity. Many early contributions to understanding state capacity simply used the term interchangeably with what the chapter terms "fiscal capacity." The newer literature stresses a much wider set of capacities.

Studying state capacity is an exercise in political economy because it is built on an understanding of how government works and less on an idealized vision of government in terms of how one would like it to be. And much literature in policy economics simply assumes the presence of an effective state rather than analyzes how the supporting structure is created that makes the policy implementable and effective.

Figure 1: Distribution of Climate Vulnerability



Data source: Besley et al. (2021).

For example, in the case of fiscal capacity, while one can develop a theoretical framework to motivate tax reform, what is the actual political process by which any policy can be successfully realized? What incentives would governments have to administer such a reform?

This is not just about abstract debates. Many regard introducing and implementing a carbon tax as vital in mitigation strategies, supporting a green energy transition. But defining the tax base and monitoring compliance, as well as resisting voter backlash and reform reversal, are important practical issues before any realistic policy can be put in place. Moreover, policymakers must think more long term about domestic resource mobilization, encouraging domestic savings, and building an institutional investor base managing these savings and investing them in assets driving the net zero transformation.

State effectiveness is inherently multidimensional. Besley & Persson (2011) emphasized the state's ability to support markets by enforcing contracts and protecting property rights, which is central and requires effective court and regulatory systems; they refer to this generically as "legal capacity." Such capacity is fundamental to establishing an effective market economy by supporting a thriving business environment to encourage the entry of new firms, as in models of "creative destruction" alongside private investment. Both are essential for economic growth. As discussed below, there is increased discussion on how new forms of state capacity or changing orientation of existing organizations is needed to support the green transition.

A third core dimension is "collective capacity." This refers to the ability of the state to turn resources into public goods and services for citizens, such as increasing life expectancy and augmenting educational attainment to decreasing infant mortality. Thus, state capacity can encourage human flourishing and increase individual capabilities (Sen, 1999). This is relevant to climate action, given the many forms of infrastructure investment needed to support climate action.

A possible fourth dimension, not often discussed in the literature on state capacity, is the capacity of state institutions to transform themselves. Institutions must change as the economy's structure and the level of technology change.

Transformation capacity is also related to legal capacity. But it deals with the ability of the government bureaucracy at different levels and parts of the system to innovate, whether through genuine innovation or, more commonly, by adapting or imitating ways of organizing themselves from other parts of the world. This dynamic sense of state capacity or institutional innovation will be critical to the net-zero transformation.

Although multidimensional, many dimensions of state capacity share a common origin, and state capacities reinforce each other. For example, building a market economy and a broad-based tax system go hand in hand. Greater fiscal capacity permits greater expenditure on public infrastructure, goods, and services for citizens, thus augmenting collective capacity. What helps a bureaucracy promote economic growth through increased productivity will also likely help foster green innovation. Measures of state capacity tend, therefore, to cluster across space and accumulate over time [see Besley & Persson (2014a), Besley et al. (2021)].

The policy effectiveness of many states worldwide is limited by their ability to raise taxes, provide public goods, enforce contracts, and support markets for innovation. And the idea that states' ability to provide for their citizens affects their capacity is supported by the strong observed association between state effectiveness and measures of life satisfaction across countries (Box A).

There is also evidence that state capacity is highly conducive to economic growth (Dincecco & Katz, 2016). High-state capacity states support private investment by increasing market effectiveness. Improving this form of state capacity creates a form of endogenous growth. Collective capacity supports economic change, ensuring that the benefits of growth are widely shared by expanding public provision.

Investments in public infrastructure also have productivity benefits. State capacities can also support innovation. First, there is a need to ensure that the state promotes competition between firms, allowing dynamic young firms to enter and grow. Second, state capacities can support the entrepreneurial role of the state, identifying strategic priorities and supporting them. Third, effective industrial policy is generally only possible when supporting state capacities are in place to ensure effective design and implementation.

2.2.2 Investing in State Capacity

Just as with physical infrastructure, investments in state capacity are possible when the government is acting in a far-sighted way. For example, building fiscal capacity typically requires establishing a competent bureaucracy and developing fair, transparent, and broad-based tax systems. This involves efforts to improve administration and monitoring to enforce tax policy. Some forms of taxes are easier to collect; state capacity can start from those taxes and branch out into other forms of taxation.

Enhancing legal capacity often necessitates the creation of market-supporting institutions that can protect investors against predation and other anti-competitive behavior. Most often, this is underpinned by an independent judiciary and a competent court system with well-trained judges who can enforce the rule of law. In addition, a government bureaucracy staffed by a meritocratic and reasonably paid civil service free from corruption and nepotism can more likely enforce the regulation.

When it comes to legal capacity, it is about building new organizations or strengthening existing ones, such as national development banks (NDBs), land registries to protect land property rights, credit registries to enforce debt contracts, and even patent systems to protect intellectual property rights. These are often key to building an effective financial sector to support investment [see La Porta et al. (1998), Beck & Levine (2005)].

It is not difficult to see how thinking in terms of investing in state capacity translates to net-zero transformation. Achieving carbon neutrality will require investments and innovation across a broad range of areas—new products, processes, and ways of organizing activities reducing GHG emissions—and these often need state support, particularly in their nascent stages. New entrants and their intellectual property must be protected, NDBs could be repurposed to support the green transition, and sophisticated bureaucracy will be required to operate markets for emissions and offsets of emissions.

2.3 Capable States, Improved Climate Actions

It is instructive to look at what countries are already doing to understand patterns of successful actions or potential constraints to address climate change. Of particular interest is the ability to plan a long-term emission reduction strategy. During the Paris Agreement, all parties agreed to communicate long-term strategy documents outlining policy plans for reducing their GHG emissions in the long run.[1]

Yet a common concern with developing a long-term climate strategy is that it requires capable states to credibly devolve resources and the ability to design and commit to policies with a long-time horizon. As discussed, state capacity encapsulates a state's ability to achieve policy goals, often via transforming resources into public goods, and is seen as a prerequisite for effective policymaking. This is particularly the case for climate action, given its complexity and need for a long-term commitment.

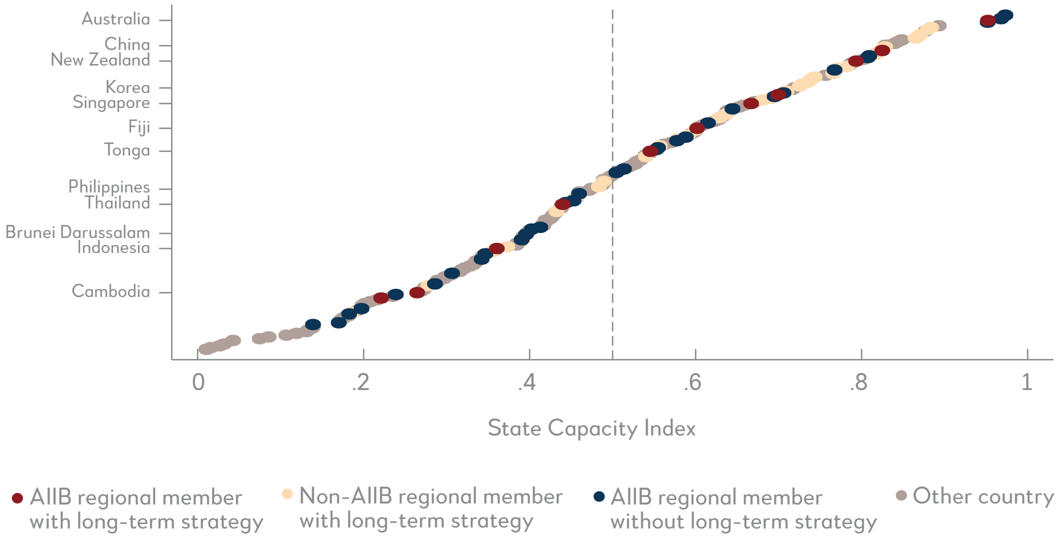
Figure 2 plots the global distribution of state capacity. Red circles indicate AIIB members that have committed to a long-term strategy for GHG reduction and communicated this document as part of their Paris Agreement (with these countries directly listed along the y-axis). Conversely, blue circles indicate AIIB members with no communication of long-term strategies. As can be seen, most AIIB members with long-term strategies are classified as high-capacity states (64 percent).

Looking at the global distribution of countries, 74 percent of countries with public commitments to long-term climate strategies have high state capacity compared to 37 percent among countries without long-term strategies. It appears that state capacity is an important factor associated with the preparation of a long-term climate strategy.

Table 1 shows some sampled economies according to their climate vulnerability and level of state capacity. Most climate-vulnerable countries have low state capacity. Conversely, high state capacity

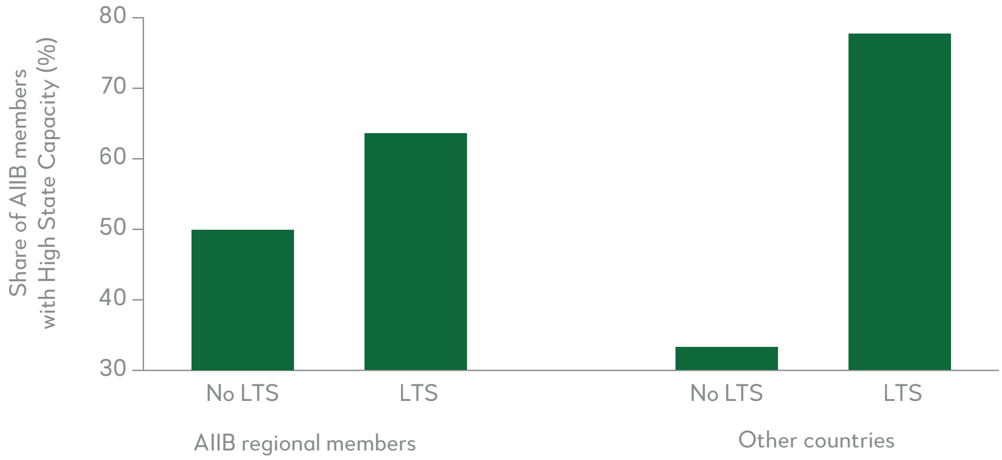
[1] Long-term strategy documents can include plans to reach net-zero emissions, usually by 2050, and may cover adaptation strategies.

Figure 2: State Capacity and Climate Pledges



Data source: Besley et al. (2021).

Figure 3: Adoption of Long-Term Strategy and State Capacity



Data source: Besley et al. (2021).

countries are also less prone to climate hazards. This classification can help inform the support provided to countries to build climate action. For example, it suggests that countries such as Tonga and Viet Nam, which have high state capacity, have the potential to undertake more climate action in the short-run and invest in long-term planning. On the other hand, vulnerable and low-capacity states would benefit from concerted support to build adaptive capacity alongside their development of climate strategies.

2.4 Three Central Institutional Challenges Facing States

Every country starts from a different place and has a unique cultural and institutional configuration. But some important general challenges emerge to varying degrees in various places that one needs to build into any analysis of what can be done. Multilateral development bank (MDBs), including AIIB, can also be an important force to help shape the "green transition"—firms produce goods with

Table 1: Climate Vulnerability Scores and State Capacities

Country	State Capacity index	Trust in Government	Innovation index	ND-Gain Climate Vulnerability	Any Long-Term strategy	Net-Zero Pledge
Afghanistan	0.17			0.59	0	0
Australia	0.95	0.33	48.3	0.33	1	1
Azerbaijan	0.77	0.88	28.4	0.41	0	0
Bahrain	0.40		28.8	0.45	0	1
Bangladesh	0.35	0.82	20.2	0.55	0	0
Brunei Darussalam	0.39		28.2	0.38	0	0
Cambodia	0.26		22.8	0.50	1	1
China	0.82	0.93	54.8	0.40	1	1
Cook Islands					0	0
Cyprus	0.55	0.47	46.7	0.35	0	1
Fiji	0.60			0.44	1	1
Georgia	0.97	0.39	32.4	0.41	0	0
India	0.29	0.52	36.4	0.51	0	1
Indonesia	0.36	0.70	27.1	0.45	1	0
Iran	0.64	0.50	32.9	0.40	0	0
Israel	0.51		53.4	0.33	0	1
Jordan	0.40	0.62	28.3	0.38	0	0
Kazakhstan	0.97	0.73	28.6	0.35	0	1
Korea	0.70	0.49	59.3	0.37	1	1
Kyrgyz Republic	0.24	0.56	24.5	0.37	0	0
Lao PDR	0.18		20.2	0.53	0	1
Malaysia	0.81	0.67	41.9	0.37	0	1
Maldives	0.34			0.54	0	1
Mongolia	0.58		34.2	0.40	0	0
Myanmar	0.20	0.80	18.4	0.55	0	0
Nepal	0.22		22.5	0.52	1	1
New Zealand	0.79	0.52	47.5	0.32	1	1
Oman	0.70		29.4	0.42	0	0
Pakistan	0.31	0.54	24.4	0.53	0	0
Philippines	0.46	0.70	35.3	0.47	0	0
Qatar	0.44	0.83	31.5	0.39	0	0
Russia	0.55	0.52	36.6	0.34	0	1
Samoa	0.45			0.50	0	0
Saudi Arabia	0.59		31.8	0.40	0	1
Singapore	0.67	0.81	57.8	0.40	1	1
Sri Lanka	0.41		25.1	0.48	0	1
Tajikistan	0.71	0.91	23.9	0.43	0	0
Thailand	0.44	0.49	37.2	0.43	1	1
Timor-Leste				0.51	0	0
Tonga	0.55			0.57	1	0
Türkiye	0.50	0.62	38.3	0.36	0	1
United Arab Emirates	0.95		43.0	0.37	0	1
Uzbekistan	0.81	0.97	27.4	0.40	0	0
Vanuatu	0.14			0.55	0	0
Viet Nam	0.61	0.97	37	0.48	0	1

Sources: Besley et al. (2021).

greener technologies and households consume greener alternatives—by helping create an enabling environment for institutional transformation. The three central challenges of building long-term solutions to support investment and innovation are credibility, fragmentation, and expertise.

2.4.1 Credibility

This refers to the government's ability to set out a strategy for a policy understood by citizens and businesses and where there is widespread trust that the government will deliver on that strategy. Limited commitment inherent in the political process can cause a "trap" that prevents a green transition. Thus, if the government is not committed to a green transition, the private sector investment needed for such a transition will not take place, and citizens will be reluctant to make changes that will lead to greener lifestyles, such as driving EVs, installing insulation, or using green energy sources.

Giving firms a clear sense of the commitment to green subsidies or regulation is also essential as they make their technology choices. The policy is likely most effective when they understand that the government is committed to maintaining green policies. Governments that dissemble will have difficulty convincing firms and consumers to make low-carbon investments. This credible commitment is also important for innovation since innovators are more likely to commit to creating green products when they are confident that a green transition will occur.

How to create government credibility is much debated in the economics literature on institutions. However, it is clear that short-term considerations inherently sway governments as shocks buffet them and as different individuals come and go in government. In democracies, the election cycle is a natural source of policy change, and there is little to stop one government from deciding to overturn a policy instituted by previous governments, leading citizens to doubt the long-term credibility of policy strategies.

One area where credibility has been best developed historically is central banking. It is now appreciated that low and stable inflation is best achieved by having clear policy rules alongside some form of accountability.

But institutional design has many details, including the nature of the powers granted to banks to discharge their duties. Some central banks are goal independent, able to set their own goals, while more often, they are operationally independent, responsible for laying down a government-promoted policy. Independence in regulation is quite common in many areas of the economy, particularly where there is a concern that policymakers will lobby for the relaxation of regulations selectively.

Institutional details are key, and any bespoke institutions created for climate action are unlikely to have direct powers. But as guardians of long-term commitments and expertise, and holding government accountable for long-term strategies, they could play a vital role. Similarly, climate councils created in many countries to monitor the design and implementation of climate action can be an effective institutional response to ensure that the policy discussion continues to evolve, and all relevant government ministries and agencies are involved.

Multilateral and national development finance institutions can help build credibility by investing early along with private sector partners. Such investments matter most in areas where policies are more likely to be vulnerable to political cycles, e.g., in projects with significant government subsidies or potential environmental impacts.

2.4.2 Fragmentation

Coordinated action is often important in meeting the challenge of creating an effective government. This means that different policy aspects work together so that actions taken in one part of government reinforce, rather than contradict, those taken elsewhere. And a key function of organizing government is to find ways of ensuring that different branches work together where necessary.

An example of policy fragmentation in climate policy is when tax and subsidy policies do not support other regulatory efforts to back the green transition. For example, many countries still maintain energy subsidy policies for fossil fuels while encouraging firms and consumers to switch to green energy sources.

One key challenge in institution building is the potential for fragmentation of power across different spending and taxing ministries. There is also a need to coordinate across tiers of government, making a judicious choice of local and national initiatives. Many governments organize spending across various functions, but the interdependencies between forms of spending can be important in building an integrated climate strategy. For example, transportation and energy policies need to join up with tax policy to create a holistic approach. Without an overarching strategy, the kinds of complementarities between functioning governments will not be exploited to the fullest extent possible. This is a challenge since the predominant way state capacities have been built historically is by improving the operation of the state, one function at a time rather than building integrated spending strategies.

To illustrate this point, consider the challenge of electrifying the vehicle stock to cut carbon emissions. This will not reduce carbon emissions unless the electricity is produced using low-carbon technologies, such as nuclear, hydrogen, or renewables. So, there has to be a link to energy policy.

Encouraging people to buy EVs also has specific challenges, such as installing a suitable EV-charging infrastructure. This has to be financed; often, this means coordinating with land-use planning to designate locations of charging points and highway investment to plan the location. Tax policy also has an important supportive role.

The pricing of fossil fuels, such as gasoline and diesel, will affect the incentives to switch. Greening the public transportation fleet such as buses requires coordination, often dealing with municipal governments and transport regulators. Since such fuels are heavily taxed in some countries, there may be a need to consider a shift in overall tax policy to offset these effects. Also relevant is the design of policies to offset distributional consequences from the transition, as different groups will be hit differently.

This is only a very specific illustration. But a strategy in this area must be able to coordinate across branches of government to ensure an integrated approach—a real challenge for policy-making. A powerful proposal intended to achieve this objective using international financial assistance as one important driver of such collaboration is to apply the idea of country platforms to climate policy. These platforms, owned by the hosting government, would bring together all the relevant partners, national and international, including ideally the private sector as well as the philanthropists in the design and implementation of national net-zero policies.

2.4.3 Expertise

Effective governance requires expertise. Throughout history, building state capacities has been the professionalization of bureaucracies with the proper training. But the effective government also requires building organizational capacity by monitoring service provision and designing accountability and implementation systems. Thus, expertise is much more than what individuals know individually versus what an organization knows collectively and can solve problems.

The 20th century saw the building out of government expertise in areas like health, education, and the provision of old-age security. The most effective organizations have embedded this expertise in processes that allow them to deliver effectively. Building expertise increases the "street-level" authority of public organizations. By solving problems, higher tiers of government can take advantage of more on-the-ground expert knowledge. When firms and consumers trust the integrity and expertise of the bureaucrats and officials they are dealing with, they will more likely take government advice, enhancing the state's effectiveness in creating climate action.

New areas of expertise are needed in the case of climate change. The government must develop core competencies that will allow it to deploy its capacities effectively. To give another illustrative example, governments must build adaptable solutions that balance different energy sources under different assumptions about how technology will likely evolve. Nobody knows how technology will change for sure. For example, many were surprised by the speed of technological improvement and cost reductions using solar power. Given the state's vital role in the green transition, the government must either access or build its source of credible expertise to give suitable guidance for policy.

2.5 The Way Forward

2.5.1 Build Systems of Climate Action Governance Capacities

Right now, it is challenging to know how effective different governments will likely be in supporting climate change, how much credibility institutions have, how fragmented governance systems are, and whether the right kind of expertise is already in place. Making these as comparable as possible across countries will also be helpful in policy dialogs. Although the idea of "best practice" is always a dangerous idea—like all institutions, how they function depends greatly on the context—it is useful to know what kinds of policy solutions are in place to inform the discussion. At present, there is almost nothing that enables this to be done systematically.

Although many different indicators could be collected and which could be granular by sector, at the very least, there is a need to understand what kinds of climate action mitigation and adaptation strategies are in place, how they are being implemented and communicated, how well-resourced they are, and how well joined up they are across government. Climate action governance indicators could also assess the extent of expertise and whether the plans are subject to scrutiny, with their implementation being monitored independently.

As a first pass, it is imperative to do this for the energy transition, particularly moving away from coal-fired power toward renewables. A governance assessment would include the types of incentive programs in place and the funding strategies for the transition. Starting with the energy transition can provide proof of concept for broader government strategies.

2.5.2 Tracking Public Opinion and Business Understanding

Climate action hinges on shifting the behavior of citizens and businesses. How knowledgeable they are and how clearly they understand the likely transition path of government will likely play a role in whether the government can encourage the actions needed to enable a green transition. But there is little data on how opinion is shifting, especially granularly. A range of data suggests that the more educated citizens understand the challenges posed by temperature increase much more than the less educated. Investing in good quality data on what citizens and businesses are doing is important. It will enable us to understand policy responsiveness and design better policies.

One key example in this area is the role of "fairness" in managing a green transition. Many citizens believe it is important that the burden is shared fairly across the economy. But little is known about what is deemed a fair process or policy. Many countries have used deliberative methods to help understand these views, particularly why citizens are resistant to some kinds of behavioral change.

2.5.3 Bespoke Institutions

One key question is how far the challenge of increasing climate action requires new institutions. Certainly, this requires discussion in a country-specific context. However, the case for doing so rests on whether this would increase policy credibility, reduce fragmentation, and build authority through increased expertise.

Although not a model that is suitable everywhere, the United Kingdom (UK) Committee on Climate Change was created in 2008 to increase the capacity of the government to meet the challenge of reducing carbon emissions. The UK government has legally binding carbon emission reductions. However, the climate change committee ensures that progress toward meeting these goals is assessed independently. The committee has been critical of the government when it has not been proceeding fast enough.

The National Infrastructure Commission, created in 2015, is responsible for the government's strategic plans for infrastructure and the role it has to play in the green transition. The government must explain why it has not followed the recommendations. This, too, brings both new expertise and credibility to investment plans. It has also helped reduce policy fragmentation between spending ministries and those privately owned areas of infrastructure, which are regulated rather than directly controlled by the government.

One key feature of an independent institutional framework is having direct access to the public and being able to criticize the government when it fails to take the necessary action. It also enhances the credibility of a policy when the arguments for making particular policy proposals are publicly known rather than guarded by a narrow range of experts. It can also increase public understanding of the need for climate action. However, the government still needs to do many things in traditional ways, such as using the power of the tax system to manage a green transition, both affecting who pays and the incentives for investing in low-carbon technologies.

Although not a model that is suitable everywhere, the UK Committee on Climate Change was created in 2008 to increase the capacity of the government to meet the challenge of reducing carbon emissions. The UK government has legally binding carbon emission reductions. However, the committee ensures that progress toward meeting these goals is assessed independently. The committee has been critical of the government when it has not been proceeding fast enough. The National Infrastructure Commission, created in 2015, is responsible for the government's strategic plans for infrastructure and the role it has to play in the green transition. The government has to explain why it has not followed the recommendations. This, too, brings both new expertise and credibility to investment plans. It has also helped reduce policy fragmentation between spending ministries and those privately owned areas of infrastructure that are regulated rather than directly controlled by the government.

2.5.4 Institutions Specific to Innovation

Innovation is centrally important in the green transition. Having clear and credible policy commitments will help focus on innovative activity. Although private sector investment has an important role, the government has a significant role in research and ensuring the best technologies are adopted. Getting the balance right between centrally directed technical change and harnessing private initiatives is vital. Considering how far industrial strategies are likely to be effective is a crucial debating point, given that the future technological balance is not entirely clear. A case in point is debated around the future of hydrogen, which requires considerable infrastructure investment to create a thick global market in hydrogen. The choice of hydrogen technologies is still uncertain.

Experience suggests that a big push in developing new technologies will have a role to play. For government investment in technology to have its biggest impact will depend on credible strategies at a country level and international coordination. Building a "critical mass" in specific technological expertise and the right amount of vertical integration within sectors to build viable supply chains is also challenging.

Creating innovation incentives will be facilitated by building state capacities with a mission orientation toward climate action. This requires the right balance of accountability for spending public money and insulation from short-term political pressures. As with other forms of institutional capacity, this is not a process of creating best practices but allowing for information to flow and for lessons from successful experiences to be recognized. Making technologies freely available must be balanced against commercial incentives, as witnessed in the efforts to create and roll out vaccines during the COVID-19 pandemic.

2.6 Concluding Remarks

Climate action requires coordinated action across branches of government and firms, consumers, and governments. State capacities are the bedrock on which effective state action is built. Governments raise taxes to finance investment in infrastructure and steer private investment and innovation toward net zero. They enforce regulation and fund basic R&D to encourage innovation, including adaptation and imitation of innovation done elsewhere, to speed up the transition to net zero. Project lending tied to improvements in state capacity can enhance the effectiveness of the capital accumulation process in supporting climate mitigation and adaptation. MDBs can improve their effectiveness by investing in building state capacity and respecting the wide variety of starting points that countries begin from.

Box A: State Capacity—How this Affects Citizens' Trust and Environmental Concerns

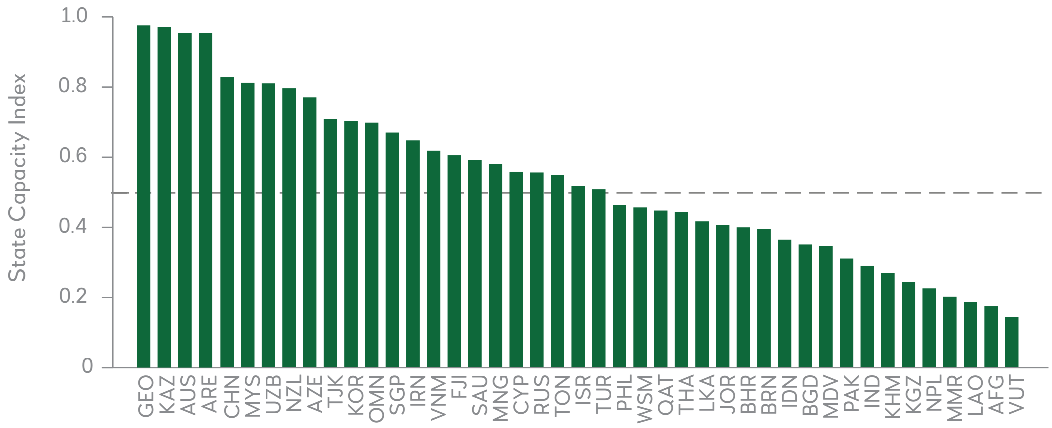
There is emerging literature on measuring state capacity. Whether this should be done one dimension at a time or there should be efforts to aggregate into single indices is open to debate. Efforts to create unique state capacity indices have collapsed these different dimensions into one (O'Reilly & Murphy, 2022).

Given fiscal capacity refers to expanding broad-based tax systems, income tax as a share of total tax revenue is a sufficient proxy of a state's tax-raising powers. Unlike more basic taxes, such as trade excises at ports, income tax requires a well-trained bureaucracy to enforce tax withholding. Legal capacity can best be captured by an index that measures the quality of contract enforcement.[a]

Following Besley & Persson (2014a), collective capacity is the average educational attainment (average years of education for the working population, 15–64) and life expectancy.[b] Data for educational attainment comes from Barro & Lee (2013), and data for life expectancy comes from the World Development Indicators. Finally, following the work of Besley et al. (2021), Figure A.1 plots the distribution of state capacity across AIIB members, with the dotted gray line representing the global average.

There is a lot of heterogeneity in levels of state capacity across economies, ranging from countries such as Afghanistan and the Lao PDR at the lower end of the distribution to high-performing countries such as Georgia and Kazakhstan. The causes of this are varied and country specific. Besley & Persson (2011) emphasized the value of creating cohesiveness and stability in policymaking, enabling the state to take a far-sighted view that is conducive to investing in the state. Histories of significant political violence are generally not conducive to building state capacities, and this generally shows up in patterns in the data.

Figure A.1: Distribution of State Capacity



AFG = Afghanistan, ARE = UAE, AUS = Australia, AZE = Azerbaijan, BGD = Bangladesh, BHR = Bahrain, BRN = Brunei Darussalam, CHN = China, CYP = Cyprus, FJI = Fiji, GEO = Georgia, IDN = Indonesia, IND = India, IRN = Iran, ISR = Israel, JOR = Jordan, KAZ = Kazakhstan, KGZ = Kyrgyz Republic, KHM = Cambodia, KOR = Korea, LAO = Lao PDR, LKA = Sri Lanka, MDV = Maldives, MMR = Myanmar, MNG = Mongolia, MYS = Malaysia, NPL = Nepal, NZL = New Zealand, OMN = Oman, PAK = Pakistan, PHL = Philippines, QAT = Qatar, RUS = Russia, SAU = Saudi Arabia, SGP = Singapore, THA = Thailand, TJK = Tajikistan, TON = Tonga, TUR = Türkiye, UZB = Uzbekistan, VNM = Viet Nam, VUT = Vanuatu, WSM = Samoa.

Notes: the index refers to 2016 values. Dotted grey line refers to global average.

Data sources: Besley et al. (2021).

Measures of state capacity tend to be strongly positively correlated with the gross domestic product (GDP) per capita, thus underpinning a nexus between state capacity and development. This is illustrated in Figure A.2. Even if there are issues concerning reverse causality and heterogeneity, it points to the idea that more effective states are generally those that are more prosperous, relative to "fragile states" where the government can find

continued on next page

Box A: *continued*

it difficult to achieve any policy goal (Commission on State Fragility, Growth and Development, 2018). One should also expect a positive association between levels of state capacity and innovation if the state can bolster markets and the private sector via formal legal institutions. This is plausibly one such mechanism that connects high-capacity countries to economic performance. The Global Innovation Index from the World Intellectual Property Organization (WIPO) gauges how conducive a country's institutional environment is for innovation. Figure A.3 indeed shows that innovation and state capacity are positively correlated.

Over the last decade, significant attention has been paid to the role of norms and values in supporting state effectiveness (Acemoglu & Robinson, 2019). Original notions of building state capacity have been focused on "top-down" efforts by incumbents to achieve their intended policy goals. Citizen compliance is either assumed or acquired via state-enforced coercion. The main focus in this literature has, hence, been on the state's actions.

Yet, states comprise two actors: the state (i.e., government) and citizens. An alternative "bottom-up" approach to state effectiveness focuses more directly on the role of compliance by households and firms with public policies. Here, the state and citizens work in a mutually reinforcing, reciprocal relationship (Besley, 2021). If the government can prove its competence to citizens in successfully delivering public goods and services, then citizens will more likely comply with the demands of the state. This is particularly relevant for the kind of state action needed for climate change, where state and private action toward a green transition is mutually reinforcing.

Take fiscal capacity, for instance, one key attribute of state capacity. While the state can try to overhaul tax systems to make them more efficient, encouraging compliance or "tax morale" can also be just as effective in raising tax revenues (Luttmer & Singhal, 2014). Why would households and firms be intrinsically willing to pay taxes if they knew the public purse would be poached for politicians' self-enrichment?

Trust in government is consequently the fulcrum of voluntary compliance. A range of policy issues require government and citizens to work together, and this reciprocal relationship rests on mutual trust. COVID-19 has been a case in point, with successful interventions resting on government measures and broad compliance with public guidelines.

One can look at the Trust Survey Report of the Organisation for Economic Co-operation and Development (OECD) to underpin the role of compliance matters in the climate change policy domain. It shows that while over half of respondents across OECD-member countries think governments should prioritize climate change action, only one-third have faith in policy success on this issue (OECD, 2022).

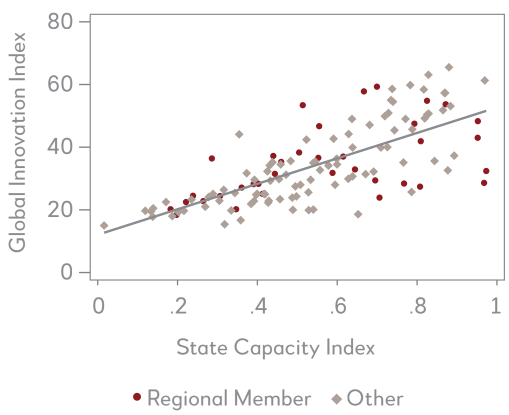
Figure A.2: State Capacity and Income Level

GDP = gross domestic product.

Note: Both variables refer to 2016 values.

Data source: Besley et al. (2021).

Figure A.3: State Capacity and Innovation



Note: The State Capacity Index refers to 2016 values, and the Innovation Index refers to the most recent 2021 values.

Data source: Besley et al. (2021) and the Portulans Institute and the World Intellectual Property Organization (WIPO).

continued on next page

Box A: *continued*

Figure A.4: Confidence in Government and Environmental Concerns

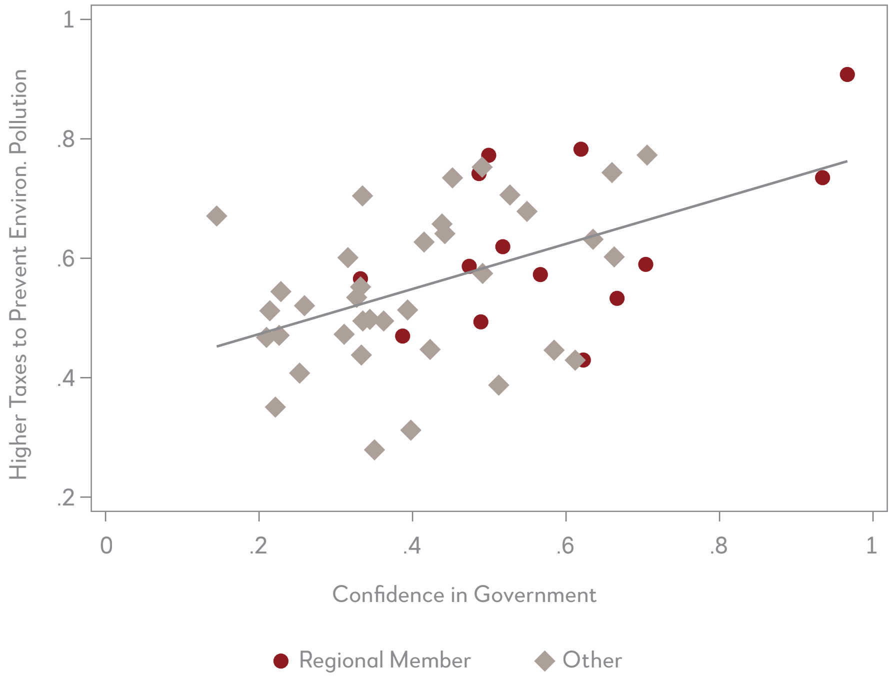


Figure A.4 uses data from the Integrated Values Survey (IVS), looking at the proportion of respondents across countries who (a) express confidence in government, and (b) are willing to pay higher taxes to prevent environmental pollution.[c] Despite some missing data, there is a positive correlation.[d] Investing in state capacity from "above" and relying on voluntary compliance from "below" are not mutually exclusive methods to engender effective states. Bringing trust and confidence in government into the picture emphasizes how building a strong social contract between government and the governed is a key dimension for effective policymaking.

[a] Data for tax capacity comes from the International Center for Taxation and Development. Data from legal capacity comes from World Bank Doing Business (though this has been discontinued).

[b] Both variables are min-max normalized before averaging.

[c] The IVS merges two data sets: the World Values Survey (WVS) and the European Values Survey (EVS). Given our focus on regional AIIB members, most data used comes from the WVS, which asks a nationally representative population a set of common questions across approximately 100 countries since 1981, including questions on trust in institutions.

[d] This association is robust when using the GALLUP World Poll to get a wider sample of countries and looking at whether citizens are satisfied with national efforts to preserve the environment.

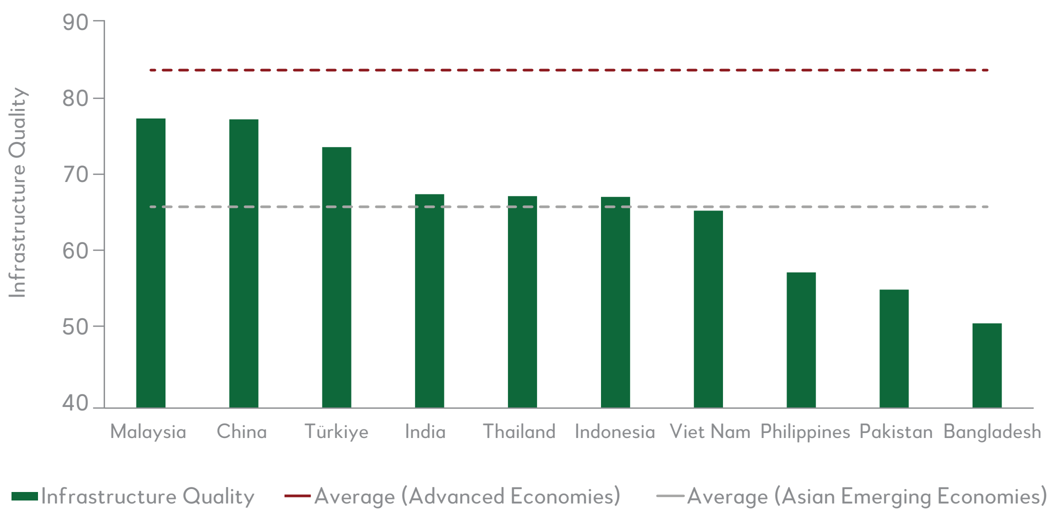
CHAPTER 3
ENABLING PPPs AND THE PRIVATE SECTOR FOR NET ZERO

This chapter enumerates the role of the private sector in green and resilient infrastructure. In doing so, the chapter makes a slight distinction between PPP and non-PPP (purely private) investments. It also discusses how the private sector enables the creation of green infrastructure. Finally, as the net-zero transition requires a quantum jump in green infrastructure investment, the chapter highlights some factors that can facilitate PPPs toward green investments.

Despite the strong growth over the past decades, large sections of populations in Asia still lack basic infrastructures such as electricity, drinking water, sanitation and digital connectivity. Infrastructure quality across most Asian economies lags the average for the advanced economies (Figure 4).

The situation is exacerbated because these populations are significantly exposed to climate risks. S&P Global (2022) found that lower- and lower-middle income economies are likely to see 3.6 times greater gross domestic product (GDP) losses than upper-middle- and high-income economies

Figure 4: Quality of Infrastructure across Select Asian Economies



Data source: World Economic Forum (2019).

because of climate hazards. Consequently, Asian economies face the twin challenges of bridging the current infrastructure gap while allowing flexibility in infrastructure design to mitigate future climate-related risks. Clearly, the private sector and PPPs must play a bigger role ("billions to trillions").

3.1 Overview of PPPs and Private Sector Infrastructure Investments

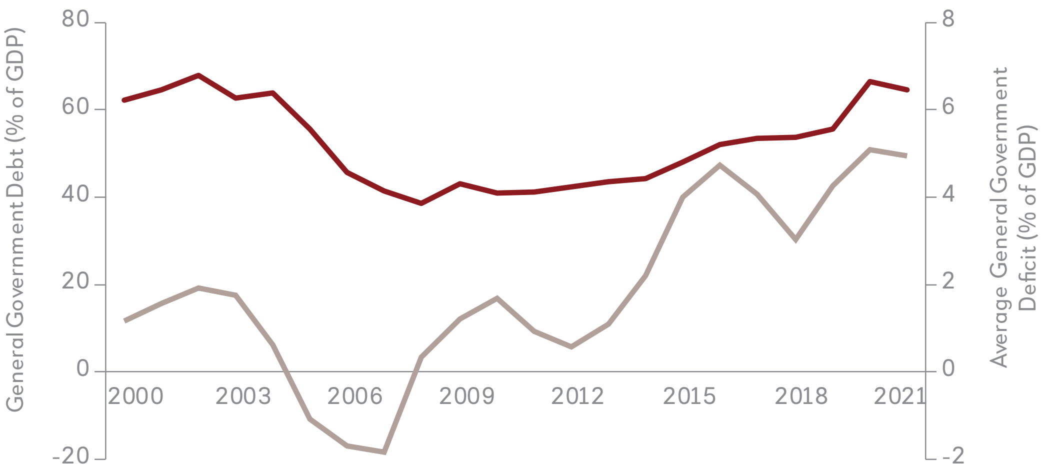
The financing requirement is colossal. According to ADB (2017b), 45 developing economies in the Asia and Pacific region need about USD26 trillion of investments from 2017 to 2030, including climate mitigation and adaptation costs. Much of this is front-loaded (IEA, 2021b). For example, achieving net-zero emissions by 2050 would require annual investment in the energy to more than double from USD2.3 trillion in 2016-2020 to almost USD5 trillion in 2030.

The huge financing requirement can partly explain the hesitancy of most developing economies in Asia to adopt net-zero targets at COP26.[2] The public sector, which has been funding more than 80 percent of infrastructure investments, is increasingly constrained by rising fiscal deficits and public debts, especially in the aftermath of the COVID-19 pandemic (Figure 5).

Perhaps unsurprisingly, there is evidence that fiscally constrained states or regions tend to use more PPPs to attract much-needed resources [see Hammami et al. (2006), Yurdaku et al. (2022)].[3] The correlation appears more positive for Asian economies (Figure 6). This could be due to Asia's higher growth rate attracting PPPs or high infrastructure needs. With the demand on the private sector to bridge the infrastructure gap, it is also imperative that there is a policy framework and enabling environment to direct more of these toward the net-zero transition.

The first wave of privatization ushered in during the 1980s to 1990s—alongside new economic paradigms and regulations—was driven by fiscal crises in many developing economies and inefficient management of SOEs [Arezki et al. (2017)]. PPPs, in principle, can allow financing risks to be more optimally distributed (Bing et al. (2005)).

Figure 5: Public Debt and Fiscal Deficit in Asian Economies



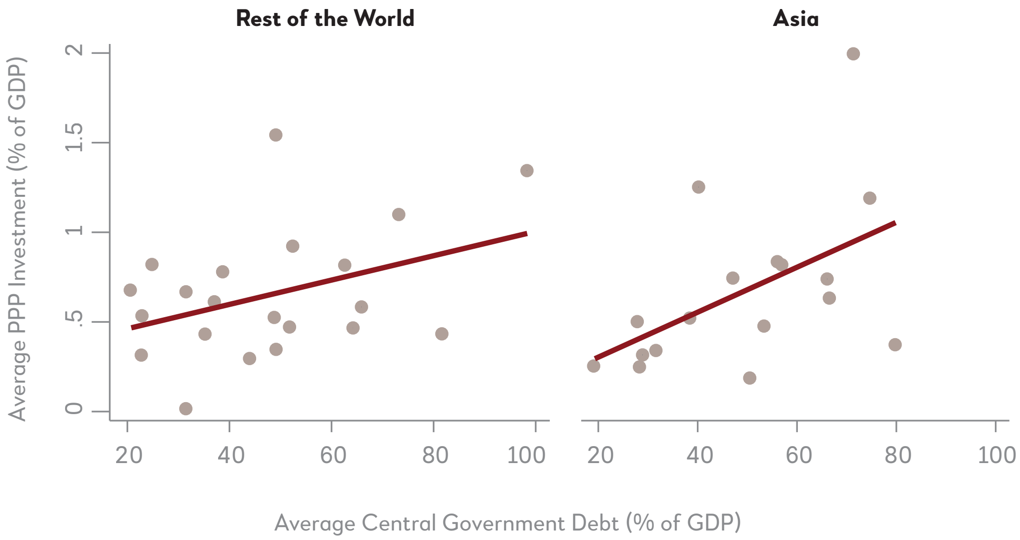
GDP = gross domestic product.

Data source: IMF World Economic Outlook and AIIB staff estimates.

[2] As highlighted earlier in the report, states with weaker capacity were found to have made less climate commitments.

[3] The report also presents more evidence of this using provincial and state level data for China and India, respectively.

Figure 6: PPP Investment and Fiscal Deficit



GDP = gross domestic product, PPP = public-private partnership.

Data source: World Bank PPI Database, IMF World Economic Outlook Database and AIIB staff estimates.

Importantly, PPPs act as natural filters to ascertain economic viability since only viable projects are attractive to private sector participants (Engel, 2016). PPPs can be cost-effective, with contracts holding the private sector participant explicitly accountable (Davies & Eustice, 2005). Moreover, the private sector can foster innovative design, skills and technology and improve the operational efficiency of the projects (Iossa & Martimort, 2015).

However, PPPs alone are not a panacea. As mentioned, PPPs are used more intensively in fiscally weak economies that often lack state capacity. It is crucial that countries engage with PPPs for the right reasons and not aggravate the exact risks they should contain. PPP financing costs can be higher than traditional public investment as private firms do not have access to low-cost financing, are less able to pool risks, and can add to frictional and management costs. PPPs can generate a "fiscal illusion," where states may not need to raise upfront financing but have to forego revenue and be saddled with large contingent liabilities.

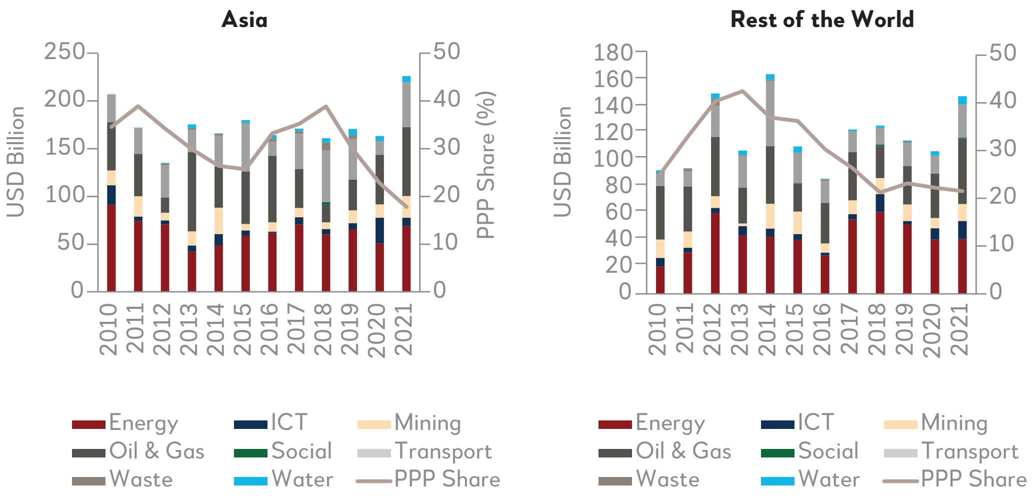
3.1.1 Structural Trends

Overall private sector investment (comprising PPP and non-PPP investments) in EMDEs increased from USD300 billion in 2010 to USD375 billion in 2021 at an average annual rate of 2.0 percent.[4] However, the aggregate numbers mask some key trends, which are discussed below. First, notwithstanding some cyclical volatility, Asia emerges as an essential market for private sector investments. Moreover, there are key sectoral differences (Figure 7). Asian economies tend to invest more in electricity generation, transport and oil and gas projects, and less in social, water and ICT projects than economies in the rest of the world.

Second, the oil and gas sector continues to attract sizeable private sector investments in both Asia and the rest of the world. Most of the investment in the oil and gas sector took place in the non-PPP segment. High energy prices and a lack of viable alternatives in the short-term continue to make this sector attractive to private investment.

[4] While the IJGlobal database contains information on both PPP and non-PPP transactions, its coverage of PPP projects is less comprehensive than the World Bank's Private Participation in Infrastructure (PPI) database, which focuses exclusively on PPP projects. For a comprehensive coverage, the chapter combines the PPI database for evaluating PPP projects with IJGlobal database for non-PPP projects. Both PPP and public sector finance projects are excluded from the IJGlobal database.

Figure 7: Private Sector Investment in Infrastructure



ICT = information and communication technology, PPP = public-private partnership.

Note: For mining and social sectors, only non-PPP data is available.

Data source: World Bank PPI Database, IJGlobal Dataset and AIIB staff estimates.

The share of this sector in private investment in Asia has increased by a third between 2010-2011 and 2020-2021 to reach 41 percent—part of this could also be explained by the decline in investment in traditional infrastructure sectors like energy and transport due to the pandemic. This underscores the shifts needed, including the need for carbon pricing, to drive the required investment reallocation in Asia.

Finally, private sector investments in social (i.e., health, education and social housing), water, and waste management sectors that remain vulnerable to climate change remain abysmally low. In Asia and the rest of the world the combined share of these sectors is less than four percent. Such sectors are hard to monetize and, hence, would not easily attract private sector investments. The transformation capacity of the state, introduced in the second chapter, will be crucial here to bring some policy innovation to attract private firms. These infrastructure sectors are not only an important factor for human capital development and economic growth; they are also instrumental in addressing climate related issues in future (Macdonlard & Patrinos, 2021).

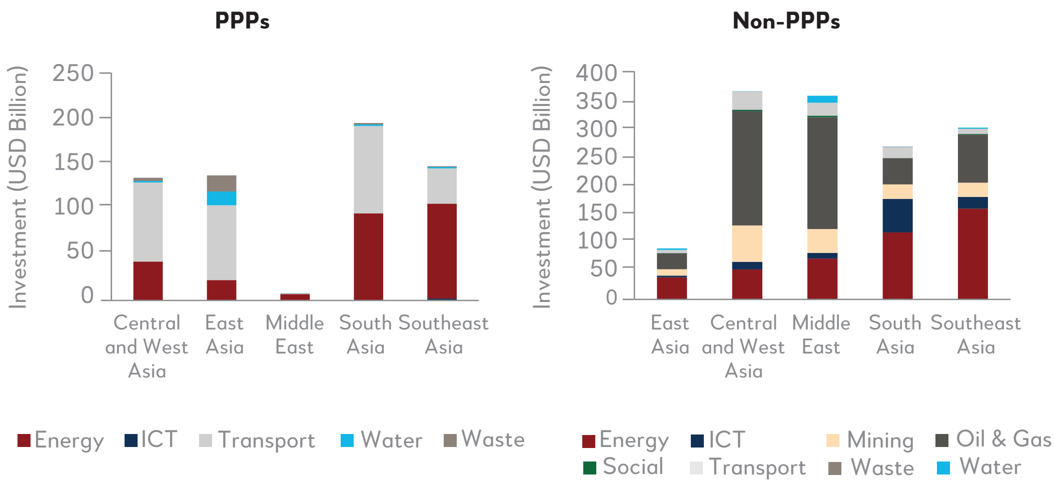
There is also a great deal of disparity across the different regions within Asia (Figure 8). Under non-PPP arrangements, oil and gas and mining account for a significant share of investments across all the regions, ranging from 25 percent in South Asia to 70 percent in the Middle East and Central and West Asia.[5] The attractiveness of fossil-fuel investments to the private sector (especially in the Middle East and Central and West Asia) highlights the challenges to the green transition.

South and Southeast Asia have invested almost half of their non-PPP investments in the energy sector to improve energy access. South Asia is also the biggest recipient of ICT sector investments among all the regions in Asia. Barring the Middle East, other regions in Asia have attracted considerably higher PPP investments, but the majority of it is in the energy and transport sector.

East Asia is the only region with significant PPP investments in the water and waste sector in the last decade, at par with energy investments. In comparison, despite being the most populated region in Asia, South Asia has a negligible level of investments in the water and waste management sectors, leaving all the investments to be done by the public sector. Given that most South Asian economies are fiscally constrained, it would be important to attract PPP investments in water and waste management sectors to provide universal coverage to the households.

[5] National oil companies in these regions have invested heavily under public sector finance (not counted here) in the last decade which will amplify the share of oil and gas sector in aggregate investments.

Figure 8: Private Sector Investment within Asia (2010-2021)



ICT = information and communication technology, PPP = public-private partnership.

Data source: World Bank PPI Database, IJGlobal Dataset and AIIB staff estimates.

3.2 PPPs: A Vital but Still Imperfect Tool for Green Infrastructure in Asia

The share of Asian economies in global PPP investment rose from two-fifths in 2000 to nearly two-thirds in 2021, aided by fast-growing PPP investments in Asia. However, the rise did not happen uniformly and PPP investments showed considerable volatility (Figure 9). The large economies of China and India account for 50 percent of the investment in Asia, with Türkiye, Indonesia, Russia, and the Philippines accounting for another 30 percent (Figure 10).

India adopted PPPs early. However, post-2012, various factors such as overly optimistic demand projections, lack of full due diligence by the financiers, and delays in getting requisite approvals resulted in a steep decline in PPP transactions. From 2016 onward, the government introduced certain reforms that rejuvenated private sector participation.[6] China has been promoting PPPs in the infrastructure sector with the 13th and 14th Five-Year Plans emphasizing the need to accelerate PPPs, which grew at a healthy rate of over 30 percent between 2012 and 2021 driven by the transport, and water and sewerage sectors. SOEs remain a significant capital contributor to PPP projects. Southeast Asian economies like Indonesia, and Viet Nam have witnessed strong growth, aided by PPP-related legal and regulatory reforms. Türkiye's PPP investment grew by 43 percent annually between 2009 and 2016.

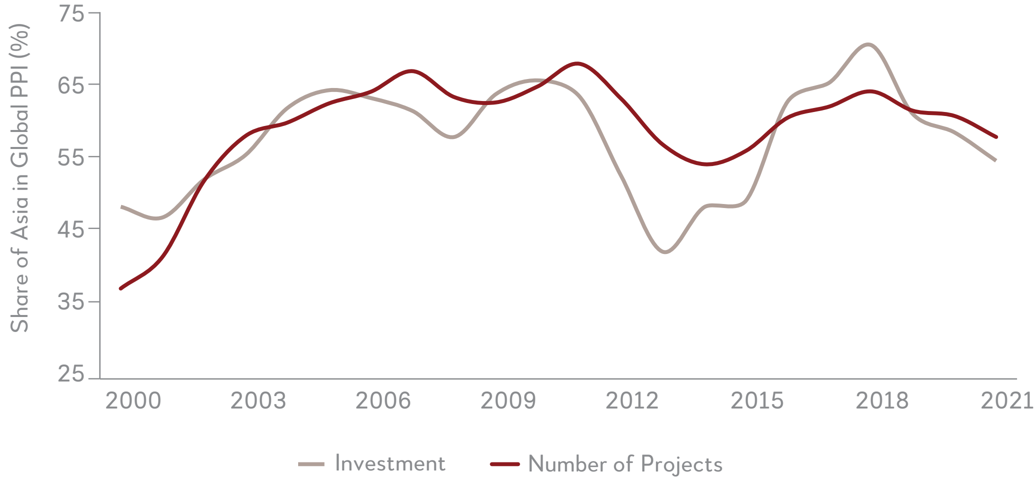
As highlighted in Figure 11, energy and transport account for more than 90 percent of the PPP investment in Asia in the last two decades. Energy remains the dominant sector across most economies, accounting for more than 80 percent of the overall investment in Pakistan, Thailand and Viet Nam.

PPP investment in water, sanitation and solid waste is also muted at less than 10 percent for most countries. Only Malaysia (23 percent) and China (22 percent) have been successful in attracting sizeable investments in this sector. The ICT sector has attracted minimal PPP investment with India (0.3 percent) and Indonesia (1.2 percent) being the only major economies to attract any investment.[7]

[6] This will be elaborated further in the report.

[7] Since 2016, ICT excludes those investments where government's participation is limited to regulation and licensing. The database includes investments like fiber optic cables, which has an active government component.

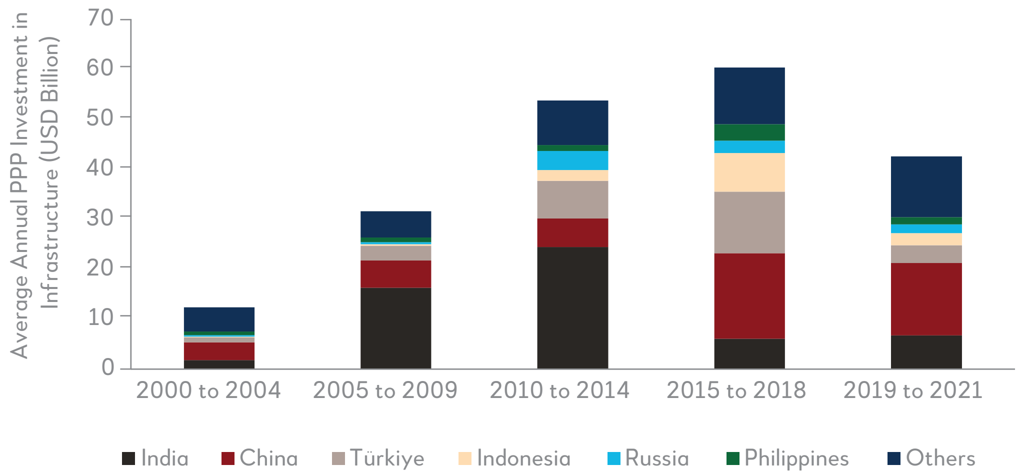
Figure 9: Share of Asia in Global PPP Investment (3-Year Moving Average)



PPI = Private Participation in Infrastructure, PPP = public-private partnership.

Data source: World Bank PPI Database and AIIB staff estimates.

Figure 10: Average Annual PPP Investment in Selected Asian Economies



PPP = public-private partnership.

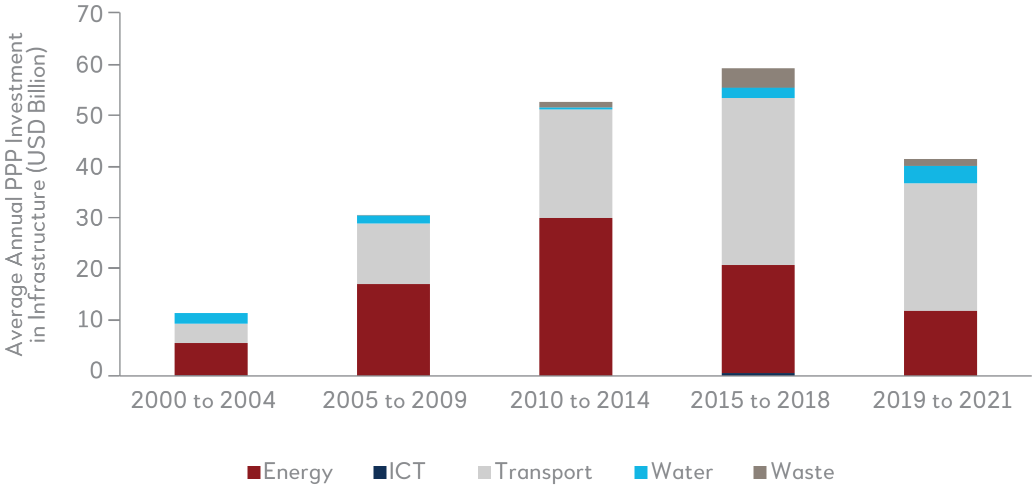
Data source: World Bank PPI Database and AIIB staff estimates.

3.2.1 Renewable Power Generation

Encouragingly, there has been a decisive rise in clean energy investments by the private sector over the last decade. The share of renewables in PPP electricity generation investment has increased threefold over the last decade (Figure 12). The rise has been even more striking in the case of non-PPP investments where the share grew four times between 2015 and 2021. Between 2011 and 2021, USD104 billion was invested in renewable energy generation, matching the USD101 billion in conventional power PPPs. This is a marked improvement from the preceding decade, with investment in conventional energy between 2000 and 2010 being four times that of renewables.

The shift toward clean energy is also reflected in capacity additions. Asia added 63GW of renewable capacity through PPPs between 2011 and 2021, three times higher than the previous decade, while the addition to conventional capacity fell by 44 percent (Figure 13). A similar shift was also witnessed in non-PPP projects, especially since 2015.

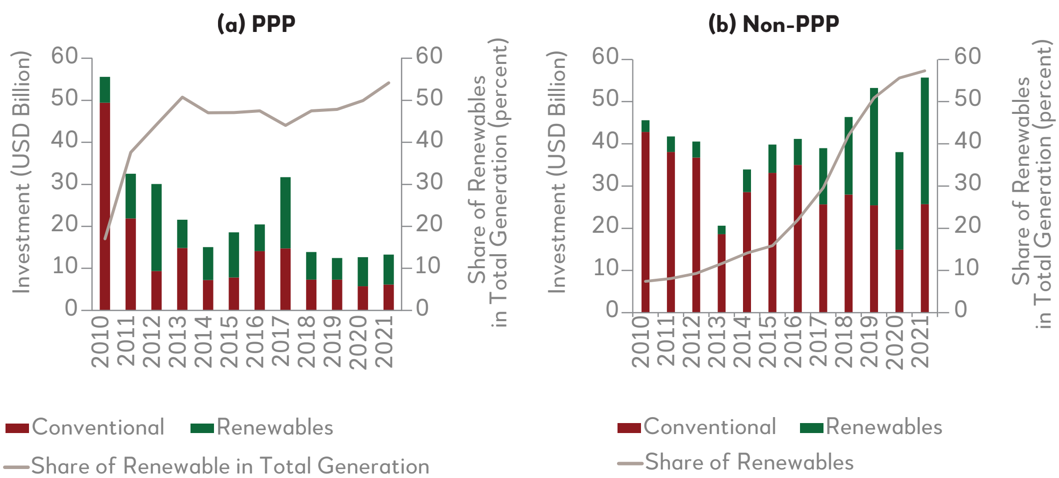
Figure 11: Average Annual PPP Investment across Sectors in Asia



ICT = information and communication technology, PPP = public-private partnership.

Data source: World Bank PPI Database and AIIB staff estimates.

Figure 12: Private Investment in Renewables and Conventional Electricity Generation in Asia



PPP = public-private partnership.

Data source: World Bank PPI Database, IJGlobal Dataset and AIIB staff estimates.

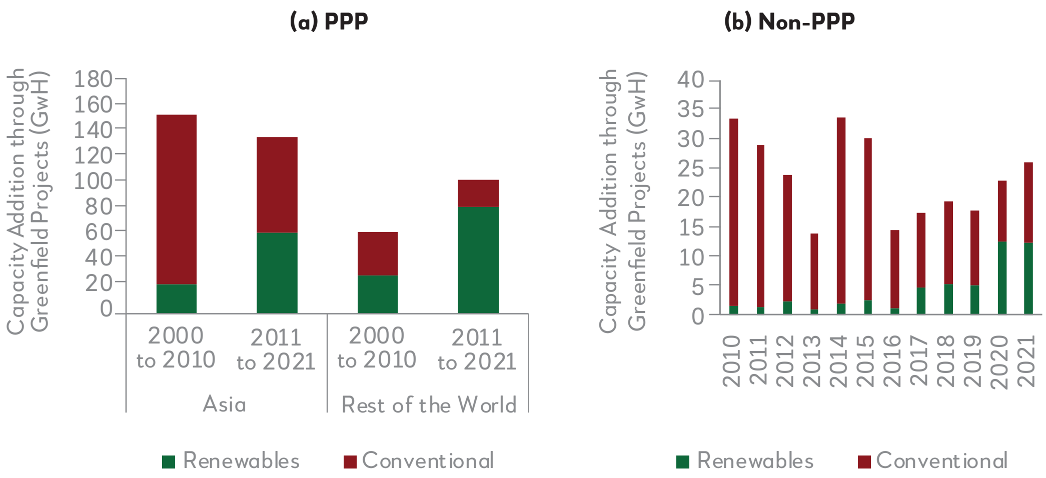
While annual renewable capacity additions increased seven-fold between 2015 and 2021, conventional capacity additions dropped by 50 percent.[8]

The surge in renewable energy investments by the private sector was led by solar and wind power (more than 83 percent of the investments in renewable PPPs). Similarly, around 62 percent of the investment in non-PPP projects took place in these sectors, with another 24 percent of mixed renewable investments having solar or wind as one of the major components (Figure 14).[9] Across both PPPs and non-PPPs, the share of solar energy investment has increased, offsetting wind as the largest source of renewable energy. Another 20 percent of the PPP investment occurred in the small hydro and biomass sectors whereas geothermal accounts for 9 percent of non-PPP investment.

[8] It should be noted that the same generation capacity of the renewables translates into lower power generation for the grid as compared to fossil-fuel generation.

[9] Under non-PPP, majority of mixed renewable projects also consists of wind, solar and corresponding battery storage projects.

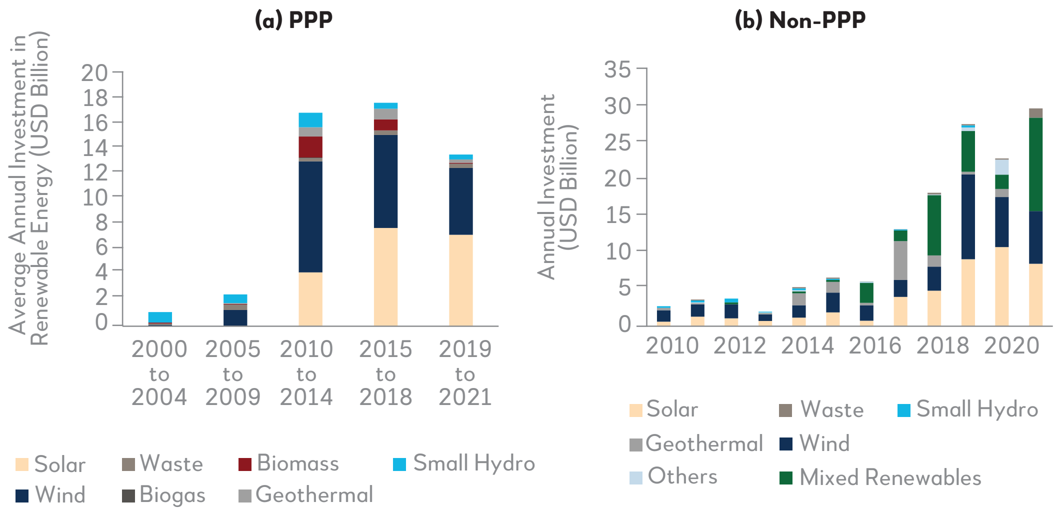
Figure 13: New Capacity Additions under Renewables and Conventional Energy in Asia



GwH = Gigawatt-hour, PPP = public-private partnership.

Data source: World Bank PPI Database, IJGlobal Dataset and AIIB staff estimates.

Figure 14: Average Annual Investment in Renewable Projects in Asia



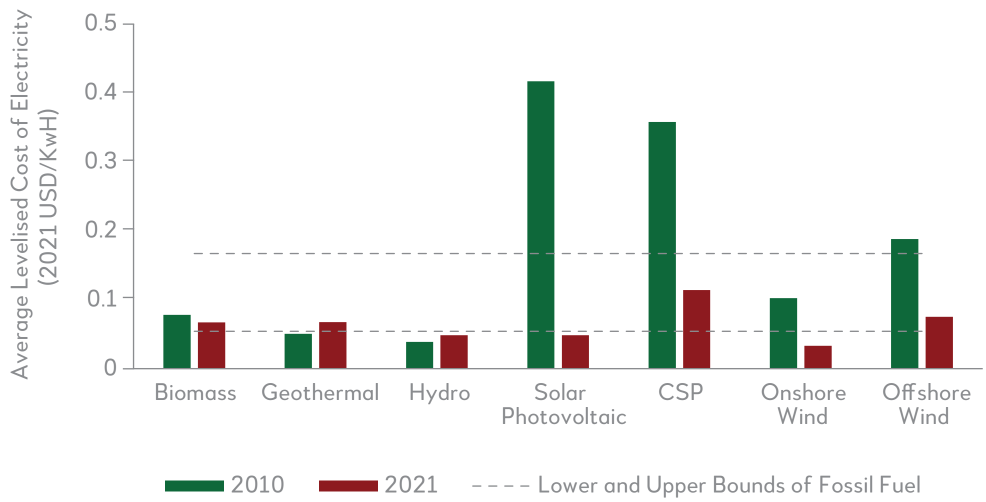
PPP = public-private partnership.

Data source: World Bank PPI Database, IJGlobal Dataset and AIIB staff estimates.

The cost of electricity produced by solar photovoltaic and concentrated solar power (CSP) plummeted by 85 percent and 68 percent, respectively, while the cost for offshore and onshore wind dropped by 56 percent and 48 percent respectively (Figure 15). Technological innovation and increasing maturity have been key drivers, focusing on improving conversion efficiency and reducing component costs. The trend is expected to continue with innovations like granular silicon for polysilicon, larger size/N-type for the wafer in solar, carbon fiber for blade, and vertical axis for turbine in wind, further improving efficiency and reducing costs (Credit Suisse, 2022).

These shifts in private sector investments have allowed economies to move much more decisively toward net zero. Since 2015, renewables have accounted for an overwhelming majority of new electricity generation capacity addition through PPPs in Türkiye (100 percent), China (89 percent), and India (89 percent).

Figure 15: Levelized Cost of Electricity by Technology



CSP = concentrated solar power, KwH = Kilowatt-hour.

Data source: IRENA (2021) and AIIB staff estimates.

3.2.2 Transport Sector

The transport sector accounts for more than 17 percent of GHG emissions. Asia's cumulative PPP investment in the transport sector amounted to USD313 billion between 2010 and 2021, significantly higher than the non-PPP investment totaling USD75 billion. However, there is a great deal of variation across the subsectors. Railways, ports, and airports account for 70 percent of non-PPP investment in the transportation sector (Figure 16).

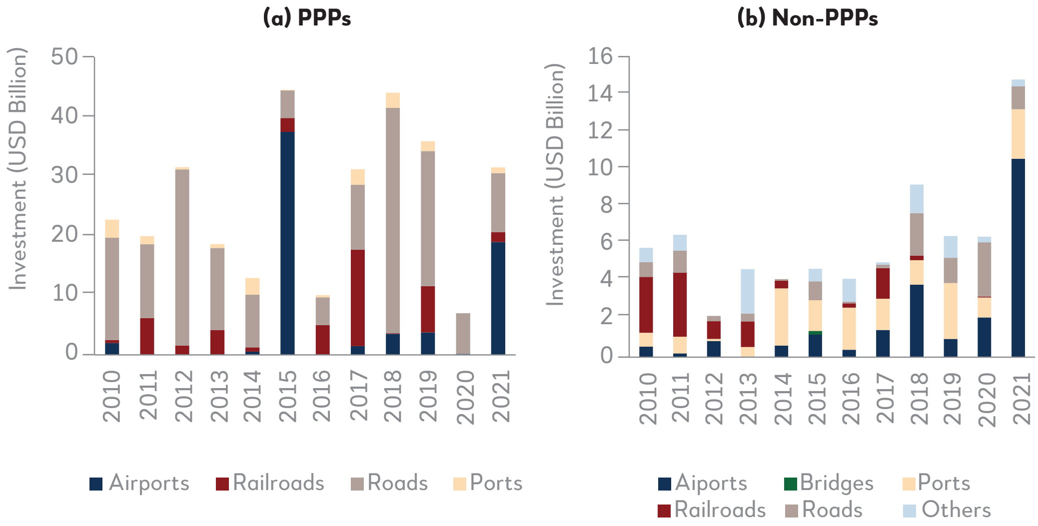
On the other hand, roads dominate PPP investment in this sector, accounting for 58 percent of the investments. This has resulted in the building or upgradation of nearly 40,000 km of roads. Investment in roads will continue as the rising global population and per capita income necessitate higher freight and passenger traffic. Increased road capacity, which reduces congestion, can help lower GHG emissions. However, this is likely to be temporary, as a rise in "induced traffic," with travel becoming easier, can increase vehicle miles travelled and offset the initial reduction in GHG emissions.

This is where EV development, coupled with higher renewable power, is key. Technological innovations have contributed to making EVs more attractive. Lithium-ion-battery cell and pack prices have declined by more than 80 percent between 2013 and 2021, making EVs more competitive compared to internal combustion engine vehicles. The stock of EVs on the road has tripled over the last three years, primarily driven by strong sales in China, Europe, and the United States. Supportive policies, including subsidies, have been instrumental in pushing the adoption of EVs, especially in the electric two/three-wheeler segments.

To further augment the use of EVs, the public sector can lead by designing regulations to bring the latest climate change mitigating technologies by involving the private sector. For example, while building new highways or motorways under the PPP framework, the public sector can keep a provision for EV-charging stations and even source renewable energy for such stations by leasing the area, especially around motorways, for solar or wind power generation where viable.

The provision of charging stations on inter-city roads will assist in the early adoption of EVs in the economy because of the limited mileage of the vehicle provided on a single charge. Similarly, the public transport sector can be transformed by upgrading current diesel-based mass-transit systems through electrification and introducing new electrified metro projects in most Asian economies. Faster, cheaper, and safe mass-transit systems will not only be vital in shifting the population from roads to public transport but also reducing carbon emissions. However, these will help achieve other developmental goals like raising female labor force participation (Kim, 2019).

Figure 16: Private Sector Investment in the Transport Sector in Asia



PPP = public-private partnership.

Data source: World Bank PPI Database, IJGlobal Dataset and AIIB staff estimates.

Railroads, which have the potential to take carbon-emitting trucks off the road and promote reduced use of cars, account for only 15 percent of PPP investment in the transport sector, and 35 percent of non-PPP investment. Within transport, low-carbon transport infrastructure includes metro and other urban rapid transport, high-speed inter-city rail and associated investment.

Overall, PPP investment in low-carbon transport infrastructure has remained volatile, driven by a few mega deals in selected years. Nevertheless, on average the share of these projects in overall rail and road transport increased between 2010 and 2018 (Figure 17). The decline during 2019-2021 could be explained by the effect of the COVID-19 pandemic and governments around the world prioritizing healthcare and social protection. At present, low-carbon transport infrastructure in Asia remains geographically concentrated across a few countries, with China, India and ASEAN economies predominantly accounting for such investment.

Airports account for 22 percent of PPP investment, slightly higher than its share of 20 percent in non-PPP investment. It should be noted that airport PPP investments tend to be driven by a few mega deals whereas non-PPP investments are more evenly distributed. Non-PPP investment in ports is more than double the quantum of PPP investment.

3.2.3 Fossil Fuel-Based Power

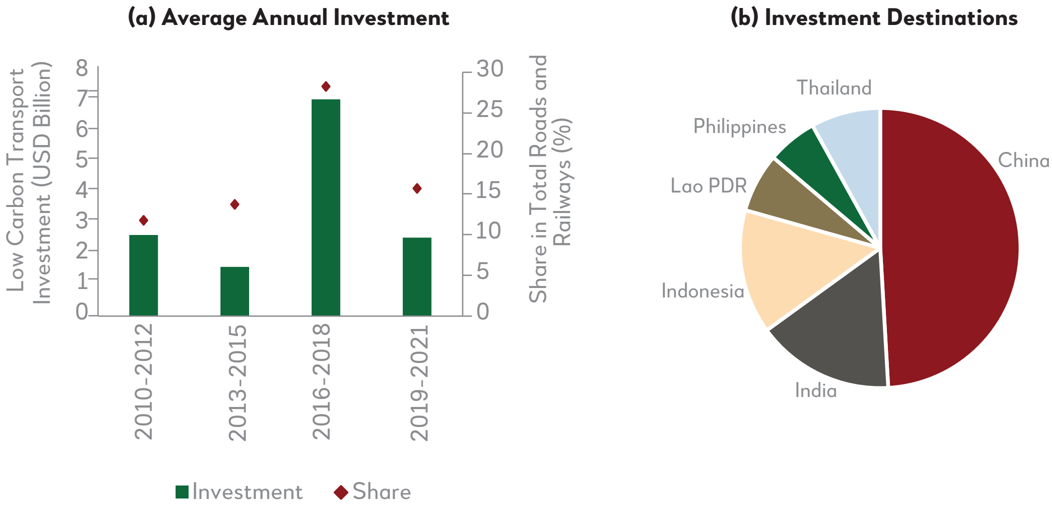
Despite the promising private sector trend toward renewables and low-carbon transport, sizeable private sector investments remain in fossil fuel-related infrastructure. Overall, since 2015, 38GW of capacity addition using fossil fuel has been added in Asia through greenfield PPP investments. Around half of this involved the use of coal, while around 18GW used natural gas. Nearly 80 percent of this capacity addition has been concentrated in Southeast and South Asia (Figure 18).

The addition of large fossil fuel-based power generation could affect the economies' participation in global value chains (GVCs). For example, many South and Southeast Asian economies have sizeable garment industries. With global buyers now committed to greening their respective value chains, there would be a need for more decisive policy actions.

3.3 Improving Institutional Factors to Drive Renewable PPPs

Many factors, which influence the development of PPPs, have an important bearing on low-carbon infrastructure. The quality of governance, especially control of corruption and the rule of law, plays an essential role in developing PPPs [see Hyun

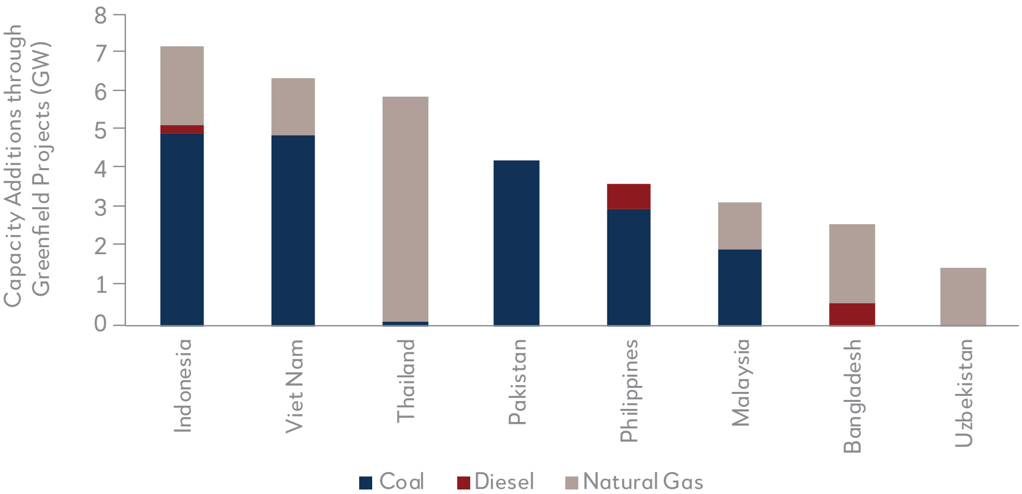
Figure 17: PPP Investment in Low-Carbon Transport Infrastructure in Asia



PPP = public-private partnership.

Data source: World Bank PPI Database, and AIIB staff estimates.

Figure 18: New Fossil Fuel Capacity Addition (Since 2015)



Data source: World Bank PPI Database, and AIIB staff estimates.

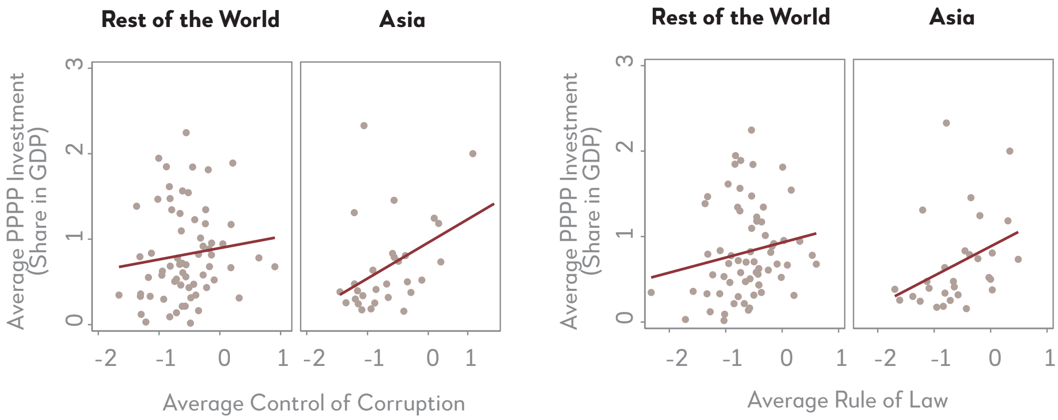
et al. (2018), Di Liddo et al. (2019), Sarmentoa & Renneboog (2020)]. OECD (2012b) also provides the key principles to improve PPP governance.

Being long-term in nature and designed in an environment of incomplete information, PPP contracts can create opportunities for corruption, reducing the efficiency of projects, raising transaction costs, and increasing the likelihood of ex-post renegotiations. Therefore, investors should be protected from the opportunistic behavior by corrupt officials [see (Hammami et al., 2006), (Michele et al., 2018)].[10] In line with this hypothesis, PPP investments are found to be higher in economies with better control over corruption (Figure 19a).

The quality of legal framework plays an important role as PPPs involve long-term contracts among multiple players across changing economic circumstances. An effective rule of law is essential

10 At the same time, studies have found that perceived corruption rises as the number of PPP arrangements increase as PPPs tend to be vulnerable to corruption (Cuadrado-Ballesteros & Peña-Miguel, 2020).

Figure 19: Institutional Quality and PPP Investment



GDP = gross domestic product, PPP = public-private partnership.

Note: Averages are taken over the period 2011 to 2021.

Data source: World Bank PPI Database, World Bank WDI Database and AIIB staff estimates.

to build trust between partners (Sarmentoa & Renneboog, 2020). An efficient rule of law also allows speedy renegotiations and resolution of disputes in a fair, fast, and reliable manner—this is vital for PPPs (Guasch et al. (2008)). This is again supported by the finding that economies with better rule of law tend to have higher PPP investment (Figure 19b).

Across both Figure 19(a) and Figure 19(b) the relationship between PPP investment and institutions is more positive in Asia than in the rest of the world. This could result from the public sector exerting a greater influence on market transactions in these economies.

With most PPP projects involving a significant volume of funds and long-term commitments, the presence of an environment that engenders a level playing field emerges as an important driver of private sector participation (OECD, 2012a). Countries striving for competitive neutrality foster greater private sector participation in the energy sector and a higher share of renewable energy investment (Box B).

In addition to the overall environment, some specific PPP-related aspects of the regulatory environment also bear on the success of PPPs. Figure 20 shows the relationship between the PPP environment and the share of PPPs in overall capital stock across Asian economies.

First, the scatter plot indicates a positive relationship between the environment and a country's engagement in PPPs. Second, the absence of economies at the top-left quadrant indicates that no economy achieved a higher level of PPP capital stock without a higher score for the PPP environment. Thus, PPP investments will likely take off only after the environment has reached a threshold level. Finally, improving the PPP environment, while being a required condition is insufficient as other factors may deter private sector participation. For example, Bangladesh and China score well on PPP environment but have a low ratio of PPP engagement due to the robust role of the public sector in capital formation.

Apart from institutional quality, the public sector capacity required to design and implement PPP contracts also impacts PPP investment. Lee et al. (2020) found that factors such as the presence of a PPP unit, contract award method, and nature of government support have a significant bearing on the success of the PPP project.

Across the Asian economies, great deal of heterogeneity exists in the public sector's capacity to enable PPPs. Across all 38 Asian economies covered in World Bank (2020a), a regulatory framework exists that allows PPPs. However, in more than 80 percent of these economies there is no framework to align PPPs with national investment priorities. Moreover, no specific procedures are outlined, even if there is a framework. Similarly, nearly two-thirds of the economies have no dedicated funds to project preparation and help improve coordination.

Box B: Competitive Neutrality and PPPs For Net Zero

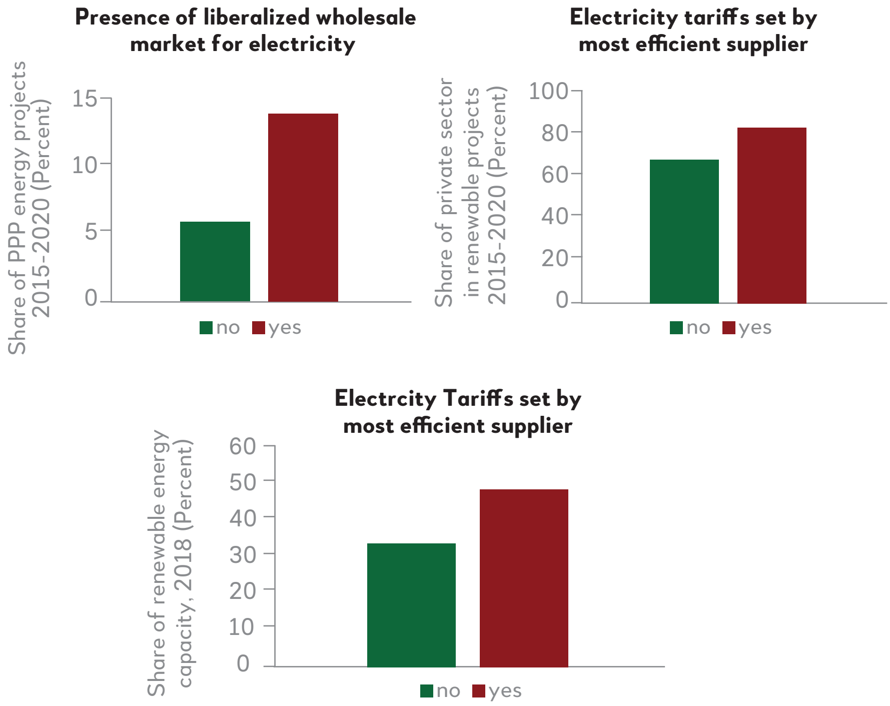
Public-private partnerships (PPPs) can be an important mechanism for introducing competition, especially in economies dominated by state-owned enterprises (SOEs). PPP contracts tend to benefit from being built around competitive and transparent procurement procedures and following market dynamics more broadly. This gives policymakers important information on price points, available technologies, and market conditions. Naturally, competition policy and regulations matter for PPPs, particularly when considering joint venture PPPs, where contestability and a level playing field in the market is vital to achieving targeted efficiency gains.

Data on infrastructure transactions support this argument, indicating that regulatory frameworks less conducive to competition are associated with lower private participation in infrastructure projects. Furthermore, the trends are similar for private participation in the form of PPP arrangements and non-PPP-related private participation. Analysis of IJGlobal and the Organisation for Economic Co-operation and Development (OECD) Product Market Regulation (PMR 2018) data sheds light on the role of market competition and private sector engagement in infrastructure investments. Using a sample of 48 OECD and non-OECD countries, this analysis tallies the presence of private firm co-sponsors in IJGlobal Infrastructure transaction data based on country responses to OECD product market competition questionnaires.

The results indicate that preferential treatment of SOEs may stifle private sector participation in infrastructure. For example, international experience shows that countries, which allow special legal exemptions to SOEs, on average report 10 percent lower private participation as a share of all infrastructure projects (Figure B.1). However, sector-specific results are more salient and highlight competitive neutrality characteristics beyond SOEs.

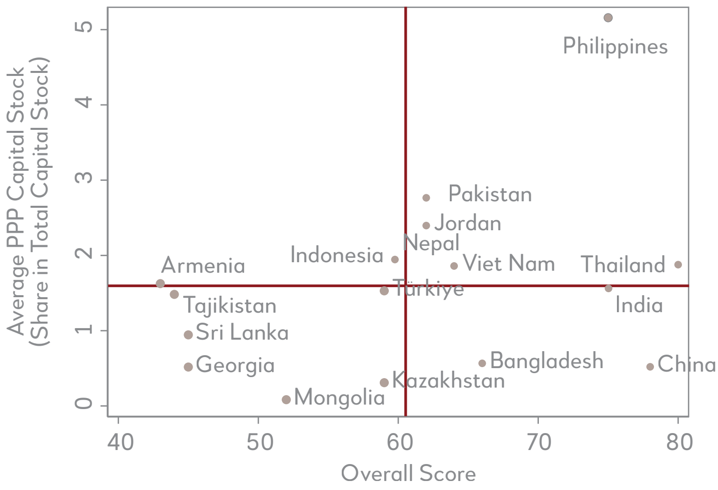
Consider the energy market: the presence of a liberalized wholesale market for electricity increases the share of PPPs in energy projects from 6 percent to 14 percent on average. In the same vein, electricity tariffs set by state authorities instead of the most efficient producer, are linked to lower private sector participation in energy generation infrastructure projects.

Figure B.1: Impact of Market Liberalization



Data sources: OECD Product Market Regulation Database Questionnaire 2018, IRENA Electricity Capacity Database 2021, IJGlobal Database 2022 and AIIB staff estimates.

Figure 20: PPP Investment and PPP Environment



PPP = public-private partnership.

Note: The horizontal and vertical lines are the averages for overall PPP environment score and average PPP capital stock.

Data source: IMF (2021), EIU Infrascope Database and AIIB staff estimates.

A dedicated PPP unit in the government that facilitates the PPP program is essential for PPPs to operate. Such a unit is present across almost all the Asian economies, but most carry out only the basic functions like designing regulations, promoting PPPs and building capacity. In only a handful of the economies these units are involved in identifying projects from the pipeline, procurement-related activities, and consultation with affected economies, all of which play a vital role in successfully implementing the projects (Figure 21).

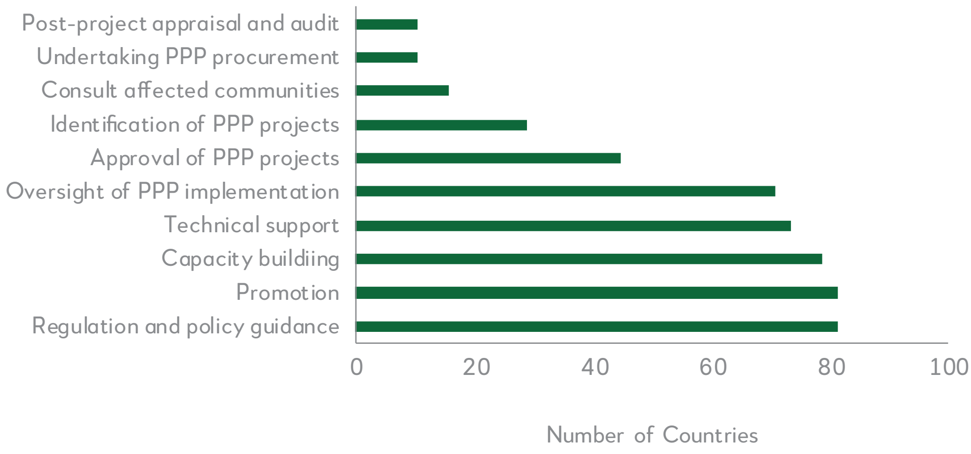
The World Bank (2022a) also evaluates the regulatory quality of 140 economies, including 38 economies in Asia across the core phases of the infrastructure project cycle: preparation, procurement, contract management and unsolicited proposals. Figure 22 compares the performance of five regions in Asia across these parameters. East Asian economies emerge as having the best regulatory ecosystem in Asia with economies in the Middle East and Southeast Asia having the weakest environment (Figure 22).

With PPP projects typically being large and complex and involving long-term commitments spanning several decades, rigorously assessing the viability of the projects during the preparation phase is critical. Most Asian economies, barring those in East Asia, tend to score lower on project preparation compared to the average for emerging economies. Most Asian economies undertake socioeconomic, fiscal affordability, risk and bankability and environmental assessment during the preparation stage.

However, less than half of these economies undertake any procurement assessment or evaluate potential interest from the market in the project. Moreover, in none of the Asian economies a detailed assessment is undertaken on identifying the technology available and the opportunities for innovation in these projects. PPPs can play a stronger role in net-zero transition if climate change effects are integrated into the project design to enhance long-term viability and value for money. Thus, clear, and contractually bound performance metrics can incentivize adaptation and mitigation of climate change during the design stage.

Next, the quality of the procurement process plays a critical role as it helps select the appropriate private sector partner, who can unlock value through innovation and greater efficiency. Again, East Asian economies have the best procurement practices followed by economies in Central and West Asia. Therefore, a crucial step in conducting a PPP transaction is identifying the optimal procurement procedure to select the best private sector partner to implement the project. Contracts can be awarded either through competitive bidding

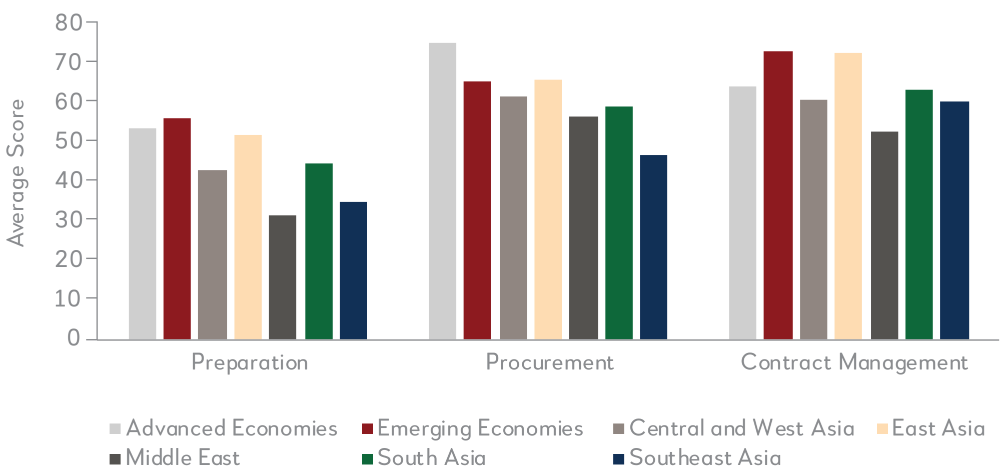
Figure 21: Functions by PPP Units in Asian Economies



PPP = public-private partnership.

Data source: World Bank Benchmarking Infrastructure Development Database.

Figure 22: Benchmarking PPP-Related Processes



PPP = public-private partnership.

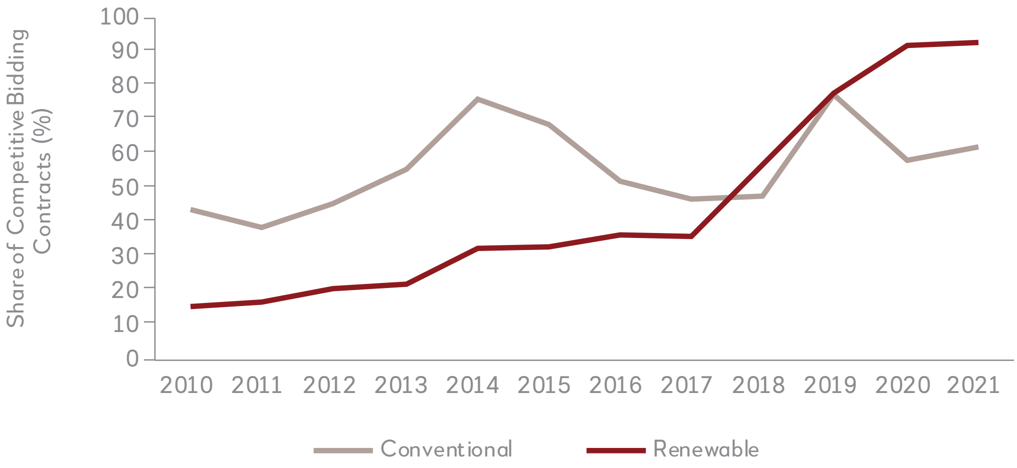
Data source: World Bank Benchmarking Infrastructure Development Database.

or direct negotiations.[11] In the latter, a contract is awarded based on an explicit agreement with a private player. Competitive bidding has helped countries procure new renewable energy capacity at the lowest possible price, supporting the net-zero transition (Figure 23).

Despite the general trend toward competitive bidding, other best procurement practices tend to be less common among Asian economies. For example, more than two-thirds of the economies do not have any specific procedures dealing with single bids. Similarly, less than one-third of the economies require a financial model to be submitted with the proposal. Less than 20 percent of the economies have a process to allow bidders to suggest innovations or have a standstill period for unsuccessful bidders to challenge the award decision. There is a tremendous opportunity for learning and percolating best practices across the region.

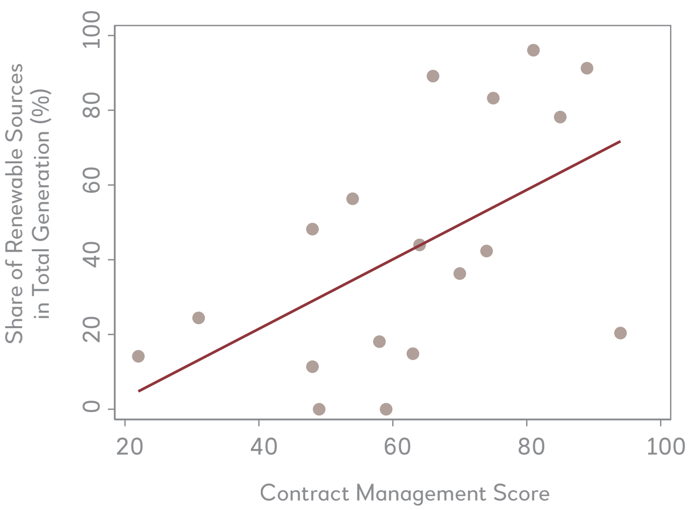
[11] Open tendering where all interested bidders can participate or restricted tendering where there is a pre-qualification stage, assessing the capacities of bidders, thereby reducing the risk of low-quality bids.

Figure 23: Contracts Awarded by Competitive Bidding



Data source: World Bank PPI Database, World Bank Benchmarking Infrastructure Development Database and AIIB staff estimates.

Figure 24: Contract Management and Investment in Renewables



Data source: World Bank PPI Database, World Bank Benchmarking Infrastructure Development Database and AIIB staff estimates.

The Asian economies have adopted a sizeable number of good contract management practices identified in World Bank (2020a) like allowing the repatriation of income generated from PPP projects, refraining from the unilateral modification of PPP, making available alternative dispute resolution mechanisms and ensuring arbitration awards are enforceable by local courts. However, in most Asian economies, the information pertinent to project construction and operation performance or detailed qualifications of the contract management team is not disclosed.

A robust contract management environment will foster net-zero transition as renewable sector projects are particularly affected by delayed tendering schemes, renegotiations of power purchase agreements, land acquisition policies and delays in grid connectivity. It is evident from Figure 24 that economies with a stronger contract management score have witnessed a larger share of renewable investment in overall energy generation. Regulating renegotiation of PPP contracts prevents opportunistic amendments. Moreover, many renewable energy projects tend to be complex involving multiple stakeholders across multiple jurisdictions that are governed by different laws. Hence, a robust dispute resolution mechanism becomes crucial for the successful operation of these projects.

Lack of progress on the above factors has resulted in the cancellation of PPP projects, which imposes large efficiency losses (Figure 25). Cancelled and distressed projects account for USD21 billion or 2.4 percent of the overall PPP investment in Asia (World Bank, 2022a). The transport sector accounted for 51 percent of the cancelled projects followed by energy at 22 percent.

Melecky (2021) identified several factors behind projects becoming distressed. Certain sectors such as railroads, toll roads, treatment plants, and water utilities remain more vulnerable to distress. Macroeconomic shocks like banking and debt crisis and currency devaluation also raise the probability of project cancellations. On the other hand, projects with government support will less likely face early termination. At the same time, institutionalized checks and balances on the public sector reduces risks of expropriation through a policy change or political interference. Lee et al. (2020) also indicated that local government contracts, indirect government support, and MDB support mitigate the risk of project cancellation.

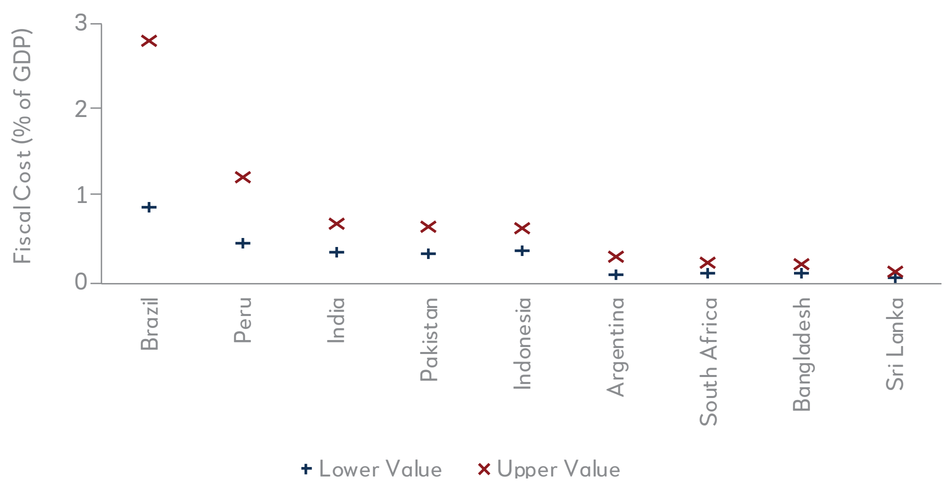
Early termination of projects raises the fiscal costs for the government as it is the ultimate guarantor of the infrastructure services and has to step in. Melecky (2021) and Dappe et al. (2022) highlighted that some economies in South Asia and Latin America face the highest fiscal costs from early termination of projects (Figure 25).

3.4 Conclusion

Over the last decade, the private sector has been increasing its footprint in financing green and resilient infrastructure. Overall, there has been a decisive shift toward clean energy for electricity generation and rising participation in low-carbon transport. However, there are substantial regional variations with several economies continuing to add fossil fuel generation capacity in recent years. Similarly, a handful of countries drive the growth in low-carbon transport.

Bridging the infrastructure deficits and meeting the climate targets, which economies have set up for themselves, will require the pace of green investment to be accelerated manyfold. This will be contingent on a policy framework and enabling environment that facilitate investments toward the net-zero transition. Attracting more PPP investments to achieve this goal will require building appropriate incentives

Figure 25: Fiscal Costs from Early Termination of PPP Projects in Selected Economies



GDP = gross domestic product, PPP = public-private partnership.

Data source: Based on Melecky (2021) and Dappe et al. (2022).

and strengthening institutions. This can be done in many ways like ensuring suitable risk allocation, strengthening public sector capacity, facilitating a level playing field, improving project structuring, etc. MDBs can play a vital role in overcoming some of the bottlenecks. In addition to directly supporting PPPs through financial assistance, MDBs can strengthen the project cycle, help reduce the credit risk for the private investors, incentivize the public sector to honor the contract terms, and ensure rigorous standards of due diligence.

CHAPTER 4

MOBILIZING DEVELOPMENT FINANCE AND INVESTMENTS THROUGH STATE-OWNED ENTERPRISES

The role of SOEs in development has received much academic study and policy discussions over the past decades. This topic remains highly relevant due to the need to mobilize large sums of development finance to plug infrastructure gaps in EMDEs.[12] Compared to more traditional fiscal avenues, mobilizing capital through SOEs can be advantageous under the right conditions. As corporate entities with more market-based incentives and professional management, SOEs can be effective in investing and managing public assets, yet at the same time tap private markets for capital mobilization.

SOEs will also be confronted with climate change mitigation. As discussed later in the chapter, SOEs as a sector is a large emitter and current data point toward continued sizeable new investments in conventional fossil-based power by SOEs. Many SOEs will have to change directions quickly and undergo wholesale business transformation to be consistent with net zero in the next few decades. Attending to this is also the need to mobilize large financial resources toward mitigation and adaptation. Though estimates vary, SOEs have a sizeable footprint in many economies, particularly in Asia (Kowalski et al., 2013). In recent decades, China's experience highlights the efficacy of SOEs in mobilizing capital and developing high-quality infrastructure.[13]

Nevertheless, SOEs are not always well-governed or managed. Naturally, this has engendered skepticism around SOEs' participation, particularly in EMDEs. SOEs' financial liabilities are sometimes seen as causes, or amplifying factors toward, financial crises.[14] There are further concerns, ranging from low productivity and innovation to poor incentive alignment, inferior financial or economic performance, or worse—outright corporate malfeasance. The concerns also speak of crowding out of the private sector.[15] Baum et al. (2019) showed that SOE performance interacts with country-specific conditions, resulting in even poorer performance (compared to private enterprises) when there are country institutional weaknesses. Privatization of SOEs is often seen as a remedial policy tool.

[12] For analysis and data in this chapter, advanced economies, EMDEs' classifications are taken from the IMF.

[13] There is also evidence that SOEs are more suited for large-scale infrastructure projects than PPPs (Christensen & Greve, 2018).

[14] Bova et al. (2016) provided historical data of substantial fiscal risks arising from SOE debts in various crises. World Economic Forum (2021) documented the presence of large liabilities of SOEs in South Asia and the associated risks. Molnar & Lu (2019) documented the high level of debts accumulated in China's SOE sector.

[15] See World Economic Forum (2021), Samphantharak (2019), Ng & Menon (2013), Phi et al. (2019) for a non-comprehensive overview of the literature.

Yet privatization is often not a realistic political option. Specifically, for GHG emission–intensive assets, there is the concern that privatization simply results in such assets being held by private sector investors with fewer incentives to report the emissions or deal with the emission externality (resulting in so-called "emission leakage" between assets). It is argued that it will be better for such assets to remain in public hands for appropriate mitigation or even accelerated sunset.

Recognizing the size of the SOE sectors and the often critical public roles they play, the privatization agenda of the past decades has evolved into a richer and more nuanced set of policy recommendations around SOE reforms to make them more bankable as catalysts for development [see World Bank (2014), IMF (2020)]. The need for significant investments to plug the infrastructure gaps in EMDEs and accelerate the net-zero transition again calls for a more productive set of SOEs to meet these challenges. Effective SOEs constitute an important capacity for development—"The other government", so to speak.

Leveraging large data sets and focusing the analysis on infrastructure sectors, this chapter documents some recent trends around SOE participation in markets. It provides new empirical facts to shed light on some "old" questions. In particular, the chapter dives into a few critical concerns: (a) whether and how large SOEs' financing advantage is, (b) whether SOEs crowd out private investments, and (c) how SOEs are doing for the net-zero transition. Finally, the chapter provides further policy discussion on the role of SOEs in mobilizing development finance.

4.1 SOEs in EMDE Markets: Still Considerable Investment into Fossil Fuel Infrastructure

As part of the background research undertaken in preparing this report, a list of SOEs is derived using the ORBIS data set based on the 2021 ownership structure. This list of SOEs is then matched with historical transactional data consisting of infrastructure deals data from IJGlobal and financing data from Refinitiv.[16] Financing data comprised both bond issuance and contracted syndicated loans. Together, these have provided rich data on the financing activities, financing costs, and PPP-related infrastructure investments undertaken by SOEs.

These data sets provide useful information on how SOEs raise capital in the market and their PPP-type investments. But these will not tell how much fiscal subventions SOEs receive for their activities conducted directly on behalf of line ministries without going through the market. This chapter's findings are thus related to SOEs' mobilization of market capital and should be interpreted as such.

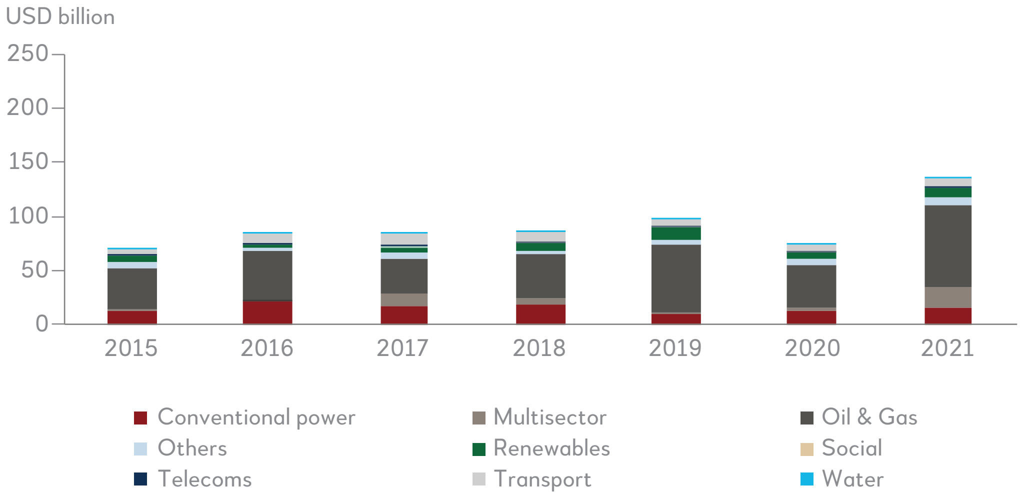
Firstly, based on IJGlobal data, SOEs' project finance for infrastructure in Asia has largely flatlined in the past five years as with private sector project finance. Secondly, it is nonetheless important to note that SOEs played a significant countercyclical role in the aftermath of the pandemic as seen in the sharp increase in 2021 (following the decline in both SOE and private sector investments in 2020 due to the pandemic) (Figure 26).

Thirdly, the sectoral profiles also reveal that SOEs continue to invest in conventional fossil power generation and oil and gas infrastructure. This contrasts with the private sector, where IJGlobal data shows such investments remain largely unchanged over the past five years (Figure 27). Furthermore, the SOE sector as a whole also invests less in renewables compared to the private sector. On the one hand, this may be a sign that the SOE sector does not crowd out the private sector in the renewable space. But on the other hand, this could be added evidence of SOEs' continued attachment to fossil fuel assets and the lack of a more decisive shift toward renewables.

Given that the world needs to scale up renewable power significantly over the next decade to meet net-zero targets, concerns over SOE crowding out the private sector are perhaps overstated. Rather, SOE capacity is needed for constructing renewable utilities at scale, much like their significant role in conventional energy.

[16] See Appendix 1. Identification by legal form is necessary as some SOEs are defined by statutes rather than share ownership. Note that IJGlobal data includes only market-based infrastructure deals and excludes fiscally financed infrastructure development. The analysis here thus captures SOEs' participation in market activities, as opposed to development through fiscal subventions. Similarly, the Refinitiv data set also captures market transactions only. Private debts contracted by SOEs, fiscal or quasi-fiscal support, are not observed.

Figure 26: Closed Infrastructure Project Finance Transactions by SOEs in EMDEs

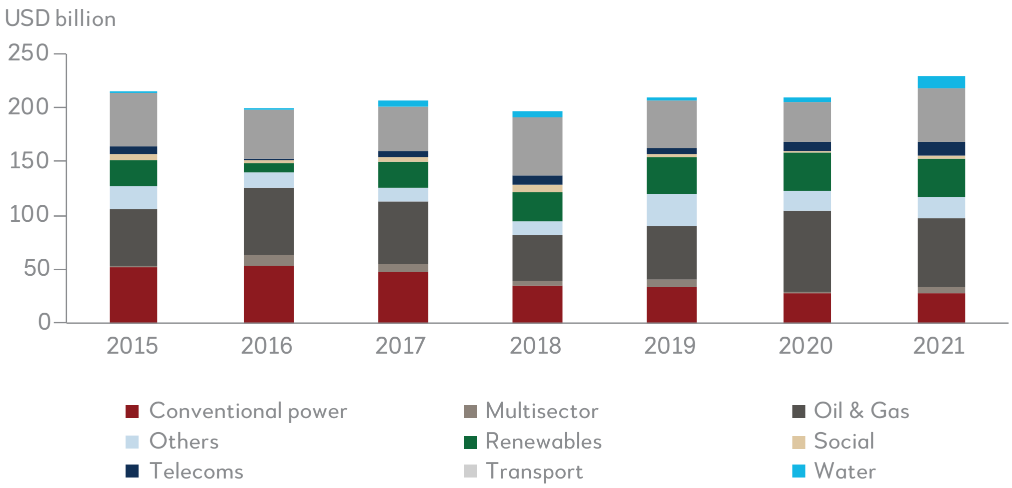


EMDE = emerging and developing economy, SOE = state-owned enterprise.

Note: Data includes closed transactions from 2015 to 2021 but excludes financing deals for acquisitions.

Data source: IJGlobal and ORBIS, and AIIB staff calculations.

Figure 27: Closed Infrastructure Project Finance Transactions by Non-SOEs in EMDEs



EMDE = emerging and developing economy, SOE = state-owned enterprise.

Note: Data includes closed transactions from 2015 to 2021 but excludes financing deals for acquisitions.

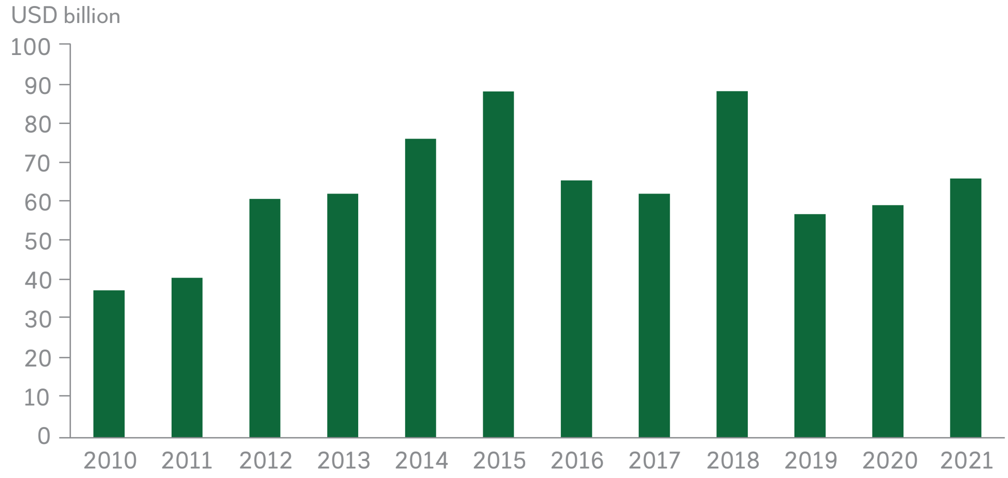
Data source: IJGlobal and ORBIS, and AIIB staff calculations.

Infrastructure SOEs in EMDEs engage in contracting syndicated bank loans, with their loan activity being around a third of the private sector (comparing Figure 28 and Figure 30). However, banks themselves face increasing regulatory or risk constraints. As a result, crowding institutional investors into infrastructure is now seen as necessary to fill the infrastructure investment gap.

Besides investing in projects, SOEs are also increasingly active in raising capital from the market. Institutional investors seeking to invest in infrastructure can face high operational, informational or risk hurdles. Hence, institutional investors would look toward suitable entry points to have exposures to infrastructure assets and yet mitigate against risks. By becoming investable, SOE bonds thus offer another avenue for private capital mobilization.

SOEs have taken advantage of the low interest rate environment of the past decade and raised capital. While the increase in interest rates would likely curtail bond issuance in 2022, the overall trend over the past decade is promising. It supports the emerging view that SOEs in EMDEs have developed more capacity to raise capital and add value. This is particularly evident in the bond market, where SOE issuance has grown faster over the past decade (comparing Figure 29 and Figure 31).

Figure 28: SOE Syndicated Loan Volume for EMDEs

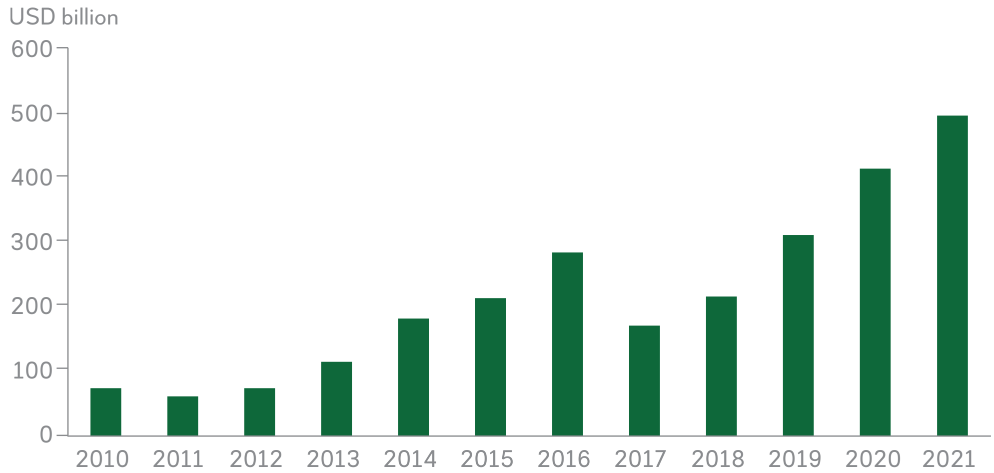


EMDE = emerging and developing economy, SOE = state-owned enterprise.

Note: Data in these charts are for infrastructure sectors only.

Data source: Refinitiv and ORBIS, and AIIB staff estimates.

Figure 29: SOE Bond Issuance for EMDEs

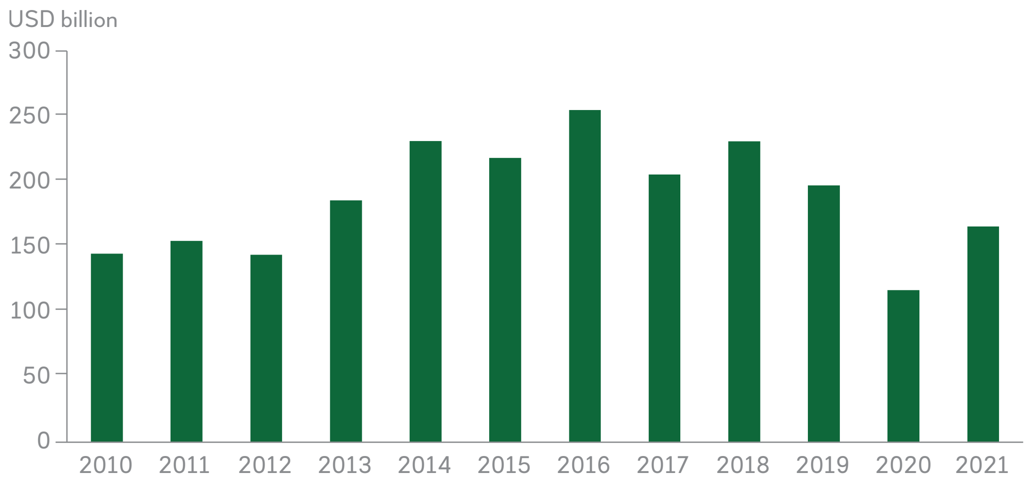


EMDE = emerging and developing economy, SOE = state-owned enterprise.

Note: Data in these charts are for infrastructure sectors only.

Data source: Refinitiv and ORBIS, and AIIB staff estimates.

Figure 30: Non-SOE Syndicated Loan Volume for EMDEs

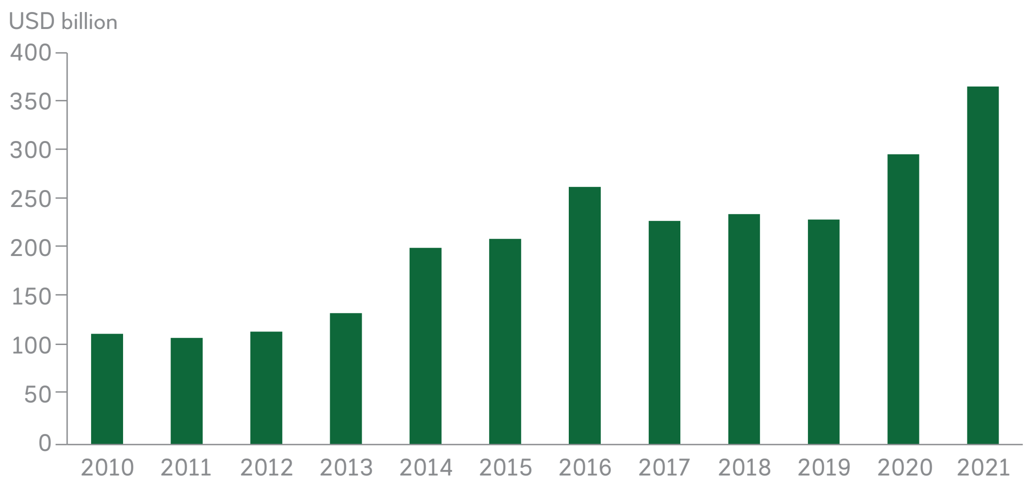


EMDE = emerging and developing economy, SOE = state-owned enterprise.

Note: Data in these charts are for infrastructure sectors only.

Data source: Refinitiv and ORBIS, and AIIB staff estimates.

Figure 31: Non-SOE Bond Issuance for EMDEs



EMDE = emerging and developing economy, SOE = state-owned enterprise.

Note: Data in these charts are for infrastructure sectors only.

Data source: Refinitiv and ORBIS, and AIIB staff estimates.

4.2 SOE Financing Advantage Seen Especially in Bond Markets

A key "old" question is whether SOEs receive improved financing terms. Finance is one key channel of crowding out, simultaneously leading to and reinforcing the higher market power of SOEs.[17] This concern is also related to crowding out.

Empirical evidence on this is often mixed, given the heterogeneous landscape between and within countries and the presence of many confounding

[17] See Ng & Menon (2013) for the documentation for threshold effects for Malaysia where private sector firms become reluctant to enter certain sectors because of SOEs.

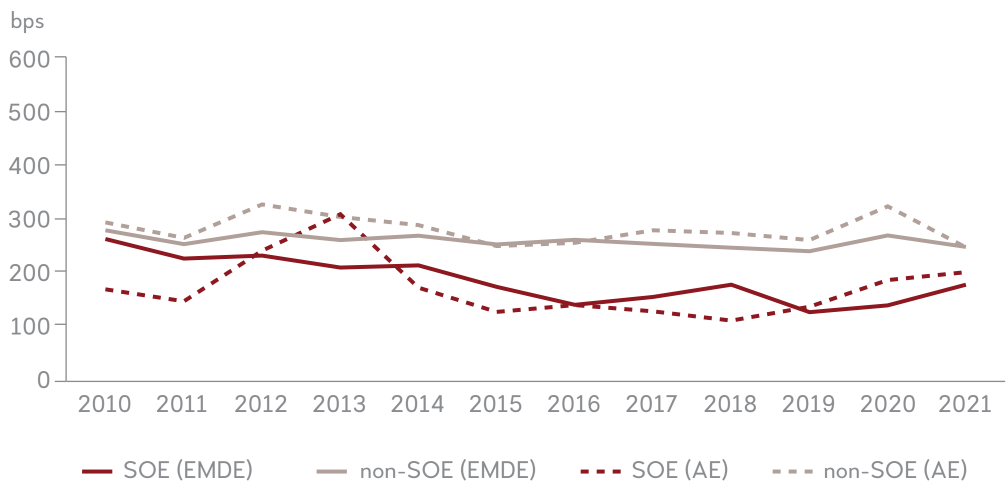
factors.[18] For example, SOEs often operate in sectors such as public utilities or large–scale infrastructure where there are public mandates or tight regulations; private enterprises could be reluctant to enter these sectors in the first place. SOEs often have large revenues or asset portfolios, and their size buffers against economic shocks and enhances creditworthiness. In addition, preferential access to finance could be seen as a tool to help SOEs achieve their public non–market social mandates. It is fair to say that the literature on this is broad and context-specific.[19]

The approach in this chapter is to take advantage of the large datasets for financing transactions and compare the financing costs between SOEs and non–SOEs. The benefit of analyzing transactions (as opposed to firm-level aggregates) is that the larger datasets make it possible to check out the financing terms of different sub–groups and for various hypotheses to be tested more robustly. The chapter presents some salient financing costs trends.

In the syndicated loan market, loans made to SOEs in hard currencies have lower spreads than those to the private sector (Figure 34). While advanced economies are not the focus of this analysis, data shows that SOEs in advanced economies also have lower syndicated loan spreads. During the difficult pandemic year of 2020 when the global economy faced an unprecedented shock, SOEs continued to enjoy consistent spreads while the private sector saw a significant spike. This stability of banking spreads again speaks of the important countercyclical capacity of SOEs. For EMDEs, the analysis also tracks financing in EMDE or non–hard currencies separately, given that these may have different pricing dynamics. Spreads are more volatile in non–hard currencies though SOEs continue to have an advantage (Figure 35).

In the next subsection, the analysis is repeated focusing on financing in non–investment grade EMDEs which have more difficulties attracting international capital. Whether SOEs can fill this gap is thus an important consideration.

Figure 32: SOE Syndicated Loan Spreads for EMDEs (in Hard Currencies)



EMDE = emerging and developing economy, SOE = state-owned enterprise.

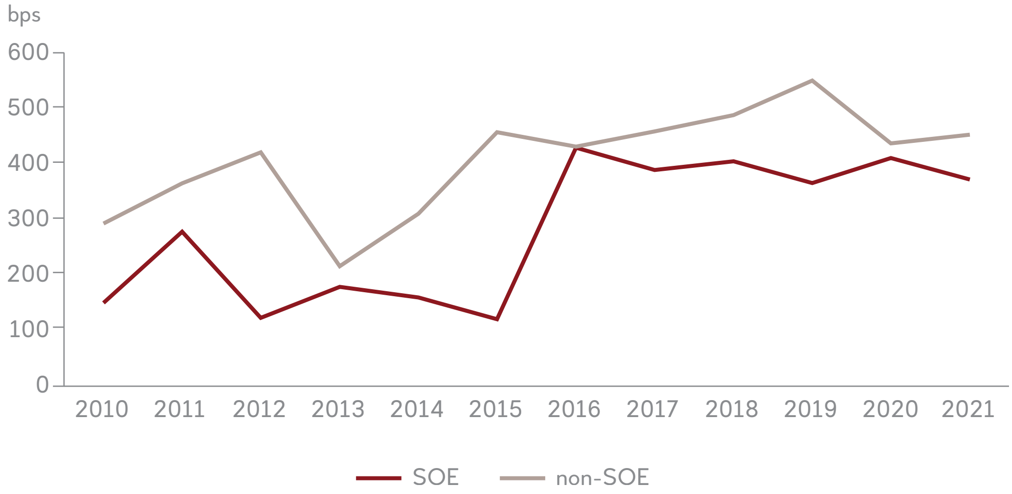
Note: Data in these charts are for infrastructure sectors only.

Data source: Refinitiv and ORBIS, and AIIB staff calculations.

[18] Empirical research has attempted to overcome this, for example, by using propensity score matching (PSM). To a certain extent, this is necessary and brings additional confidence to the findings. However, given the unique position of SOEs in many economies and the sectors they operate in make it difficult to get obtain robust PSM estimates. For example, if some SOE's position in a sector is protected by some public mandates or implicit government support, it would be difficult to create matched counterfactuals. This chapter focuses on transactions. The larger transactional datasets allow for more robust PSM tests. While this chapter presents observational statistics only for brevity, the results have been checked using PSM.

[19] On the other hand, there are government linked companies that are more commercially managed. Ramírez & Tan (2004) find no evidence of preferential finance access for Singapore's government-linked companies.

Figure 33: SOE Syndicated Loan Spreads for EMDEs (in Non-hard Currencies)

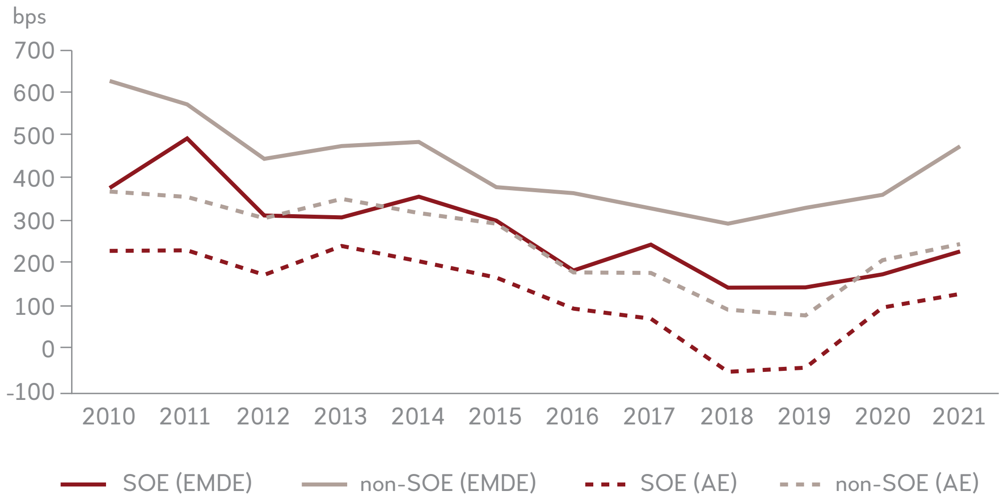


EMDE = emerging and developing economy, SOE = state-owned enterprise.

Note: Data in these charts are for infrastructure sectors only.

Data source: Refinitiv and ORBIS, and AIIB staff calculations.

Figure 34: Bond Yields at Issuance for EMDEs (in Hard Currencies)



EMDE = emerging and developing economy, SOE = state-owned enterprise.

Note: Data in these charts are for infrastructure sectors only. Yields data are at the point of issuance and are expressed as spreads over LIBOR.

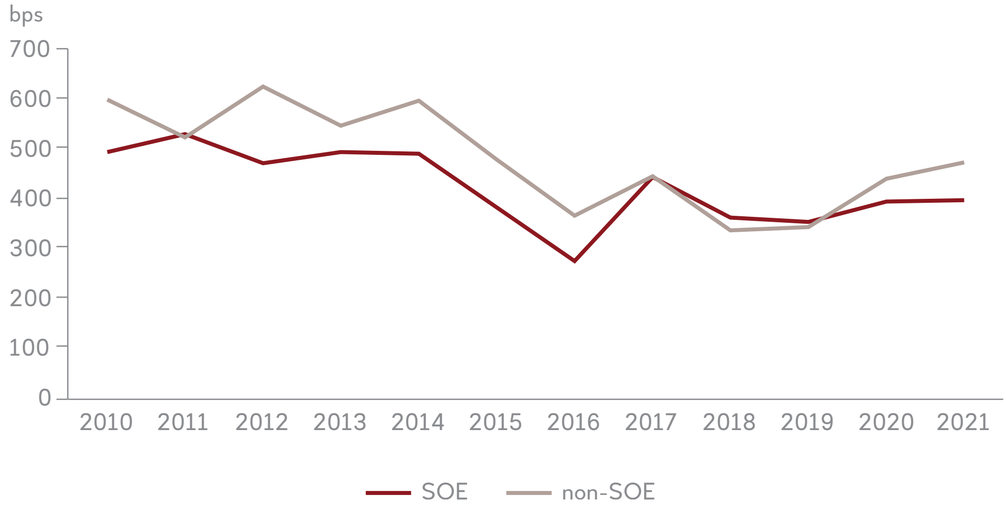
Data source: Refinitiv and ORBIS, and AIIB staff estimates.

4.2.1 SOE Financing Advantage Present in Non-investment Grade EMDEs

Many EMDEs have not reached investment-grade credit ratings. The interesting question is whether SOEs still have a financing edge over the private sector in these economies. As a backdrop, across all economies (investment or non–investment grades), the data shows that spreads (for syndicated loans) and yields (for bonds) are negatively correlated with the sovereign's credit worthiness, and this applies to both SOEs and the private sector. The weaker the sovereign ratings, the higher the borrowing costs. This is not surprising.

A country's creditworthiness reflects its level of development, governance, macroeconomic strengths, etc.—and these factors affect both SOEs

Figure 35: Bond Yields at Issuance for EMDEs (in Non-hard Currencies)



EMDE = emerging and developing economy, SOE = state-owned enterprise.

Note: Data in these charts are for infrastructure sectors only. Yields data are at the point of issuance and are expressed as spreads over LIBOR.

Data source: Refinitiv and ORBIS, and AIIB staff estimates.

and private sector firms. For SOEs, often perceived as an extension of the state, the correlation between sovereign strengths and SOE financing costs is only natural. For the private sector, the transmission channel is perhaps more indirect. Still, it can be rationalized by the fact that they operate in country environments with certain risks, which, in turn, impact their borrowing costs.

Focusing on the subset of loans in non-investment (or speculative) grade EMDEs, the data shows that SOEs continue to enjoy a borrowing cost advantage—albeit a smaller one—compared to private sector companies.[20] This is also evident from the data for bond yields bonds.

Among the hard-currency syndicated loans by companies in investment grade EMDEs, SOEs enjoy an average borrowing cost advantage of around 89 basis points (bps) (142 bps vs. 231 bps) over the period 2015-2019. However, focusing on loans in non-investment grade EMDEs, SOEs continue to enjoy an average borrowing cost advantage of 100 bps (221 bps vs. 325 bps) over the same period. In short, spreads in non-investment grade EMDEs are higher, but the advantage is maintained for SOEs.

For bonds issued in hard currencies, SOEs in investment grade EMDEs enjoy an average 146 bps yield advantage at issuance for 2015-2019. The advantage is much smaller for non-investment grade EMDEs, averaging 7 bps.[21]

A few important implications follow. First, even for non-investment grade EMDEs, SOEs still have a financing advantage in hard currency loans and can help mobilize such capital. The ability to generate hard-currency financing at a lower cost makes SOEs suitable for investments with positive development externalities (infrastructure being a good example) and where hard currency financing is required.[22] Second, SOEs are also well positioned for development projects that require hard currency, including cross-border or overseas projects. Third, improvements in sovereign creditworthiness (such as through fiscal consolidation or other reforms) can further boost SOE financing, particularly for the debt market.

[20] For the analysis, the chapter uses Standard and Poor's long-term foreign currency ratings as the benchmark for sovereign creditworthiness. A non-investment or speculative grade is defined as BB+ and below.

[21] Green bond is another instrument in which SOEs can participate more actively since the market is still at a nascent stage. Box C analyzes this topic in more detail.

[22] While it is commonly observed that infrastructure is best financed in local currencies to avoid mismatches, certain infrastructure types would require hard-currency financing—e.g., those requiring high import content or those with hard-currency revenue streams. Furthermore, current account deficit EMDEs would require external financing in any case, and hard currency financing will be required.

4.3 SOEs' Particular Responsibilities for Net-Zero Transition

Based on current estimates, SOEs account for about 61 percent of total global electricity capacity installed in 2016 and around 52 percent of the capacity currently planned or under construction (Prag et al. (2018)). Benoit (2019) documented that globally, SOEs account for 6.2 gigatons of carbon dioxide (CO_2) emissions per year, which is more than the emissions of the United States (US).

Many analysts noted that SOEs often are national champions with large fossil fuel assets, potentially locked into the "carbon curse" (Mayer & Rajavuori, 2017). Concerns over energy security are undoubtedly a driver behind this. However, the net-zero transition cannot happen without SOEs transforming themselves, getting out of the "carbon curse," and playing a lead role in their respective sectors. A few key shifts on finance and capital mobilization are discussed in this chapter.

4.3.1 Accelerating Phase–out of Existing Fossil-Fuel Assets

Given the large fossil fuel-asset base of SOEs, it is neither realistic nor optimal that divestment alone should be the key public policy choice. Private sector players are not large enough to take over all the assets. Furthermore, it is also recognized that SOE divestment from fossil fuel assets would result in states losing the opportunity to lead mitigation efforts while passing the assets to "less-conscientious" or profit-driven private sector making mitigation even more difficult. Carbon leakage, so to speak.

Hence, the more viable public policy choice is for policymakers to design a credible path for SOEs toward net zero. GHG emission-intensive investments by SOEs should be limited, if not avoided altogether. SOEs must act as if a high-carbon constraint is already present. There will have to be investments into existing fossil fuel assets to reduce emissions and, where possible, for emissions to be captured. It should also be recognized that the most pollutive assets must be phased out in an accelerated manner. These policy actions would no doubt incur investment costs or accelerated write-down expenses, but SOEs have a financing advantage to do this.

4.3.2 Scaling Up and Crowding in Renewables

On the positive side, the green business can become a growth driver for SOEs. In many EMDEs, policymakers continue to use SOEs to hold fossil fuel assets as critical national infrastructure, while renewables investments are driven by the private sector or through PPPs. On the other hand, SOEs still often have related assets, such as transmission lines and grid infrastructure, are power producers with their own assets and serve as off-takers of electricity generated by private firms. This can result in incentive issues or coordination inefficiency between private sector power producers and the state grid of off-takers, slowing down the deployment of renewable power generation.[23] A more decisive policy change would direct SOEs toward large-scale investments in renewable projects.

As seen in this chapter, SOEs have a financing advantage compared to the private sector. The ability of SOEs to borrow at lower rates and longer tenors makes them ideal for financing renewables investment where the capital expenditure tends to be higher. Given the large financing needs of the net-zero transition, crowding out would be less of a constraint. They are better placed and can be incentivized by policymakers to solve coordination problems between the various players in the industry. With more renewables in the generation mix, peak loads and intermittency must be balanced. SOEs can take full advantage of their size to resolve this.

In addition, SOEs can also provide public infrastructure such as transmission lines that help crowd in private sector investors. Using data from the OECD and G20 economies, Prag et al. (2018) provided some evidence that state ownership in the power sector can be positive for renewable investments, and more would certainly be needed from SOEs.

[23] Box B provides evidence that liberalization of electricity markets can boost PPP investments in renewables.

4.3.3 Greening the Value Chain

Often straddled with multiple objectives, SOEs might not be responsive to market signals, including carbon pricing (Baranek et al. (2021)). Nonetheless, this can be flipped into an advantage as SOEs' public character makes them suitable to undertake carbon reduction mandates provided there is sufficient political will to do so.[24]

There is a need to strengthen ecosystem incentives—market and non-market—toward climate change mitigation and SOEs can be a key part of this. SOEs are often lead firms in their sectors and can thus set the necessary standards to shift the rest of the value chains toward greener production.

4.3.4 Providing Innovation Capital

Finally, an interesting shift would be for SOEs to harness their financing advantage toward innovation. As the report will show in a subsequent chapter, SOEs can also be a source of investment and implementation of new technology. For example, China's SOEs are increasingly investing in start-ups specializing in various segments of green technology, including batteries, fast charging, etc.[25]

A study of European firms found that SOEs invest more in R&D (Bortolotti et al., 2019). This can be explained by the fact that SOEs face fewer financial constraints and can raise debt from state-owned banks or private markets. However, a further question is whether SOEs can truly innovate beyond higher expenditure or input-driven R&D. Here, the empirical evidence in the literature is more mixed. The report will further discuss the framework for green technology innovation in a later chapter.

4.4 Legacy to Leadership: Harnessing Financial Advantage toward Green Development

While imperfect, SOEs have often played critical roles in mobilizing capital and developing public infrastructure in advanced economies and EMDEs. Many SOEs are integral parts of countries' development or industrial policies. The footprints of SOEs in many EMDEs are too large to ignore or divest. While SOEs already enjoy better borrowing terms, continued improvement in governance and management remains essential for SOEs to mobilize even larger sums of development capital. Putting the financial advantage into scaling up green infrastructure will be worthwhile.

The net-zero transition will take on increasing urgency. In the foreseeable future, green production will become a source of economic competitiveness. Economies that offer green production opportunities will be much better placed to attract international capital and investments and engage in GVC activities. The next decade is critical for SOEs: they need to transform their businesses and pull key economic sectors along like many of them had done in the past. SOEs in fossil fuel-exporting economies have the additional task of helping the transition away from reliance on such sectors (Peszko et al. (2020)). With political will and the right government policies, SOEs can move from legacy to leadership and harness their financial advantage toward this new mission.

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[24] As will be seen in a later chapter, China's experience shows that holding officials accountable to pollution targets has resulted in lower pollution.

[25] Chapter 6 provides a detailed discussion on SOEs' patenting in various regions. Chapter 7 provides some preliminary evidence how SOE policies in China have the potential of incentivizing SOEs towards environment protection.

Box C: Green Bond Financing Advantage? Some Emerging Evidence

Green bonds, which comprise a small portion of total bonds issued, are becoming a popular mode of financing green infrastructure. Between 2014 and 2021, bond issuance increased by 16 times. State-owned enterprises (SOEs) were not major issuers of green bonds before 2015, but they are fast catching up. In 2021, SOE issuers accounted for around 40 percent of total green bond issuance.

According to the Climate Bonds Initiative (2021) study, public sector sovereign green bonds contribute to around 10 percent of total green bonds issuance (as of 2021) and issuances from government-backed entities have been growing at a robust pace.[a] While this trend is common to many economies, governments and regulators from Asian economies such as China (including Hong Kong, China), India, Indonesia, Japan, Malaysia and Singapore have been proactive in developing guidelines and policies toward facilitating the green bonds market (Weber & Saravade, 2019). However, companies and investors are yet to tap into the large potential in the green bond space in many emerging and developing economies. Evidence suggests that green bonds issuance may lead to a reputational gain [see Tang & Zhang (2020), Flammer (2021)] which is why companies have increased their efforts toward tagging a security as green. On the demand side, green bonds have attracted the attention of investors as they have become more aware about climate risks. These bonds offer investors to engage in good practices, hedge against climate risks while achieving similar returns to investments (World Bank, 2021).

But do green bonds offer competitive returns or financing incentives compared to non-green bonds? The debate on green bond premium has recently found momentum in the academic literature. The underlying motivation is to examine the incentives for the issuers and the investors in terms of the cost of finance and returns to investment respectively for green bonds vis-à-vis all other bonds.

This chapter matches the average yields, (weighted by the amount of issuance) of the green and non-green bonds with the same tenure and currency issued by the same company. Figure C.1 (a) plots the yields of the two types of bonds issued by the same company and finds that yields of green bonds move in similar lines with the non-green bonds. In fact, the correlation between the two yields are almost 96 percent.

Fatica et al. (2021) found a green bond premium for supranational institutions while no significant difference for bonds issued by financial institutions. Using data on municipal bonds issued in the United States, Baker et al. (2018) find that green bonds are priced at a premium after controlling for a host of factors including issuer fixed effects. On the other hand, Bachelet et al. (2019) find that the difference in yields (green and non-green bonds) is positive for private issuers and negative for intuitional investors. A common finding in all these studies is the higher premium for green bonds if the external institutions verify the bonds. More recently, Larcker & Watts (2020) showed that there is no significant pricing difference between green and non-green bonds and investors treat them as perfect substitutes.

Significant heterogeneity exists. Figure C.1(b) shows the average spread between the two bonds (considering only bonds issued in USD while computing the country averages to factor out any currency effect on bond spreads). The chapter finds that for most economies, green bonds on average are usually cheaper than all other bonds. However, green bond financing in a handful of countries remain expensive (countries of the left side of the chart).

The cost of green bond issuance (third party certification), the size of the market financing green projects, and sovereign credit ratings are the main challenges that many entities in emerging markets face while issuing green bonds. On the other hand, investors remain wary of the viability of green projects while the lack of disclosure requirements make financial decision making costly Azhgaliyeva et al. (2020) and Bhutta et al., (2022) argued that improvement in regulatory processes and disclosure requirements are important factors behind the growth of green bonds. In fact, Caramichael & Rapp (2022) found that large investment grade issuers, mainly in the banking sector, experience lower cost of borrowing when issuing green bonds.

The Task Force on Climate-Related Financial Disclosures (TCFD) set up by the Financial Stability Board has been working toward these directions to develop the global framework for climate-related disclosures. As of 2021, only eight economies have aligned their official disclosure requirements to TCFD recommendations. However, the initiative has found support from 89 countries worldwide and is expected to find momentum over the next few years. Some governments and central banks in emerging markets are in the process of including green bonds in their supervisory framework.

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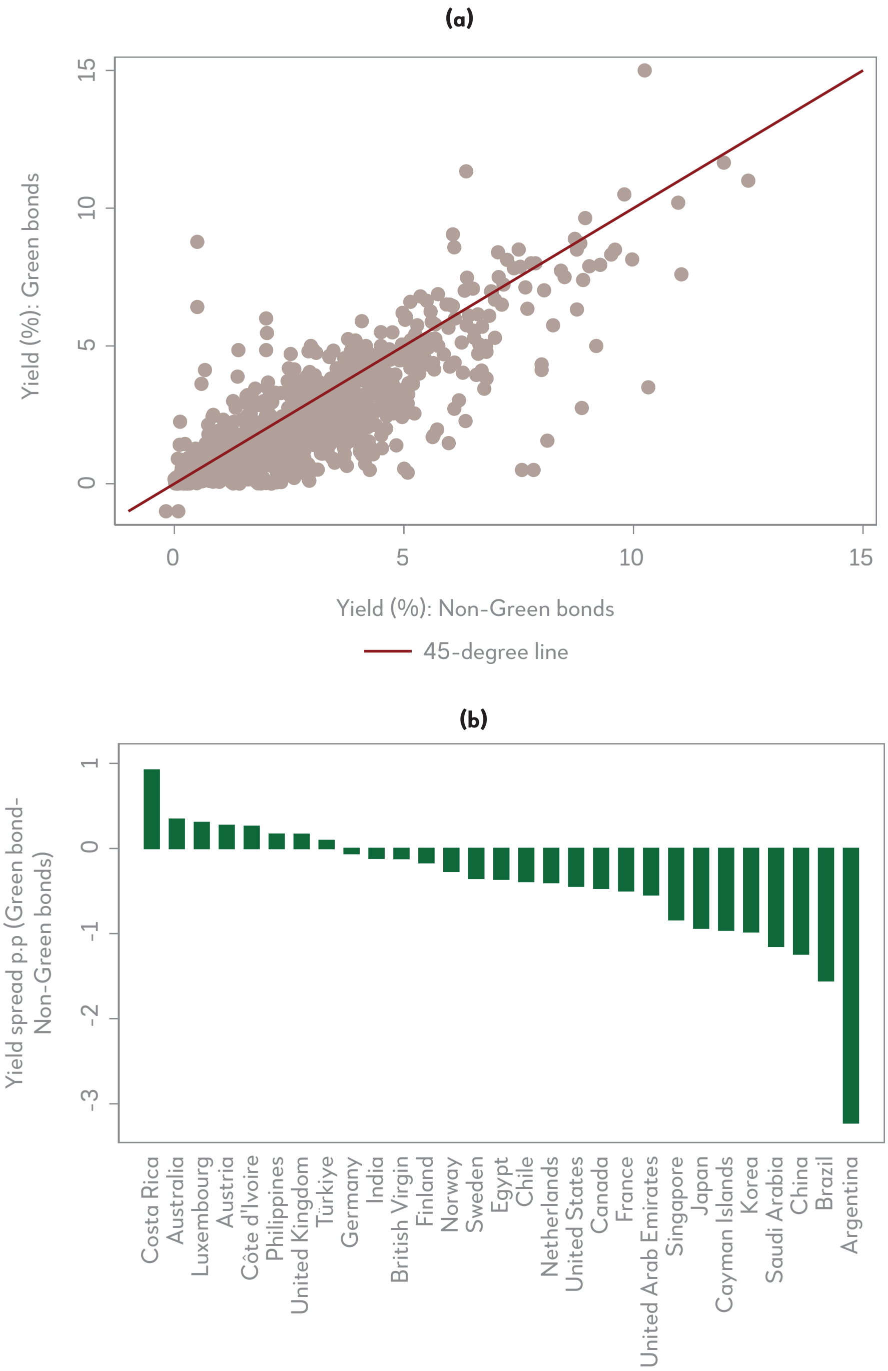
Box C: *continued*

Figure C.1: Comparing Yields: Green Against Non-Green bonds



Data sources: Refinitiv and AIIB staff estimates.

However, whether green bonds may be attributed a lower risk weight is still a debatable topic as there is no consensus on the risk-return profile of green bonds vis-a-vis non-green bonds. On the other hand, risk mitigation efforts by involving financial regulators in supervising green bonds may attract investments into these bonds in emerging economies.

[a] See more at: https://www.climatebonds.net/files/reports/cbi_global_sotm_2021_02h_0.pdf.

[b] See more at: https://www.worldbank.org/en/news/feature/2021/12/08/what-you-need-to-know-about-ifc-s-green-bonds.

CHAPTER 5

STATE-OWNED FINANCIAL INSTITUTIONS AND THE GREEN TRANSITION

Between USD3 trillion and USD6 trillion per year, depending on the estimate, are needed through 2050 to achieve the stated climate goals, with most of it frontloaded [see Prasad et al. (2022), McKinsey Global Institute (2022)]. Moreover, markets cannot deliver on the task without public intervention because of externalities, including due to the suboptimal carbon price. This, thus, puts more onus on the financial sector to drive the reallocation process. As a result, the financial sector, which is responsible for allocating resources, will need to reorganize significantly to meet the challenge.

First, the public financial sector can green its balance sheet directly by financing green assets and divesting carbon-intensive (or "brown") assets. In this regard, state-owned financial institutions (SOFIs) invest much more in fossil fuel assets than their private sector counterparts, particularly in EMDEs; hence, their special responsibility of properly managing these assets and the related risks.

Second, public banks can help green the operations of their clients and subsidiaries. In this regard, SOFIs, particularly sovereign wealth funds (SWFs), have been active in equity financing and company acquisitions, including across borders. This offers the potential for the dissemination of green standards. However, such activism has yet to take off.

Finally, public banks can help mobilize more capital from other sources, particularly the private sector. To a large extent, it is about assessing, reducing, redistributing, and managing risks. The key here is that all parties must work together and bring their respective advantages to the table. Public banks would be at the center of this collaboration.

In this regard, and looking more broadly at the infrastructure investment market, public banks are indeed involved in financing projects across many markets. They are present as cofinanciers in around a third of all project deals tend to tackle deals that are larger and more complex. This engagement should continue, with the public sector refining and further leveraging its role as agents catalyzing and de-risking projects, thus making them more "bankable."

This chapter discusses the role of SOFIs in advancing the transition to the green economy. The chapter first reviews the status of the public financial sector worldwide, including the pros and cons of imposing the net-zero agenda on this sector. The chapter then discusses the potential role of the public financial sector in the context of the green transition—for each of the broad categories of SOFIs, namely, commercial banks, national development banks (NDBs), SWFs and central banks. In doing that, the chapter draws on a unique data set that combines data on companies (ORBIS) with data on project finance deals (IJGlobal).

5.1 Public Banks Today and Rationale

Public banks remain important across the world even though government ownership has declined over the past decades due to privatization and the rapid growth of private banks that followed financial deregulation, liberalization, and globalization of the 1980s and 1990s. They still account for some 15-20 percent of banking assets worldwide, as of 2016.

In advanced economies, this share is generally lower but has increased recently because of heavy state interventions during the Global Financial Crisis (GFC). In EMDEs, their size is estimated at around 30 percent of total banking assets [see Panizza (2021), Adams et al. (2022), IMF (2022a)]. State-controlled banks dominate financial systems in many large countries, such as Brazil, China, India, and Russia.

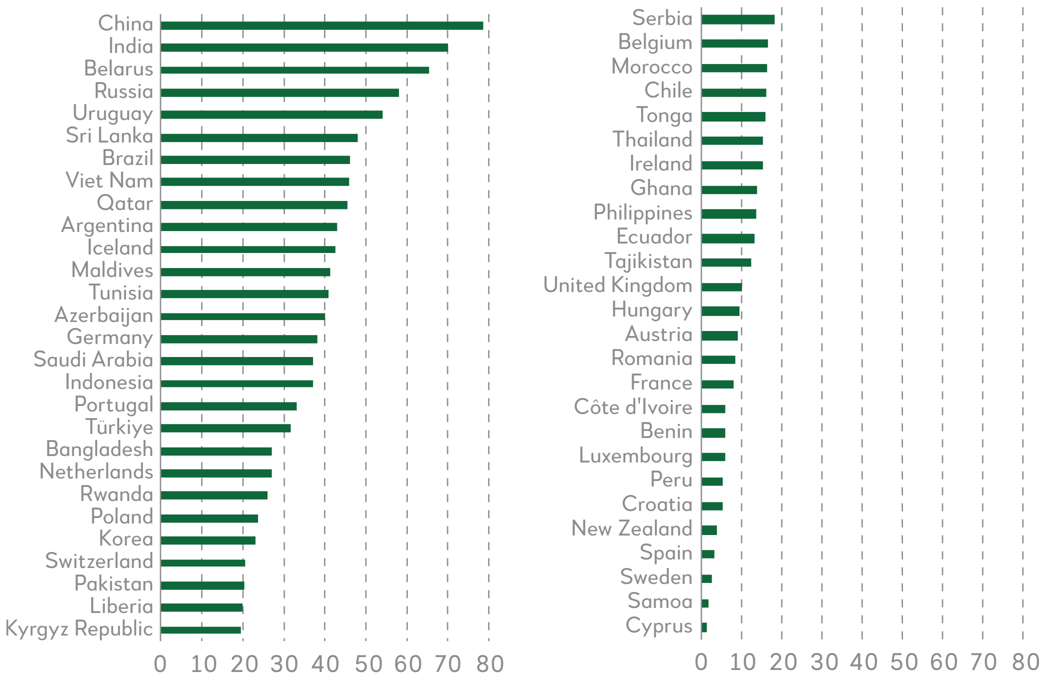
There has been a long-standing debate about the merits of government ownership in the financial sector. On the one hand, state interventions have been justified by the presence of various market failures in the sector and by the need to advance social and development objectives [see Ferrari (2022), Panizza (2021), Yeyati et al. (2007)].

More specifically, state-owned banks have been used to promote financial market development, where the organic growth of a competitive private financial sector has been slow. Public banks have also stepped in to provide access to finance to various segments underserved by the private sector, such as low-income groups, the agriculture sector, small and medium enterprises, or young firms without a sufficient credit history.

Public banks are also suitable to finance development spending, including certain types of infrastructure. These sectors are prone to externalities and market imperfections due to their long-term nature, high upfront capital costs, public good character, high idiosyncratic risks, and low profitability. Accordingly, projects with high positive social benefits could have negative financial returns (Yeyati, Micco, & Panizza, 2004) and, hence, fail to attract private financing. Without state intervention, this would lead to under-investment.

Countercyclical financing is one key advantage. When private banks retrench their lending in a downturn, state banks can step in and continue providing credit to firms and households. They can also act as vehicles for the distribution of public

Figure 36: Government Bank Asset Share of Total Bank Assets (%): Average, 2012-2016



Data source: World Bank Global Financial Development Database and AIIB staff estimates; for China: AIIB staff estimates using official data and annual reports of policy banks.

funds to the real economy (EBRD, 2020). This smooths the business cycle, sustains employment, and supports economic stability. They can afford to do that thanks to their economic stabilization mandates [see Micco & Panizza (2006), Bosshardt & Cerutti (2020)], more stable deposit base (Brei & Schclarek, 2015), and government support.

On the other hand, the negative view of state banks emphasizes the inefficiencies inherent in government ownership. According to this view, state banks are prone to political capture and corruption, by which bureaucrats and politicians misuse public resources to benefit their constituencies, pet projects, or connected entities. Furthermore, state banks are seen as distorting competition and inhibiting the development of a healthy financial sector. Soft budget constraints and conflicting mandates weaken the incentives and accountability of managers (World Bank, 2020b). The consequence is a misallocation of resources and lower productivity of the economy (EBRD, 2020).

Empirical results tend to be mixed and support both views. For example, many studies document how public banks tend to disproportionally increase lending in election years, suggesting political interference [see Dinc (2005), World Bank (2020b), EBRD (2020)]. Furthermore, some earlier studies concluded that more state ownership of banks goes along with less financial development, weaker economic growth, and more financial instability (IMF, 2020).[26]

However, more recent results are more encouraging. While convincing evidence that state ownership of banks promotes economic growth or financial development is yet to be established, the evidence to the contrary seems much weaker than previously thought (Yeyati, Micco, & Panizza, 2004). For example, Panizza (2021) fails to find evidence that public banks inhibit financial development, growth, or undermine financial stability.[27]

One consistent finding is that public banks behave more countercyclically, or at least less pro-cyclically, than their private counterparts. Micco & Panizza (2006) and Bertay et al. (2012) find that state-owned banks may play a useful role in stabilizing credit because their lending is less responsive to macroeconomic shocks than private banks.[28] Not surprisingly, state banks tend to be more countercyclical in countries with better governance (Bertay, Demirguc-Kunt, & Huizinga, 2012), which points to the importance of governance reform to improve the performance of the sector.

Notwithstanding the academic or policy debates, the GFC and the COVID-19 pandemic experiences have improved the perception of state banks, as they decisively stepped up to their roles, helped safeguard financial stability, and served as a vehicle for emergency and countercyclical government programs. Medas & Ture (2020) note that during the GFC, public banks were used in both advanced and developing economies (Brazil, Canada, Chile, India, Mexico, Poland, Tunisia, etc.) to counter the private credit crunch. According to the authors, an advantage of public banks is their ability to reach large and small firms, as well as households and subnational governments.[29]

In summary, the debate seems to have moved to be less about the "state versus market" dichotomy and more about how to best deploy public capital to help solve development challenges.[30]

[26] Another consistent finding is that public banks are less profitable than private banks, at least in EMDEs, due to lower margins, higher costs, and significantly higher nonperforming loans (NPLs) [see Panizza (2021), EBRD (2020), IMF (2020)], with the latter result implying a degree of resource misallocation (World Bank, 2013).

[27] Furthermore, lower profitability and higher NPLs cannot be used as measure of performance for public banks, or an argument against their existence, because it is within their mandate to balance financial profitability with social returns (Yeyati, Micco, & Panizza, 2004), financial inclusion, or countercyclical benefits.

[28] Also, according to new evidence by Panizza (2021), and unlike earlier findings [see IMF (2020), Ture (2021)], there seems to be no difference in countercyclicality between high and low debt countries.

[29] For example, World Bank (2020b) notes that in India, firms with connections to a public bank were able to sustain export sales, unlike those without such connections. EBRD (2020) documents a positive correlation between state bank presence in a particular region in Europe and regional income growth during the GFC. Similarly, during the COVID-19 pandemic, governments used public banks to effectively administer public anti-crisis programs (Gutierrez & Kliatskova, 2021).

[30] For example, in a survey by Yeyati & Negri (2022), around 55 precent of experts tend to agree on the need to retain some state involvement in the financial sector—second only after infrastructure with 80 percent—and quote promotion of investment/development and the mitigation of economic crises as the principal roles for public banks.

5.2 The Need for Governance Reforms

To be up to the task, the public sector corporations must reform themselves. EBRD (2020) notes that public banks' ability to balance their commercial and social objectives depends on their corporate governance and the institutional environment. Thus, there is a lot of value to be had from greater transparency, improved governance, and more efficiency. The approach is to try to solve market failures in a market-friendly way by adopting good practices from the private sector.

In a survey by Yeyati & Negri (2022) experts name clarity of mandate, the qualification of the board, transparency, and autonomy as the top four governance problems related to state ownership.

First, public banks often suffer from poorly defined missions and objectives. Lack of clarity on the two, often conflicting, commercial and social mandates complicates management, breeds inefficiency, precludes accountability, and opens the allocation of funds to abuse. Clear and simple mandates would make the rationale for state intervention explicit and enable performance evaluation, with indicators built around these mandates.

Second, reducing undue political influence over lending and staffing decisions is key to allowing public banks to pursue their mandates effectively. This will require more autonomy, starting with an independent and properly qualified board of directors (EBRD, 2020). In addition, financial independence, which requires the bank to follow sound banking practices and at least cover its operating expense, would further strengthen its autonomy. All these would make it easier to select managers and staff based on merit.

Third, more transparency is needed to enable better management, oversight, and accountability. Transparency would also help clarify the costs of the social mandate (typically obscured by hidden subsidies and paid with non-transparent capital injections) and properly assess fiscal risks. Instruments to improve transparency include annual reports (with complete financial statements), clear disclosure requirements, sound accounting standards, and periodic external audits (EBRD, 2020).

With governance reforms, it would then be easier to improve the playing field between private and public banks through a proper regulatory framework. Increased competition would likely lead to further improvements in the performance of state-owned entities.

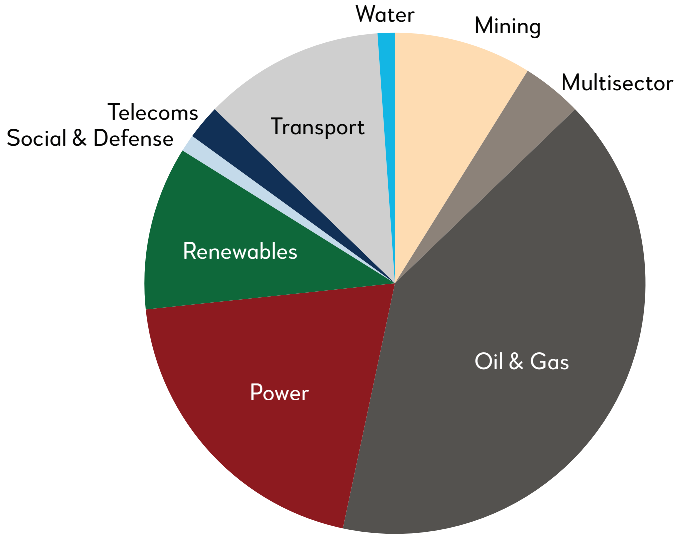
5.3 Public Banks as Climate Policy Levers

Public banks will be an important climate policy tool for governments. As mentioned, the task of the green transition cannot be left solely to the markets because of pervasive market failures and externalities. The magnitude and urgency of the challenge mean that sizeable resources must be deployed quickly. The advantage of public banks is their large size (in many economies) and public ownership. The latter allows governments to directly enforce their climate policy preferences through formal directives (Benoit, 2019) or tweaks to banks' mandates. State banks can also be reservoirs of state capacity that have not been fully tapped, and which is badly needed for the task.

There is a long way to go. Looking at infrastructure market data, public banks are generally more involved in legacy fossil-fuel projects than private banks (Figure 37 and Figure 38). Particularly in EMDEs, oil and gas and conventional power projects have accounted for a larger share of total transactions in their portfolios in recent years. It is not surprising, as in these economies the state often dominates these sectors and state banks would naturally lend to such state-sponsored projects.

The chapter also finds that public banks lag in the issuance of green bonds. The market for green bonds holds large potential to become a major source of climate finance, particularly in EMDEs. Data show that even though the financial sector and government agencies account for a major share in total bond issuance (34 and 32 percent, respectively), participation of public financial institutions has been relatively flat. Most of the growth has happened because of increased issuance of nonfinancial SOEs (contributing almost 40 percent of total bond issuance in 2021, compared to only 6 percent in 2011) (Figure 39).

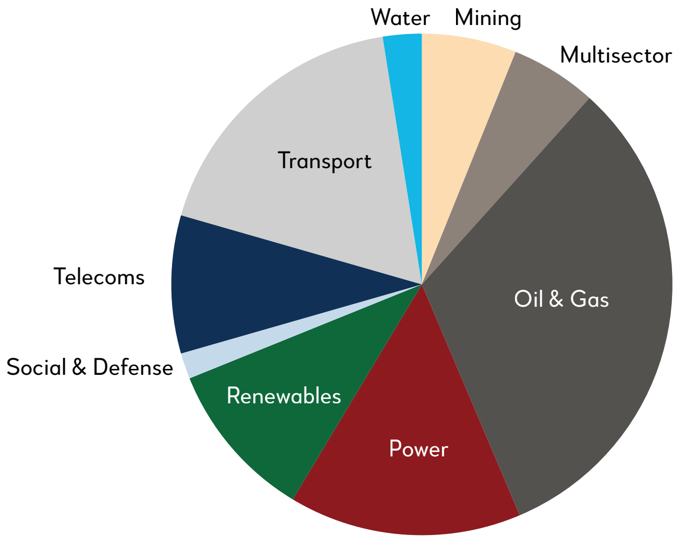
Figure 37: Closed Transaction by Sector—at Least One State Lender (2015-2021), EMDEs



EMDE = emerging and developing economy.

Data source: IJGlobal, ORBIS, and AIIB staff estimates.

Figure 38: Closed Transaction by Sector—No State Lenders (2015-2021), EMDEs



EMDE = emerging and developing economy.

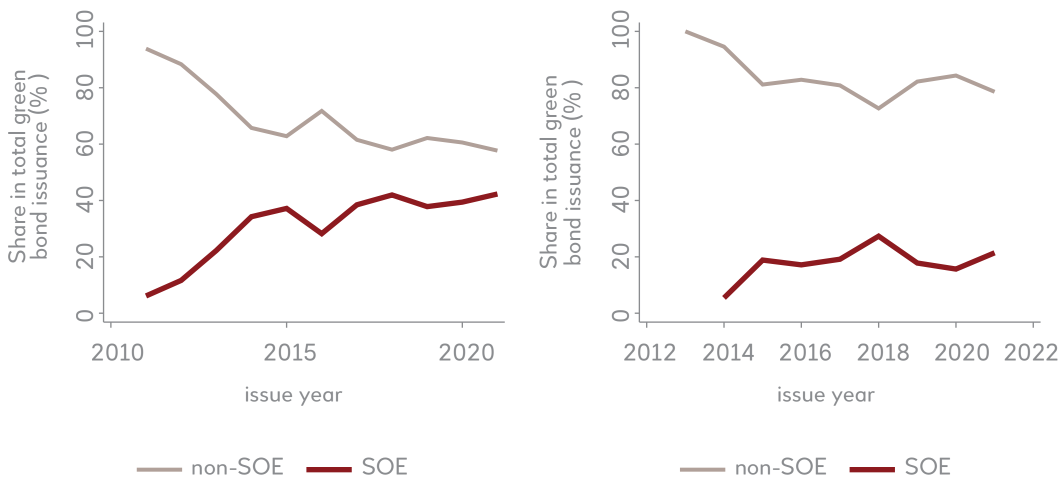
Data source: IJGlobal, ORBIS, and AIIB staff estimates.

Public banks may support the green transition in several ways. The most obvious is to finance green projects directly with their own resources. However, this could quickly tie up public resources and end up having limited positive externalities. A variant would be to finance SOEs in pursuit of their climate goals and low-carbon investments. Again, common ownership would ensure common objectives and reduce transaction costs and risks.

Another important way would be to embark on greening their financial value chains by requiring their borrowers to adhere to environmental, social, and governance (ESG) standards, adopt climate disclosure requirements, or even commit to a net-zero transition plan. This way, banks could contribute to the dissemination of international standards, taxonomies, and methods.[31] The positive impact of such action can even transcend borders,

[31] The inadequate development and adoption of such standards is a critical weakness of the system, resulting in poor transparency, confusion, mispricing of risks, informational deficiencies, and coordination failures.

Figure 39: Share of Green Bond Issuance, SOEs vs. Non-SOEs



SOE = state-owned enterprise.

Data source: Refinitiv, ORBIS, and AIIB staff estimates.

contributing to the diffusion and consistency of such standards, thanks to the recent trend of internationalization of major state banks and their SOE clients.

By far, the most promising approach is to use public banks to mobilize private capital. This is the "billions-to-trillions" route. Public resources will simply be insufficient for the task. The way to achieve it is to help dramatically increase the supply of bankable green projects, lack of which seems to be one binding constraint on scaling up climate finance (Prasad et al., 2022).

One set of problems relates to issues not properly addressed at the project development stage due to lack of expertise or poor planning (Moody's, 2022). This is not a trivial problem but capacity building and robust due diligence from experienced partners can go some way to improve the credibility of such projects. In particular, the involvement of MDBs, with their considerable expertise in climate issues, can bring confidence regarding project design, preparation and selection.

Another problem is low returns. In the absence of adequate carbon prices, many green investments, even though economically beneficial, have negative financial returns. Public banks are well placed to blend in concessional financing to reduce borrowing costs, improve the risk-return profile of these projects, and make them viable for the private sector. These resources need to be used strategically, to optimize the amount of total financing, which requires striving for additionality (not to crowd out private finance already available) and ensuring commercial sustainability (i.e., having a viable plan to phase out subsidies), while respecting local contexts and building the respective markets (OECD, 2018).

A key constraint is risk, as perceived by the private sector. These risks must be properly managed: assessed, reduced, and redistributed to the most appropriate parties. For example, the political, regulatory, and macroeconomic risks are simply too high for a private investor, driving up the risk premium and making borrowing costs prohibitively expensive (Prasad et al. (2022)). At the same time, these risks could be more easily absorbed and mitigated by the government, including through public banks. Any remaining domestic systemic risks could be diversified away with the help of international financial institutions. Public banks can thus de-risk such investments, including through various first-loss instruments, such as junior tranches, guarantees or other credit enhancements. There is also a time dimension to this process—risks are the highest at the early stages of the project. Once these early risks have been managed and the asset has proven viable, it could be off-loaded to the private sector at market prices, freeing up resources for another round of funding.

There are other more practical problems. One of them is size. A typical blended transaction may be between USD30 million and USD80 million. But the average project/fund size portfolio investors are willing to invest would be in the ballpark of USD500 million. Solutions to that problem include platform approaches or securitization techniques to aggregate smaller projects into an investable pool [see Moody's (2022), Stewart & Huntington (2022)]. MDBs are well-placed to facilitate this task. Another practical problem is the lack of standardized investment channels, resulting in high transaction costs and unnecessary complexity. Workings toward making successful designs and terms more visible to others and easier to replicate are critical for scaling up climate finance (Stewart & Huntington, 2022). Public financial institutions and MDBs can help by acting as anchor investors to give confidence to private financiers.

At the same time, one needs to acknowledge a complex two-way link between the generation of projects and the availability of finance. Some financial intermediaries are also in the business of structuring projects, i.e., they perform both functions, creating viable projects tailored to the financing available. They may also employ different kinds of capital, in particular equity and various forms of specialized capital.

Most of the above solutions have one thing in common: they require all parties to work together and bring their respective advantages to the table. Public banks should be, and often are, at the center of this collaboration. Below, we discuss how the various types of public financial institutions, with their respective characteristics, can and do contribute to the task.

5.3.1 Public Commercial Banks

State-owned or controlled commercial banks may not differ from private commercial banks, except for the ownership. They would take retail deposits from the public and extend loans directly to borrowers. They may not have any particular mandate, except for maximizing profit for the government. In this sense, they are competing directly with their private counterparts. Of all types of public banks, they seem to have the weakest justification for public ownership.

Nonetheless, public commercial banks are quite prominent in many countries and should be part of the green finance solution. Government ownership is one lever that can steer these banks into becoming champions for adopting various standards and initiatives in this field. This could spur learning and financial innovation and provide demonstration effects. However, there is a long way to go; among the 114 bank members of the Glasgow Financial Alliance for Net Zero, as of mid-2022, only 17 are public banks.

5.3.2 National Development Banks

On the other end of the spectrum are NDBs, specialized institutions, set up by governments to support economic development, with relatively narrow policy mandates, such as financing infrastructure, supporting specific sectors, or dispensing government development programs and subsidies. Instead of retail deposits, they typically receive funding from government transfers, the market, often under government guarantees, or IFIs. They could lend either directly to borrowers or act as a second-tier financial intermediary. They normally do not compete with private banks.

There has recently been a revival of interest in NDBs. By most recent estimates, around 500 such institutions worldwide—at various local, regional, national, and subnational levels—manage some USD18 trillion in assets, collectively accounting for more than USD2 trillion of investment annually, or around 10 percent of all global investment, public and private combined (Finance in Common, 2021b).

Policymakers have realized these institutions are particularly well placed to help channel financial flows to climate goals, in addition to other development objectives. After all, NDBs are part of state capacity. They have been addressing market failures, financing underserved sectors, and underwriting infrastructure for decades. They already have a development mandate, public ownership, and some autonomy. They can access finance more cheaply and at longer maturities than the private sector. Furthermore, NDBs enhanced their credentials during the GFC and the COVID-19 pandemic, becoming an essential instrument for policy response; acting countercyclically; and delivering in terms of scale, speed, and targeting of the resources deployed (Griffith-Jones, 2022). They have managed to maintain access to financing despite liquidity crunch and volatility (Finance in Common, 2021b). Over 70 new NDBs were established from 2010 to 2020 (Gutierrez & Kliatskova, 2021).

NDBs have distinct advantages to help drive climate finance, including solid market and sectoral presence, operational knowledge of the local business environment, understanding of local or national development needs and opportunities, long-term working arrangements and relationships with the relevant private and public stakeholders, substantial project expertise, and so on (Griddith-Jones et al., 2020). In this sense, they can serve as a helpful link between international climate policy targets and local solutions (Finance in Common, 2021a).

According to Griffith-Jones et al. (2020), NDBs must now step up to their expanded roles and take up a catalytical role in support of green transition finance. In addition to financing green infrastructure directly, their activities should include (a) mobilizing private (and public) capital at scale, including by blending international, national, and private resources in support of green finance; (b) influencing and shaping policies; and (c) developing bankable project and demonstrating commercial viability and replicability of new approaches and technologies.

To do that, NDBs should first receive a clear mandate to incorporate climate considerations in their operations. Second, they must be sufficiently capitalized to match the scale of the challenge. Also, they need international engagement and support, such as from MDBs, including capacity building (in project management, new sectors, or ESG) and access to concessional resources that would help them become credible players in this domain. Third, governance improvements are critical for their performance and ability to tap markets cheaply, for the willingness of international actors to engage with them, and for governments to provide capital.

5.3.3 Sovereign Wealth Funds

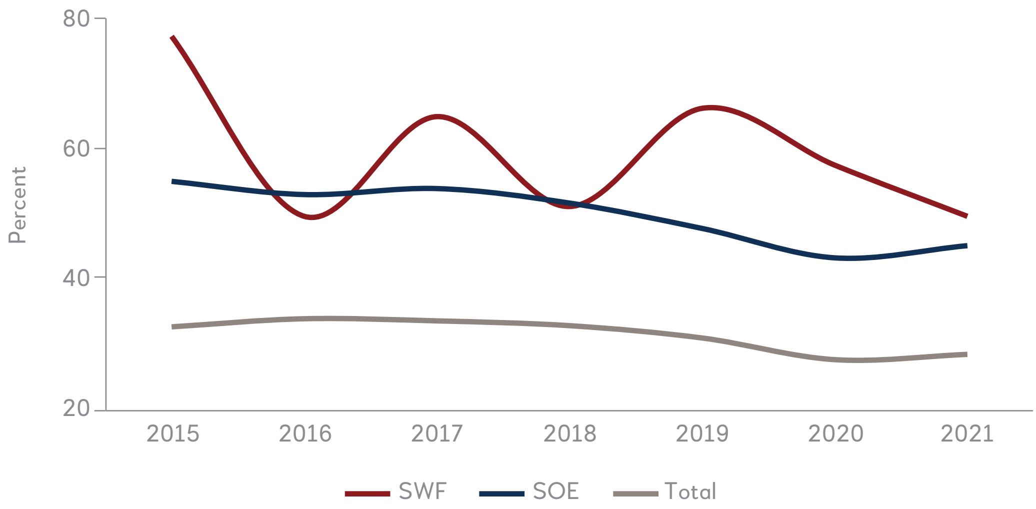
Sovereign wealth funds (SWFs) are investment vehicles owned by governments that buy, hold, and sell assets in pursuit of financial and/or economic goals on behalf of the country (Global SWF, 2021). They have a vested interest in net-zero transition, given their historic mandate of commodity wealth management and their growing presence as major market players, with over USD10 trillion assets under management (AuM). Since 2008, SWFs have seen an impressive growth both in the number of funds (approximately 60 new SWFs) and assets (tripling of AuM), driven primarily by Asia's current account-surplus economies [see Lopez (2022), Braustein & Caoli (2017)]. Still, half of the 100 or more SWFs active today come from commodity-based economies. The remaining non-commodity-funded SWFs hold direct and indirect links to fossil-intensive assets (e.g., upstream energy sector firms).

SWF investing style has evolved from under-the-radar, unregulated practices before the 2008 Santiago Principles toward market-aligned investing with greater governance considerations. Moreover, rather than being driven by macroeconomic stabilization mandates, these funds are increasingly serving a strategic investing role, shifting away from low-risk reserve currency investments and looking toward private markets. This results in a net inflow of finance toward more risky assets in emerging markets [see Lopez (2022), Global SWF (2021), Wurster & Schlosser (2021), Sharma (2017), Joshua & Reuven (2009), Aizenman & Reuven Glick (2009)] and presents a tremendous opportunity for these economies to tackle their development challenges, including sustainable and green infrastructure.

Due to expectations of a future drop in commercial demand for fossil fuels, SWFs should have an intrinsic incentive to diversify away from traditional energy assets. For energy exporters (where the bulk of SWFs resides), this would transform their investments into liabilities, or so-called "stranded assets." In theory, per their mandate to safeguard the country's wealth, SWFs are thus obliged to act preemptively.

Also, being government-owned investment vehicles, SWFs face stakeholder pressure to seriously take international commitments on climate change, ESG, and the Sustainable Development Goals (SDGs). As both financial market players and representatives of the state, "SWFs have a vested interest to play by the rules," as put by the Singaporean ex-representative to the United Nations, Kishore Mahbubani. Hence SWFs have a strong incentive to signal net-zero/ESG/SDG alignment. Indeed, a recent survey found that some two-thirds of SWFs incorporate "ESG consideration" (IFSWF, 2021).

Figure 40: Fossil Fuel Transactions as a Share of All Infrastructure Project Finance



SOE = state-owned enterprise, SWF = sovereign wealth fund.

Data source: IJGlobal, ORBIS, Sovereign Wealth Fund Institute, and AIIB staff estimates.

However, despite the rhetoric (for which the main driver seems to be a lack of shareholder opposition), the incentives for tangible change in investment (and divestment) are less clear. These dual interests conflict with real change, ultimately depending on how SWFs perceive climate risk, fossil commodity price risk, and potential returns on green assets [see Capape (2018), Sharma (2017)].

As a result, SWFs seem to lag behind other players. Analysis of market infrastructure transaction data suggests that SWFs acquire fossil assets by nearly twice the proportion of other market participants (Figure 41), including SOEs.

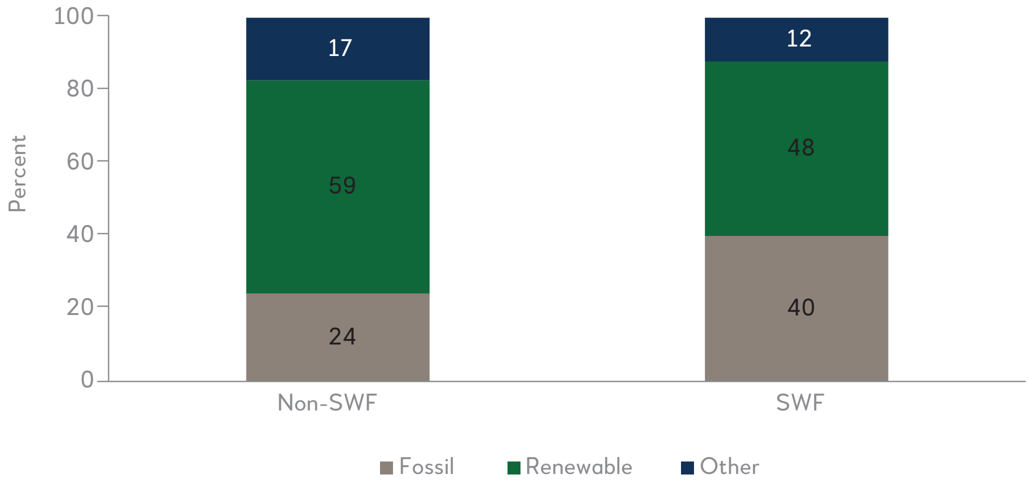
At the same time, interestingly, SWFs perform better in acquiring renewable technologies companies (Figure 42). Perhaps SWFs view fossil assets as valuable investments in the medium term while renewables as a long-term play. Alternatively, these acquisitions could offer a way for SWFs to learn about the sector before committing more substantially.

Finally, the background research for this report documents substantial cross-border investments by SWFs, with foreign equity holdings making up approximately half of all equity shares identified. High equity stakes by SWFs, including abroad, raise hopes that these vehicles can play a catalytic role and become champions for greening their respective subsidiaries along the real sector and financial value chains to which they belong, for example, by requiring that ESG standards are uniformly applied. However, data suggests that hopes for such "SWF activism" may be exaggerated. The widespread use of intermediary holding companies, including third-country holding companies, points to a relatively passive investment style and lack of day-to-day involvement in operations, including presumably lower influence on ESG alignment.

5.3.4 Central Banks

Central banks sit at the core of the financial system. They issue currencies, supply liquidity, set interest rates, operate payment systems, and supervise banks. They typically have clear and narrow primary mandates of ensuring price stability and safeguarding financial stability. Secondary mandates may include smoothing the business cycle and/or supporting the government's economic policies. Technocratic competence and some degree of independence from governments allowed them to pursue these mandates relatively effectively in many places. During the GFC and the COVID-19 pandemic, they have earned respect by deploying their formidable firepower to save the world from the worst recession. However, this reputation led to demands that central banks use their potent tools to also contribute to tackling other complex challenges, particularly climate change. One way or another, central banks will play a prominent role, by design or by default, in how the different financial institutions contribute to net-zero transition. Some central banks became champions of the cause.

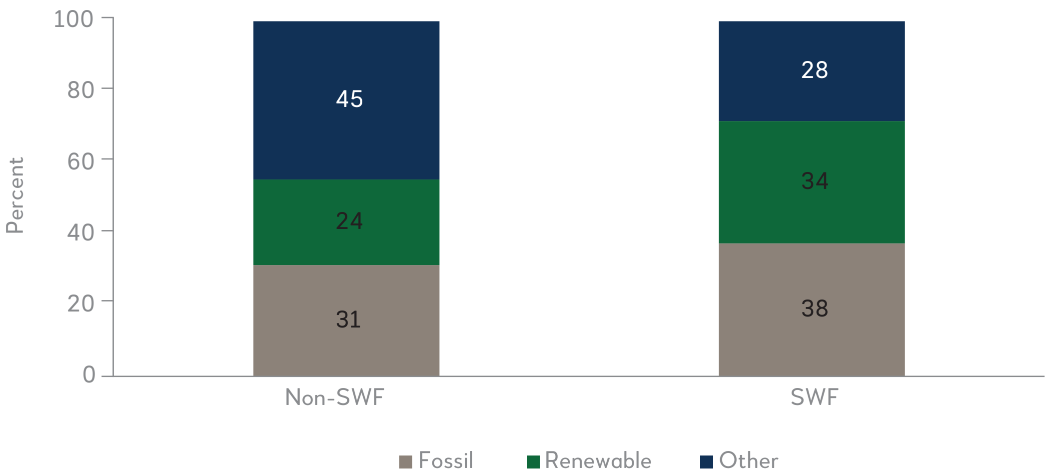
Figure 41: Proportion of Renewable Asset Acquisition



SWF = sovereign wealth fund.

Data source: IJGlobal, ORBIS, Sovereign Wealth Fund Institute, and AIIB staff estimates.

Figure 42: Proportion of Renewable Company Acquisitions



SWF = sovereign wealth fund.

Data source: IJGlobal, ORBIS, Sovereign Wealth Fund Institute, and AIIB staff estimates.

That said, fighting climate change is conspicuously absent among the central banks' mandates, which has led to a need to justify interventions in this area. Some lines of reasoning and the related implications are less contentious than others.

A relatively uncontroversial angle is that of financial stability. First, there are risks of increased damage to bank assets from extreme weather events related to climate change ("physical risks"). While not immediately, they will ultimately lead to higher losses for insurers and higher NPLs for banks. Second and more imminent risk is a sudden change in climate policies, including a higher carbon price, which would penalize carbon-intensive companies and undermine their economic viability ("transition risks"). As a result, claims on such firms would decline in value sharply and become "stranded assets" on banks' balance sheets (S&P Global, 2020). Scrutiny from supervisors is, hence, warranted to the extent these risks affect the soundness of the financial sector.[32]

A more controversial proposition is to incorporate climate considerations directly into monetary policy. The reasoning is that climate change directly threatens price stability (through sharp hikes in carbon prices amid supply constraints of green inputs or increased output volatility). It will also affect the potential growth and the equilibrium real interest rate (through structural changes to the economy, including saving/investment behavior). If so, central banks are mandated to act, including preemptively. Where secondary mandates to support government policies exist, they can also be brought up (Schnabel, 2021).

Measures contemplated within this scope include (a) "green quantitative easing" (i.e., tilting purchases toward green assets, or divesting "brown" assets, as part of monetary policy operations); (b) "green collateral" (i.e., accepting selected green assets as collateral in liquidity operations); or (c) "green targeted lending operations" (i.e., subsidized credit from central banks to commercial banks to finance green ventures). These measures would seem to violate the so-called "market-neutrality" principle, whereby central banks should not subsidize any particular group or sector of the economy, as this would lead to distortions and redistribution. However, proponents argue that by following market neutrality, central banks are in fact subsidizing carbon-intensive sectors because of externalities (too low a carbon price). This inefficiency must be, thus, eliminated by tilting the playing field (Schnabel, 2021).[33]

At the same time, it is important to be aware of the limitation of finance to deliver green transition and the related reallocation of resources in the absence of concurrent enabling policies in the real economy, including higher carbon prices or environmental policies. As Borio et al. (2022) note, expectations with respect to the financial sector may be unrealistic. For example, as the previous chapter documents, the jury is still out on the strength of green preferences and the existence of the "green premium." Even if such green preferences exist, they must be robust and universal to prevent arbitrage that would negate the benefits. Moody's (2021a) warns that a rapid expansion of banks' "green portfolio" amid inadequate taxonomies and undeveloped expertise may lead to exposures to assets of dubious economic viability ("green bubbles").

Similarly, implementing climate policies through banking regulation could lead to banks holding insufficient capital against risky green assets and/or to a relaxation of loan underwriting standards and, ultimately, mispricing of risk. Generally, addressing climate challenges first or only through the financial sector could lead to a decoupling of the sector from the real economy, higher financial stability risks, and, ultimately, setbacks to the green transition (Borio et al., 2022).

In summary, climate policy is best done by governments, ideally with a carbon tax or some other fiscal, environmental, and real economy policies and regulations. However, it is far from obvious that the political processes alone can bring about a sufficiently high carbon price (van der Ploeg, 2020). Thus, in the spirit of the whole-of-the-society approach where "everybody must contribute," the debate continues on the best ways central banks can support an orderly transition.

Many central banks—including in AIIB countries, such as Bangladesh, China, India, Indonesia and others—have already been pressing ahead in creating green finance frameworks. Measures include establishing guidelines and rules for the issuance of green instruments, and creating incentives to increase the supply of funds to environment-friendly ventures.[34]

[32] The existence of physical and transition risks calls for their proper disclosure by companies and financial institutions, proper incorporation into risk models, and stress tests. For example, the Bank of England, the European Central Bank and the Banque de France have all started conducting climate risk-related stress tests on the institutions they supervise (S&P Global, 2020). Besides improved transparency, one intended consequence is that riskier carbon assets would naturally require more capital and should, hence, become more expensive to finance.

[33] Some early steps are being taken. The European Central Bank is currently conducting a strategy review, in which climate considerations are playing a prominent role. The Bank of England is reviewing its corporate bond purchase program with a view to reducing the carbon footprint of its portfolio. The People's Bank of China launched the world's first and largest "Carbon Emission Reduction Facility," which commercial banks can tap to finance qualified green projects at a low interest rate (People's Bank of China, 2021).

[34] For example, in China, the People's Bank of China has recently introduced the "Carbon Emission Reduction Facility" where banks can finance up to 60 percent of qualifying green projects at 1.75 interest rate. In India, the renewables sector has been included under the Reserve Bank of India's Priority Sector Lending scheme.

Also, many international initiatives have sprung up in the meantime, connecting country authorities, central banks, regulators, international standard setters, and other financial governance bodies, to address large gaps and challenges related to principles, methods, definitions, taxonomies, metrics, data, and reporting.[35]

5.4 Public Banks as Partners and Cofinanciers of Infrastructure

As mentioned, public banks need to be at the center of partnerships to make sustainable projects more bankable. Here, the chapter analyzes market infrastructure transaction data to examine the extent of collaborations between the public banks and private sector financiers in the market.

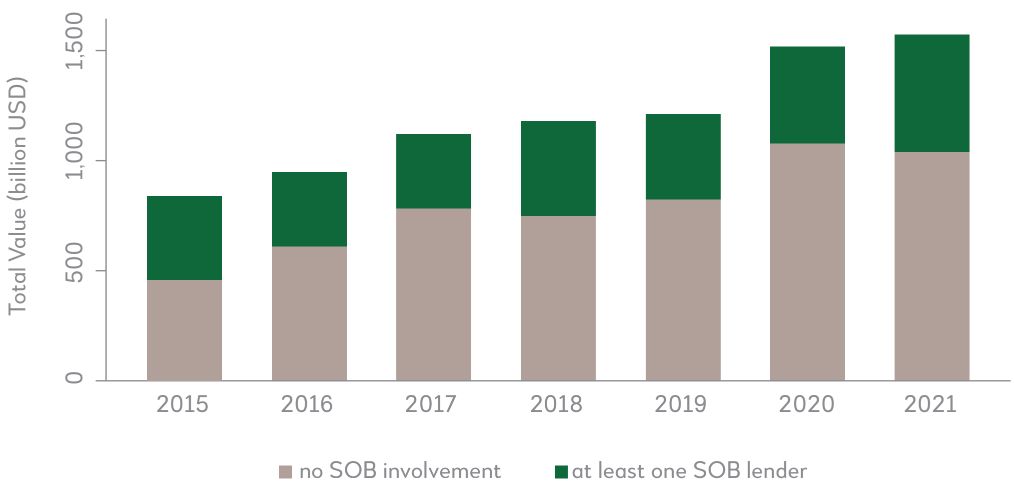
It turns out that these partnerships have been going on for some time. Globally, around a third of all closed infrastructure transactions, by value, have been financed by at least one state-owned bank as a debt provider in 2021. However, this share has been declining because of the faster growth of purely private transactions, with public banks unable to keep up with the pace (Figure 43). Involvement of public banks is higher in emerging markets and developing countries—at more than half of all transactions—presumably, because state ownership of banks is typically more prevalent in these markets (Figure 44).

The chapter also finds that public banks, on average, tend to finance larger ticket projects in terms of both capacity and project value. For example, the hydropower plant projects financed by public banks have, on average, a capacity of 420 MW, nearly 30 percent higher than projects financed without their participation. Similarly, ticket sizes for conventional energy power plants are between 12 and 37 percent larger for projects with state bank involvement (Figure 45 and Figure 46).

Interestingly, public banks are able to convene more actors. In the infrastructure transactions analyzed, deals with their involvement as a lender have six cofinanciers on average, compared with only three for deals with no public bank participation.

A similar trend is observed in the syndicated loan market for infrastructure-related enterprises, where deals with public banks as arrangers are larger and generally involve more partners.

Figure 43: Value of Closed Infrastructure Financing (Global)

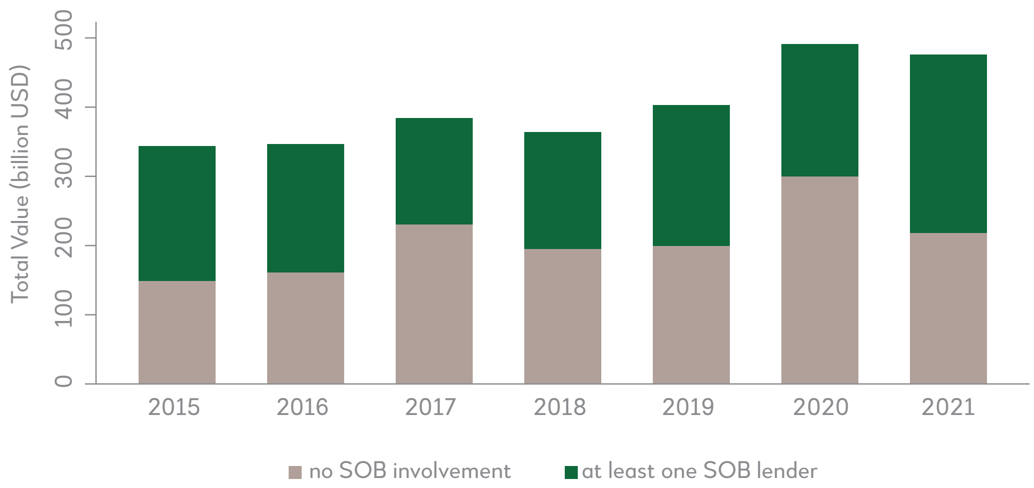


SOB = state-owned bank.

Data source: IJGlobal, ORBIS, and AIIB staff estimates.

[35] For example, a clear common taxonomy is needed to determine whether an investment project is green (or not) to ensure that green finance does not become greenwashing. Methods are needed to comparably evaluate carbon footprints, what exactly needs to be disclosed, how and by whom—all of these supported by the respective guidance.

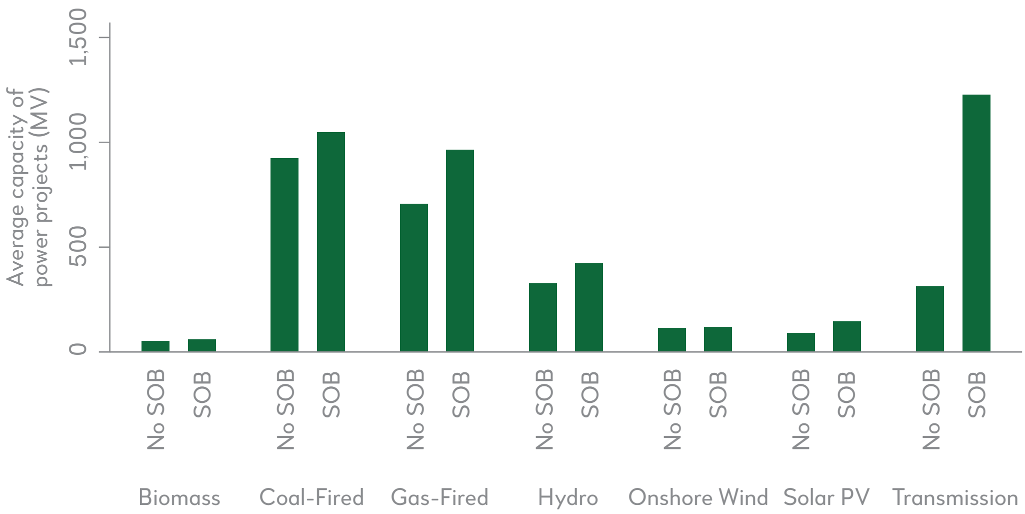
Figure 44: Value of Closed Infrastructure Financing (EMDEs Only)



EMDE = emerging and developing country, SOB = state-owned bank.

Data source: IJGlobal, ORBIS, and AIIB staff estimates.

Figure 45: Average Power Project Capacity (2015-2021)



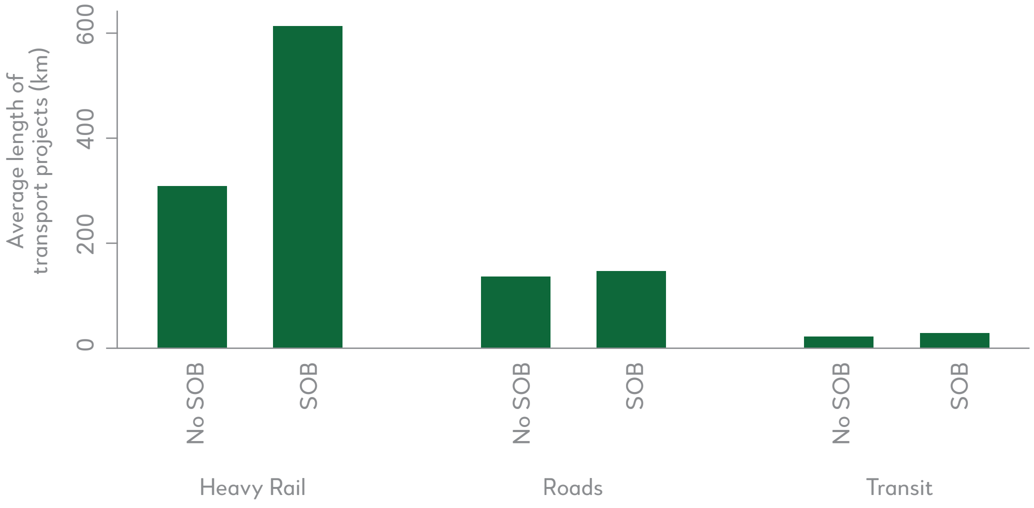
PV = photovoltaic, SOB = state-owned bank.

Data source: IJGlobal, ORBIS, and AIIB staff estimates.

Public banks typically cofinance with private commercial banks. The value of market projects cofinanced purely by state-owned parties is very small, less than five percent of the total transaction value with state bank involvement. The above evidence points to the vital role of public banks as partners and catalysts for private capital in infrastructure, including green infrastructure. They should continue, at a larger scale, to at least keep up with the market and deploy resources strategically to maximize the amount of private capital mobilized.

A critical benefit of such collaborations, including with the private sector and MDBs, is that state capacity would be enhanced and more self-sustained.

Figure 46: Average Transport Project Duration (2015-2021)



km = kilometer, SOB = state-owned bank.

Data source: IJGlobal, ORBIS, and AIIB staff estimates.

CHAPTER 6

ACCELERATING INNOVATION CAPACITY AND TECHNOLOGY ADOPTION FOR NET ZERO

A future net zero global economy will not be possible with just more investments. Critically, innovations and new technologies will be needed to reach the end state. In the near term, conventional energy sectors (fossil fuels) will need to be more efficient and produced in less harmful ways as they will likely remain the key energy source for some time. The International Energy Agency (IEA) estimates that half of the technology required to reach net zero by 2050 is under development and not yet available (IEA, 2021b). Much work in R&D, and commercialization lies ahead.

New technologies are needed to improve the viability and scaling-up of existing ones. For example, improvements in battery or other storage technologies are needed to overcome the intermittency of renewables. The combination of renewable energy production and storage has the potential to overcome longstanding concerns around energy security. With this, policymakers will be comfortable retiring baseload fossil fuels.

Furthermore, innovations are needed to reduce GHG emissions in every aspect of the economy, and eventually take GHGs out of the atmosphere. At the user end, there will also be the need for widespread electrification of various industrial processes. In addition, green hydrogen must be developed commercially and at scale, for feedstock, fuel, and even as a baseload to generate electricity to complement renewables. Finally, negative emission technology will be needed to compensate for some continued emissions by hard-to-abate sectors.

Various reports have taken stock of the key new technologies required for a successful transition to cleaner energy [see IEA (2021a), Napp (2017), Mckinsey Global Institute (2020)]. Broadly, these include technologies that

- increase production of primary energy from renewable sources—wind, solar, hydro, geothermal, and biofuels—in sustainable ways;[36]
- capture and store carbon;
- produce green hydrogen or hydrogen-related fuels and feedstocks, and capacity to store and transport hydrogen;
- facilitate the widespread electrification of end uses, including short and long duration battery and storage, transmission infrastructure, clean energy vehicles (e.g., electric, hydrogen powered), and recycling of equipment; and
- provide decarbonization for other sectors, including sustainable mining and agriculture.

[36] Digitalization of grid management aided by artificial intelligence to balance demand-supply across time or geographies are seen as opportunities to improve performance of renewable energy production. Hydrogen is increasingly seen as the key to decarbonize hard to abate sectors, and also as a fuel for baseload electricity generation in the future.

Innovation for climate change mitigation suffers from multiple sources of inefficiencies. Firstly, it is well established that the private sector under-invests in innovation when innovative firms do not capture the full benefits of their breakthroughs.[37] Secondly, this inefficiency is even larger for innovations toward climate change mitigation due to the unpriced or under-priced nature of GHG emissions in many jurisdictions.[38] Finally, to complete the picture, infrastructure deployment often also has a network effect, another source of externality that private sector companies cannot adequately deal with. Thus, there are strong arguments for more government spending on R&D on climate change mitigation and deployment of new technology at scale.

On the other hand, leaving innovation solely to state entities cannot be the solution, especially with such large uncertainties over the future paths of innovation and technology. Government administrators would be unable to assess these adequately, commercialize, and build financially sustainable businesses. Instead, industries ultimately must own and adapt their business model to be part of the transformation toward net zero.

A high-level policy tension therefore exists. In many instances, innovation processes often exhibit mixed arrangements—with private, government, and hybrid entities conducting or collaborating in R&D. Furthermore, the externality of climate change is global. Even national governments rarely have the full incentives to mitigate climate change.

Getting the right technology is an enormous undertaking. Innovations do not come in a linear process, nor with success guaranteed. It is also important to note that in most dimensions, innovation and scaling up of new technology also depend on many related innovations along complex supply chains. EMDEs face an even bigger challenge given that they lag advanced economies in many existing technologies. For many EMDEs therefore, being able to acquire and adopt new technology is as important is innovation itself. Getting the framework right for market incentives or regulations could prove a major public policy challenge.

The key question is this: how should policymakers structure the innovation process required toward net-zero goals? On the one hand, the transition clearly involves many large externalities that the private sector cannot completely capture.

Furthermore, the public sector needs to organize many necessary common standards (e.g., public infrastructure, connectivity, accreditation, data, and financing) on which businesses can rest and build. It is important to note here that externalities are also about future "dynamic costs," such as the effects of research subsidies in changing the future carbon reduction capacity and costs (Gillingham & Stock, 2018).[39] Many existing studies have articulated insights on endogenous innovation, technological diffusion, and the policy support needed.

In this chapter, data from ORBIS is used to provide recent trends on innovation toward the net-zero transition, test out several hypotheses, and draw on specific case studies, to envision some broad policy conclusions for the net-zero transition.

6.1 Innovation in Fossil Fuel Production Coupled with Carbon Capture

As highlighted in an earlier chapter, fossil fuel infrastructure continues to attract investments from SOEs and the private sector, as well as financing from state financing. This is not surprising given market incentives, especially when energy prices are high, and energy security is a key concern. The key insight of Acemoglu et al. (2012) was that the market size of older, polluting technology may still be attractive enough to encourage innovation in this sector. Fracking is one example where the technological breakthrough of the past two decades has yielded a substantial increase in gas supplies. Indeed, data shows that the patent activity in fossil fuel technologies has increased in recent years.

The top fossil-fuel companies in major economies have continued to apply for new patents in conventional

[37] Innovation itself often has large spillovers, spurring innovative breakthroughs in other sectors and geographies (Myers & Lanahan, 2022).

[38] See the discussion in the Bloomberg article: https://www.bloomberg.com/news/articles/2022-08-07/asian-carbon-pricing-not-enough-to-change-polluter-behavior.

[39] The authors note that solar panel sales increased, due to subsidies, before the steep decline in prices. Growth in the mid-2000s was associated with feed-in tariffs of rooftop PV by German Energiewende and the California Solar Initiative, which provided generous upfront subsidies for solar installations.

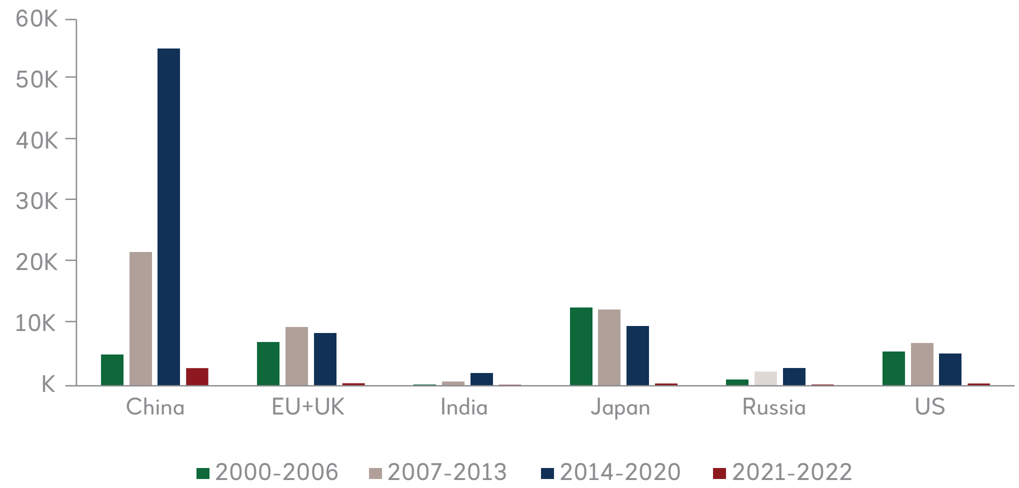
fossil fuel-related technologies, including oil drilling and chemical refining of crude oil. New patents for European Union (EU) and US fossil fuel companies are declining, but new patenting globally for fossil technology remains high. Patenting activities by Chinese fossil fuel companies increased after the financial crisis in the late 2000s, following the overall patenting trend in many other sectors in China.

To be fair, fossil fuel companies have also innovated to reduce GHG emissions generated from fossil fuel production operations. Recent reports show that fossil fuel production operations alone account for about 8 percent of total GHGs in 2019 (McKinsey & Company, 2021). In the fossil fuel production cycle, improved technologies can help reduce the impact on climate at almost every step, for example, by preventing methane flaring in the pipeline, reducing energy use in oil transport and refinement, and lowering carbon produced from chemical process in refinement (Deloitte, 2022).

Carbon capture and storage (CCS) technology at production sites is widely recognized as a potential net-zero pathway for the fossil fuel industry, and it is part of most of the Nationally Determined Contributions submitted under the Paris Agreement. Companies, including SOEs, continue to invest in fossil fuel infrastructure because of the belief that CCS technology will become economically feasible in the decades ahead. Globally, private sector firms typically lead innovation in green technologies. But in advanced economies such as the EU and the Republic of Korea, nonprivate institutions have also exhibited a keen interest in the R&D on CCS. There is also evidence that innovations around CCS (proxied by patents) were boosted after the imposition of a carbon price.[40]

Interestingly, domestic and international collaborations in CCS innovation are relatively frequent, but significant additional government finance and support will be needed to make CCS technology commercially viable. For example, supporting infrastructures, such as a nationwide CO_2 pipeline network or storage, are needed (Edwards & Celia, 2018). There are different pathways utilizing CCS technologies, but close collaboration between public and private sectors is important (Hepburn et al., 2019).

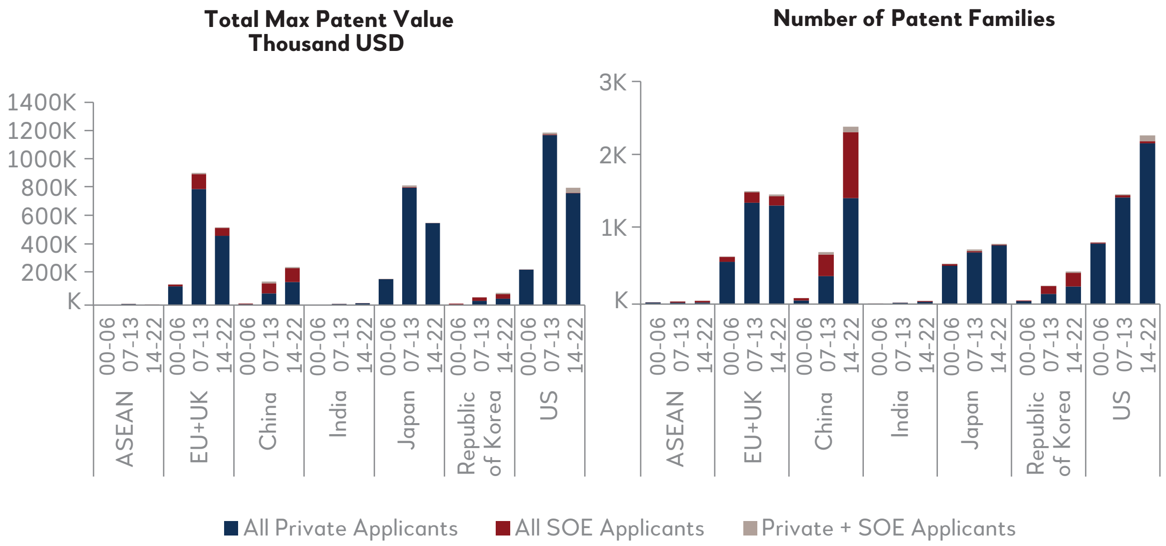
Figure 47: Number of Patent Applications (by Patent Family) of Biggest Fossil Fuel Companies



Data source: ORBIS Intellectual Property and AIIB staff estimates. See Appendix 2 for details.

[40] Perhaps it should not come as a surprise that the top owners of CCS technology patents among the patent applicants are fossil-fuel companies: Halliburton Energy Services, Baker Hughes (US); L'air Liquide, IFP Energies (France); Linde Aktiengesellschaft, BASF SE (Germany); Schuluberger Technology, Dutch Shell (Netherlands); China Petroleum & Chemical (China); Mitsubishi Heavy Industries (Japan).

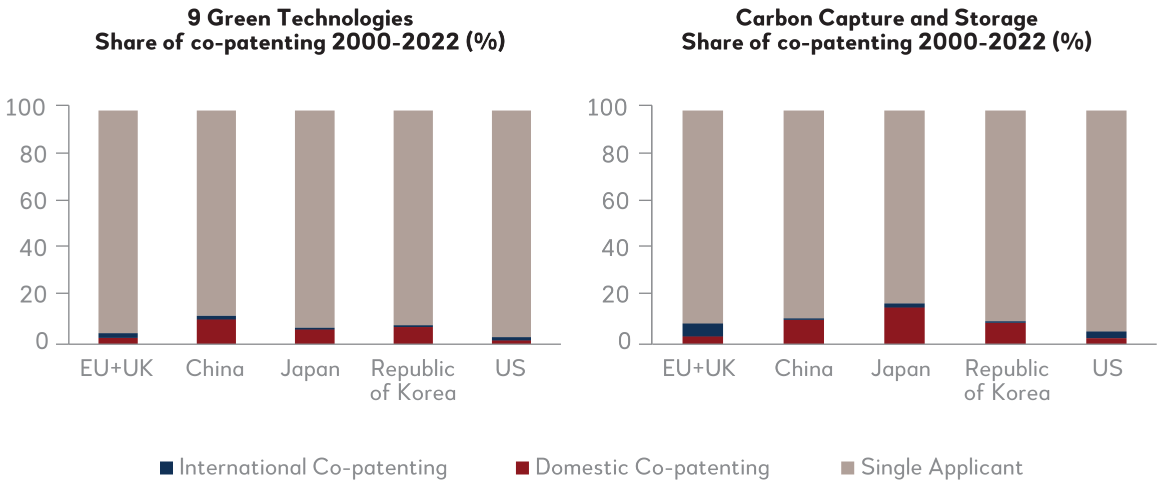
Figure 48: Patent Applications of Carbon Capture and Storage Technologies



ASEAN = Association of Southeast Asian Nations, EU = European Union, SOE = state-owned enterprise, UK = United Kingdom, US = United States.

Data source: ORBIS Intellectual Property and AIIB staff estimates. See Appendix 2 for details.

Figure 49: Patent Applications (by Patent Family) with Co-Patenting



EU = European Union, UK = United Kingdom, US = United States.

Data source: ORBIS Intellectual Property and AIIB staff estimates. See Appendix 2 for details.

However, policymakers risk overly relying on this approach to reduce emissions while continuing to use fossil fuels locking in future generations. Until CCS is proven economically viable (and this often depends on geography), it is important not to depend on its future abatement potential for fossil fuel investments today.

More broadly, there is a concern that planned emission reductions for the net-zero transition depend too much on genuinely new innovations and yet-to-be-proven future technologies—and technology overoptimism puts the climate at further risk. Hence, the key here is that even as policymakers and companies invest in innovations, this needs to be accompanied by very clear policy measures to shift away from fossil fuels.

6.2 Shifting toward Net-Zero Innovations and New Markets

There needs to be credible policy and market signals to shift companies' incentives away from investing in innovations for fossil fuels and toward net zero. Carbon pricing needs to be a vital part of the equation to reduce the returns to innovation in fossil fuel technology. Aghion et al. (2016) showed that high taxes have spurred innovation toward cleaner vehicles. On the face of it, advanced economies—many of which have implemented some carbon prices—have seen more patenting activities around renewables, possibly leading to higher patent values.

There is also a need to shift the incentives for production. Taxes on emissions are therefore necessary for emission control and to incentivize innovation to shift dynamic costs. The key insight of Acemoglu et al. (2018) is that subsidizing R&D is insufficient. It should be complemented with measures (e.g., taxes on emissions) to help unproductive firms exit. This insight is very much relevant here.

The biggest incentive to exit fossil fuel industries is perhaps the opportunities in renewables. It is possible to surmise a few key trends by examining the patenting activities in various economies. Economies with solid manufacturing bases, such as EVs, battery storage, etc., tend to see much patenting activity around production. On the other hand, economies endowed with renewable potential tend to see patenting in energy production and systems and even green hydrogen production.

On the number of patent families, China has become one of the leading countries filing the most patent applications in many green technologies, especially in solar, hydro, and geothermal power, as well as energy-saving technologies (e.g., electricity grid). EU countries are the main contributors to patent filings for wind power generation. The US files most patent families in CCS, while Japan remains the major applicant in hydrogen production, hydropower generation, and clean energy vehicles.

Patent applications reveal specializations in green technologies. But counting patent applications only partially indicates the capability and willingness to invest resources in R&D by different countries. New technologies need proper patent valuations that reflect market perceptions of future return, willingness to pay, and development cost to be utilized and commercialized in the market.

Overall, green technologies filed by applicants from advanced economies tend to have much higher patent values than emerging economies. For example, despite more patent families in recent years, the total value of patents filed by Chinese applicants is significantly lower than Japanese applicants for hydro and geothermal technologies. Similarly, patent applications in the US have been much fewer than those filed in Japan for hydrogen production, but US patents have roughly the same valuations as Japanese patents.

This has led to variations of average value per patent across economies. Patents with a much higher average value appear to be filed by the EU, US, and Japanese applicants than Chinese applicants. There are two factors behind such differences. First, patents filed by applicants from advanced economies tend to have more technical importance in green innovation, indicated by more forward citations.[41] Second, higher patent valuations are linked to higher costs spent on seeking international protection at more patent offices. Indirectly, this also shows higher expectations of future returns brought by the patent, so firms are willing to spend more on international patenting [see Dechezlepretre et al. (2016), Zeebroeck & Potterie (2011), Hu et al. (2020)].

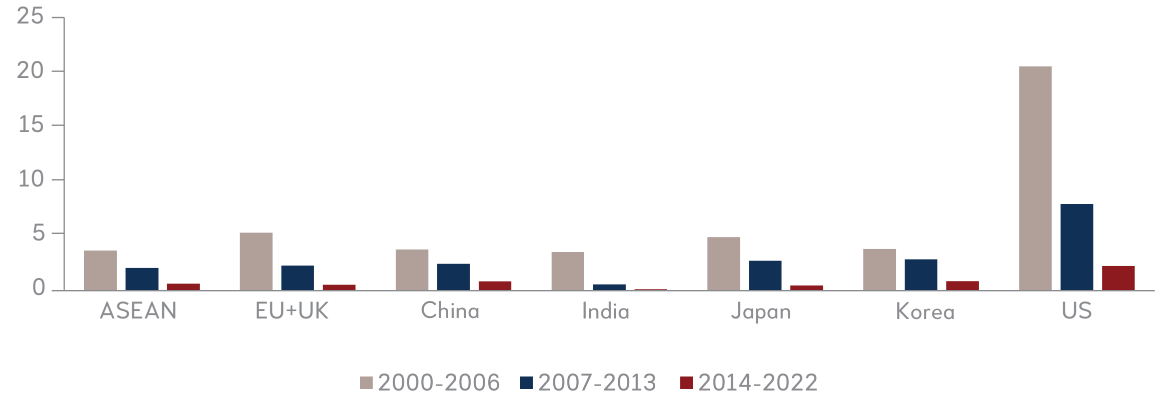
Such differences suggest there are still some gaps across economies in innovation policies supporting basic research with broader scientific significance, legal environment protecting patent rights and, the ability of firms to seek global patent protection in green technologies.

6.3 International Cooperation

The previous section highlights the recent trends in different types of innovation. Unsurprisingly, various economies and regions focused on areas of their comparative advantage. Such division of labor in the innovation space is useful. Firms in other economies can build up areas of specialties depending on their natural and industrial circumstances.

[41] Forward citations refer to patents that cite a patent after such patent is published. The number of forward citations is widely used as an indicator to measure technological significance of a patent. A higher number indicates the higher technological importance of a patent.

Figure 50: Average Forward Citations of Green Technologies



ASEAN = Association of Southeast Asian Nations, EU = European Union, UK = United Kingdom, US = United States.

Note: AIIB staff used identified nine sectors of green technologies using International Patent Classification code. This includes wind, solar, hydro and geothermal power generation. Besides, hydrogen production, clean energy vehicles, waste management (recycling) are also selected. Specific IPC codes to identify patents in these technologies are described in Appendix 2.

Data source: ORBIS Intellectual Property and AIIB staff estimates.

Figure 51: Patent Applications of Renewable Energy Technologies

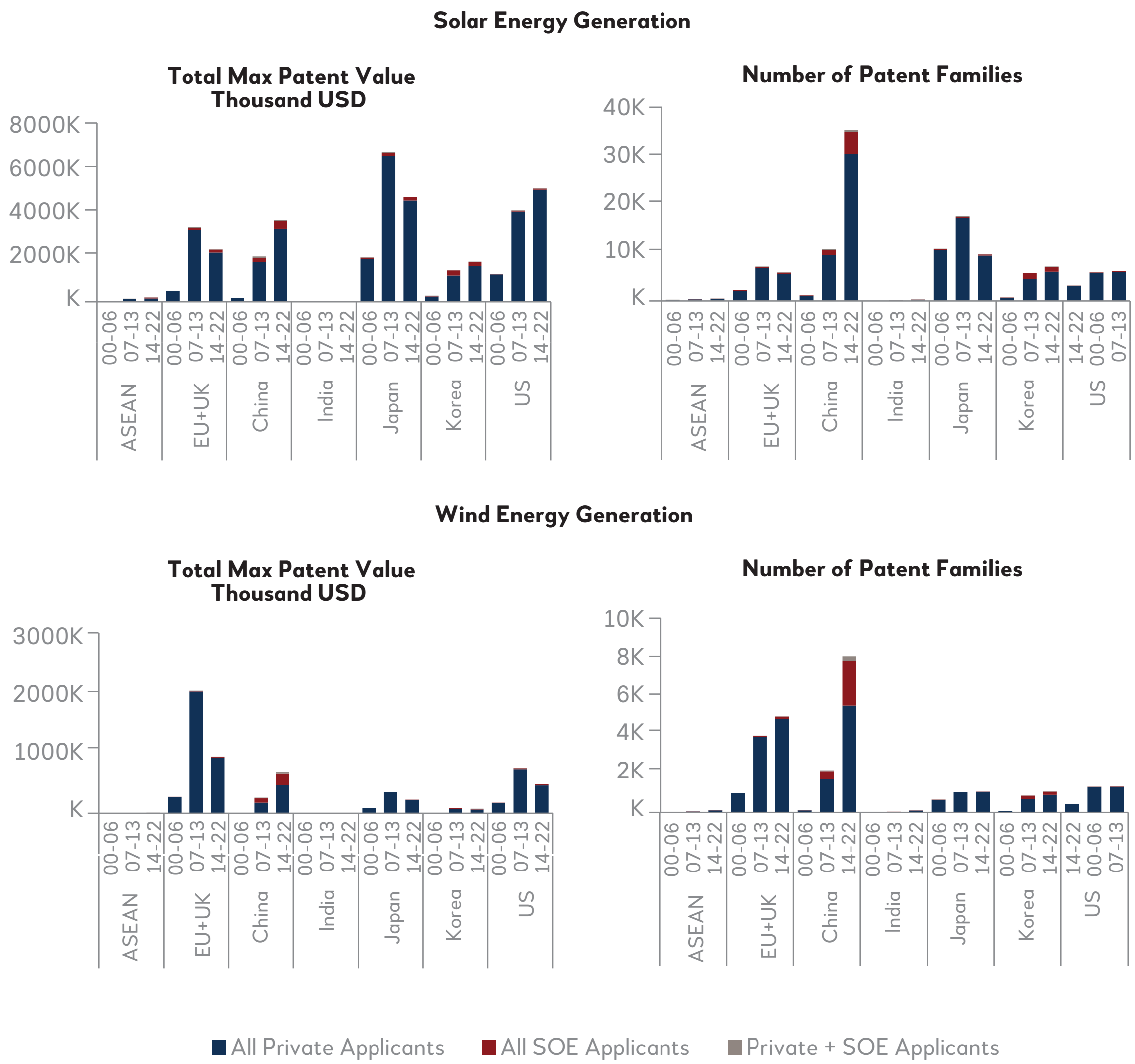


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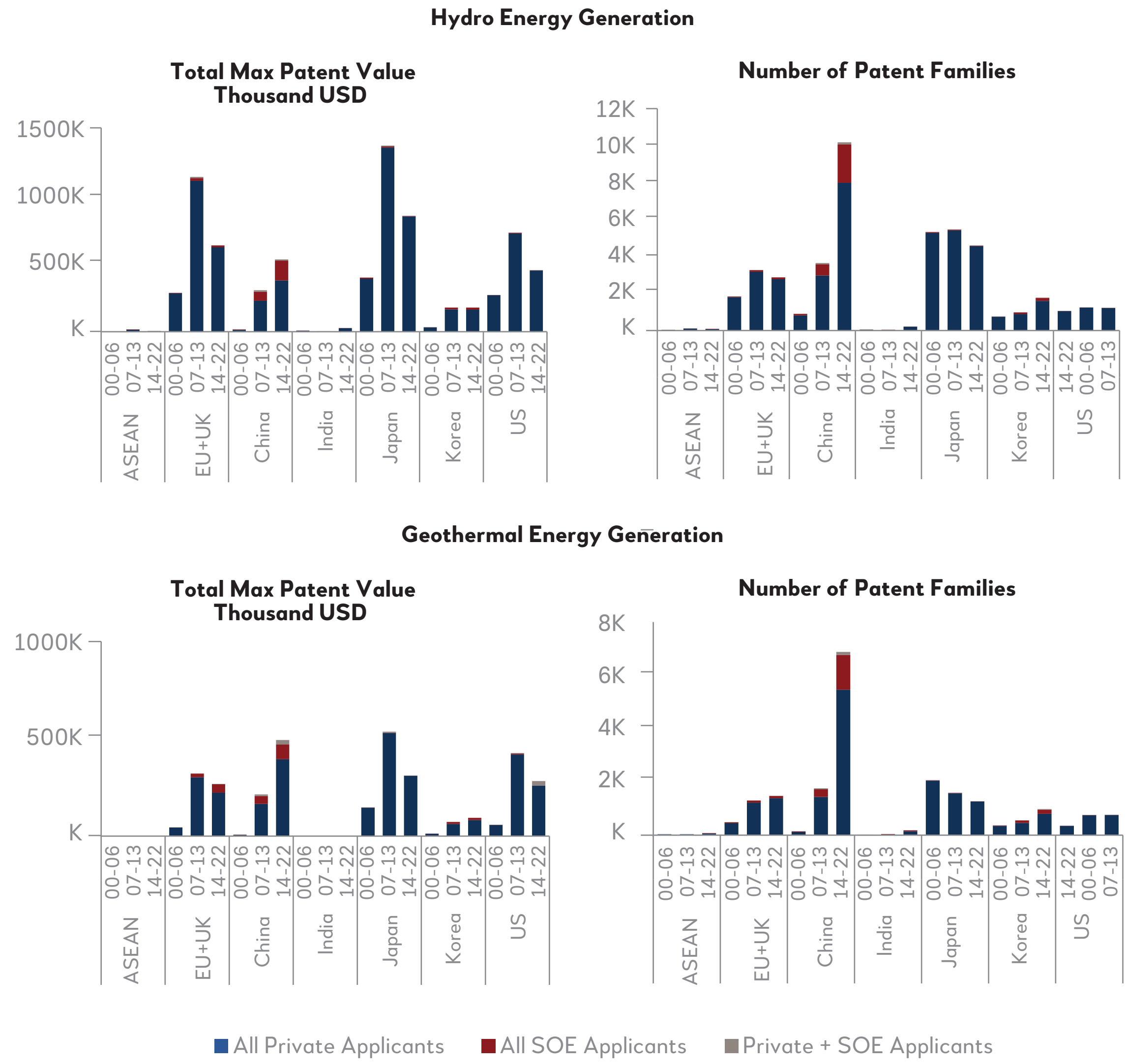
Figure 51: *continued*



ASEAN = Association of Southeast Asian Nations, EU = European Union, UK = United Kingdom, US = United States.

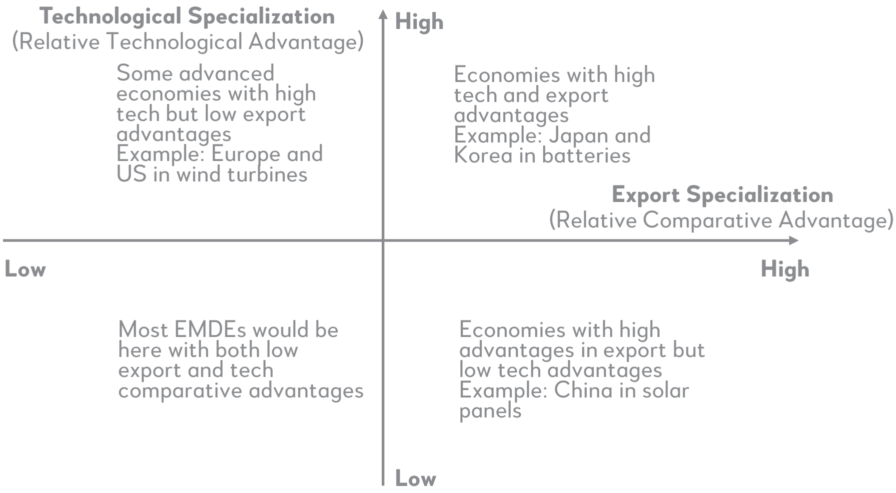
Note: See Appendix 2 for more details about the methodology calculating the number of patent families, and total sum of max patent values. Also, given the complexity of patent data, Appendix 2 describes the data filtering strategies finding the raw datasets.

Data source: ORBIS Intellectual Property and AIIB staff estimates.

There will be a need for international facilitation, if not coordination, of cross-border investment and trade to reap full benefits globally. This would allow firms with different expertise to operate across borders to facilitate technology diffusion and adaptation.[42] This will also allow clean energy supply chains to be built up in various geographies and allow for diversification and resilience. Hence, to an extent, some localization of capacity is needed, and this must be balanced against the potential deadweight costs that may arise. A common carbon price, whether on local or foreign components, is thus even more important in this context.

[42] A related discussion is how trade agreements should require some environmental or emission standards. Baghdadi et al. (2013) provided evidence that agreements with environmental provisions can lead to convergence toward lower emissions. On the other hand, agreements without environment provisions can lead to greater emissions in some trade partners and lack of convergence. The general point is that trade agreements with environmental standards can assist cross-border investments while limiting emission arbitrage.

Figure 52: Export and Technological Specialization



EMDE = emerging and developing economy, US = United States.

Data source: Global Innovation Index 2018 Report.

As renewable energy promises to provide enhanced energy security in the long term, there are also increasing concerns over the security of raw material resources that undergird renewable infrastructure. Naturally, this has heightened competition for such resources. There are also increasing concerns around access to green technology.

There needs to be careful international cooperation to ensure resources are traded equitably across various economies, and technology remains accessible, in service of every economy's transition needs. After all, GHG emissions imposes a global negative externality, and a successful transition can only happen if all economies are successful in their own transition.

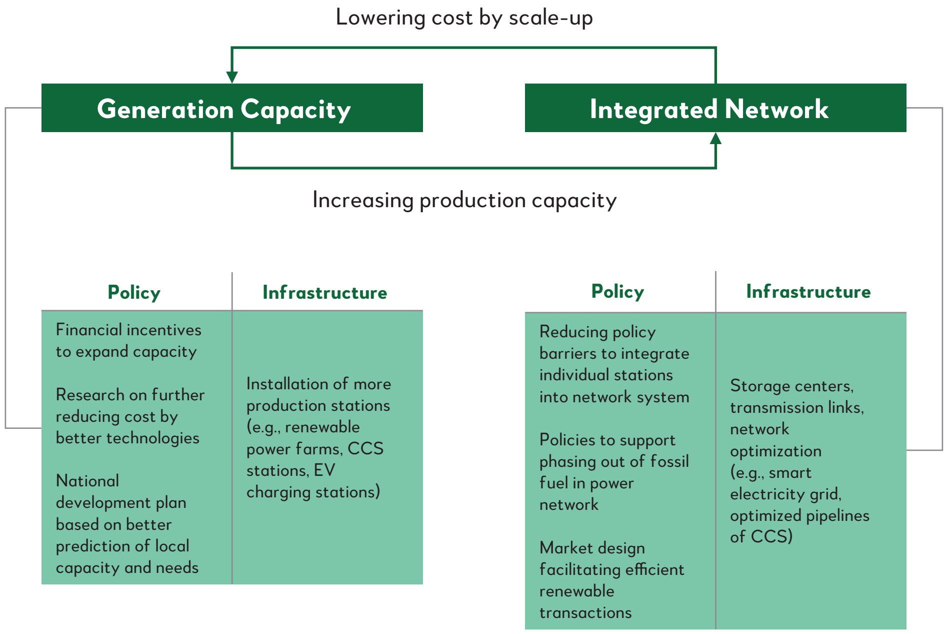
Limiting climate change is the most quintessential global public good where everybody's contribution matters and each contribution weighs equally, unlike for other global public goods like infectious diseases or maintaining financial stability (Buchholz & Sandler, 2021). It makes little sense for any economy to hoard green technology or supporting raw materials given that the damage from climate change is truly global, even more so than for the pandemic. Equally, EMDEs will also need to be open to inward investments to absorb and gain knowledge of green technology.

6.4 Innovation across Electricity Networks

To become commercially viable, existing green technologies will need a combination of policy incentives and investment in the supporting infrastructure that generates network spillover effects. Studies have shown that building up a nationwide network of infrastructure at scale is essential for the long-term financial sustainability of wind, solar, EVs, and CCS. The infrastructure includes integration into the national power grid and other networked transmissions [see Sharma (2017), Bencs et al. (2020)].

Figure 53 illustrates a framework of policy and infrastructure needed for scaling up existing green technologies, particularly renewable power. The framework highlights key policy areas supporting the generation capacity and the integrated network for renewables. On the capacity side, policies can concentrate resources on providing more incentives to expand the installation of renewable generation facilities, expenditure on research in cost reduction of green technologies, and better prediction of regional needs of new installations. On the other hand, facilitating integrated networks of renewable production facilities will need to focus on policies addressing barriers preventing integration. These include phasing out of existing fossil fuel sources in the network, and market design for efficient intra-regional transactions of renewables.

Figure 53: Generation Capacity and Integrated Network



CCS = carbon capture and storage, EV = electric vehicle.

Data source: AIIB staff.

A major challenge facing the current renewable power generation is integration into the national power grid. A part of this challenge is the technical difficulty for the power grid to absorb the volatility in the variable generation of renewables. For example, Viet Nam's wind and solar farms had to hold back their supply because the national grid has limited transmission capacity.[43] Essentially, this requires technological innovation in areas such as power grid optimization (smart grid) that can dispatch surplus power at peak supply to meet the power use at peak demand.

Countries with net-zero ambitions, led by China, Japan, and the US, are accelerating innovation in the electricity grid areas in terms of values of related patents. Interestingly, participation by nonprivate sector patent applicants in power grid technologies is relatively high in China, Japan, and Korea compared to other renewable energy sectors (Figure 54). Moreover, especially in China, the share of SOEs in patent applicants is significantly higher, with one single central SOE—State Grid Corporation of China[44]—filing the most patent applications in grid technologies.

6.5 Policy Considerations to Accelerate Green Technology

Carbon pricing is the topmost policy that can provide the critical push for innovation and technology adaptation. The unpriced nature of GHG emissions results in several interconnected negative externalities—consumption and production not fully pricing in environmental damage, the lack of inter- or intra-sector reallocation, and the weaker incentives to innovate toward net zero.[45] As highlighted in earlier chapters, investment in fossil fuel sectors remains high as incentives toward net zero remain weak in EMDEs.

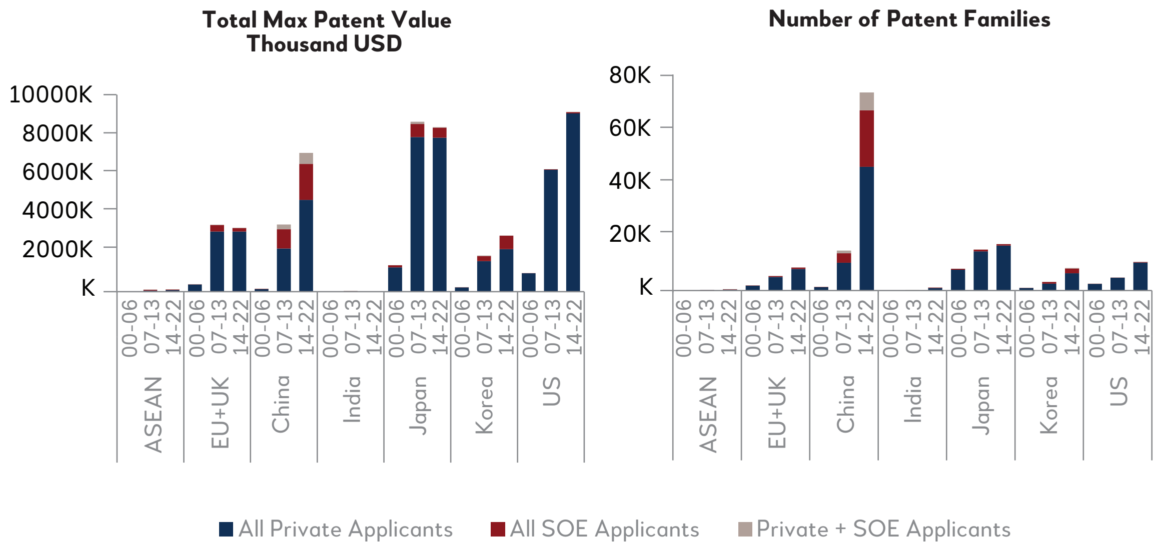
A strong argument in favor of carbon pricing is also its technology neutrality, driving reallocation based on market forces, without the policymakers having to make potentially difficult and uncertain technological bets. Here, technological neutrality must be understood in the context of net-zero transition. It refers to being neutral toward various forms of GHG emission abatement. It does not imply neutrality toward fossil sectors. Another advantage of carbon pricing is that it also increases revenues

[43] See https://www.aljazeera.com/economy/2022/5/18/after-renewables-push-vietnam-has-too-much-energy-to-handle.

[44] 国家电网 Guojiadianwang.

[45] See https://www.businesstimes.com.sg/opinion/finance-and-incentives-for-net-zero-transition-why-emdes-need-carbon-pricing.

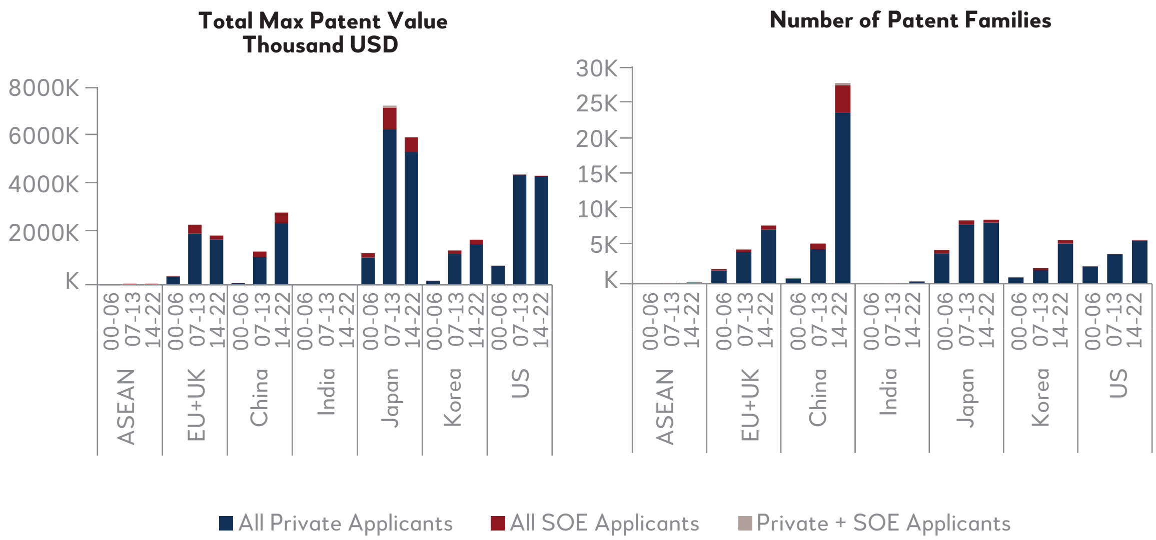
Figure 54: Patent Applications in Grid Technologies



ASEAN = Association of Southeast Asian Nations, EU = European Union, SOE = state-owned enterprise, UK = United Kingdom, US = United States.

Data source: ORBIS Intellectual Property and AIIB staff estimates.

Figure 55: Patent Applications in Clean Vehicles



ASEAN = Association of Southeast Asian Nations, EU = European Union, SOE = state-owned enterprise, UK = United Kingdom, US = United States.

Data source: ORBIS Intellectual Property and AIIB staff estimates.

for the state. Carbon pricing is a low-risk path to the extent it is politically feasible. It fixes several externalities at once and avoids risky technology bets using fiscal resources. That said, having a carbon price alone does not automatically lead to local green innovation capacity or resilience.

Hence, the second key area to consider is public support for R&D. Here, policymakers will also need to view which sectors and value chain segments would require such public R&D support with the best chances of success, weighing public funds use against the potential payoffs. One should recognize that many R&D efforts will fail—technically or commercially. This is thus a complex public policy choice, depending partly on the country's circumstances, fiscal capacity, and the strength and quality of its scientific and educational resources.

Few EMDEs can undertake large-scale R&D, nor can the states provide effective governance of such research undertakings. However, EMDEs could focus on more narrow aspects of innovation around certain parts of the value chain and/or collaborate with major companies. They could emphasize adaptation and imitation of green innovation in advanced markets to emerging and developing economy context. The upside is that a successful effort could seed real, local capacity, grow economic clusters, and achieve greater resilience for the economy at the same time.

Market design to address inefficiencies in renewables markets is also important to reduce the cost of new technologies, ensuring long-term financial sustainability of innovation. After initial commercialization, market demand and supply become the main factors driving down the costs of renewable technologies further (Elia et al. (2021)). Much of this could potentially happen in EMDEs.

In many EMDEs, renewable power markets are still incomplete, which has led to significant waste of renewables supply. Much of these inefficiencies are largely a result of policy barriers that hindered intra-state/province transactions [see Song et al. (2019), IEA (2021c), Singh (2019)].

Many EMDEs had in the past encouraged FDIs into key sectors to jump-start economic development, participate in GVCs, and benefit from knowledge diffusion from innovations elsewhere (Asian Infrastructure Investment Bank, 2021). This can be a key part of the strategy toward a low-carbon economy. To a certain extent, this can also help build local capacity, though outcomes are uncertain. Much will depend on complementary policies on workforce training, growing supporting local supply chains, and local and global circumstances. Key policy choices are summarized in Table 2.

Different policy options are needed depending on the policymaker's objectives and the country's context. Nevertheless, a realistic carbon price will be imperative to drive the reallocation process. This is especially relevant if there are policy interventions elsewhere—e.g., promoting inward investments, catalyzing R&D, etc. These efforts will necessarily create some distortions in the economy, for example, deviating from technology neutrality. A carbon price will ensure that what comes out of these policy interventions will continue to be economically viable and consistent with net zero. A carbon price is a key to solving the twin externalities—one at the production and consumption end and the other at the innovation end.

However, a carbon price on its own, even if it reaches levels where it meaningfully influences corporate decisions, cannot carry the full load of driving green innovation. Coordination will be necessary in individual sectors and across sectors as part of economy-wide "moonshots" or mission-driven industrial policies. EMDEs, using their policy instruments and governance of SOEs, need to bring together the private sector and development partners to ensure cohesion across different policy areas and innovation initiatives.

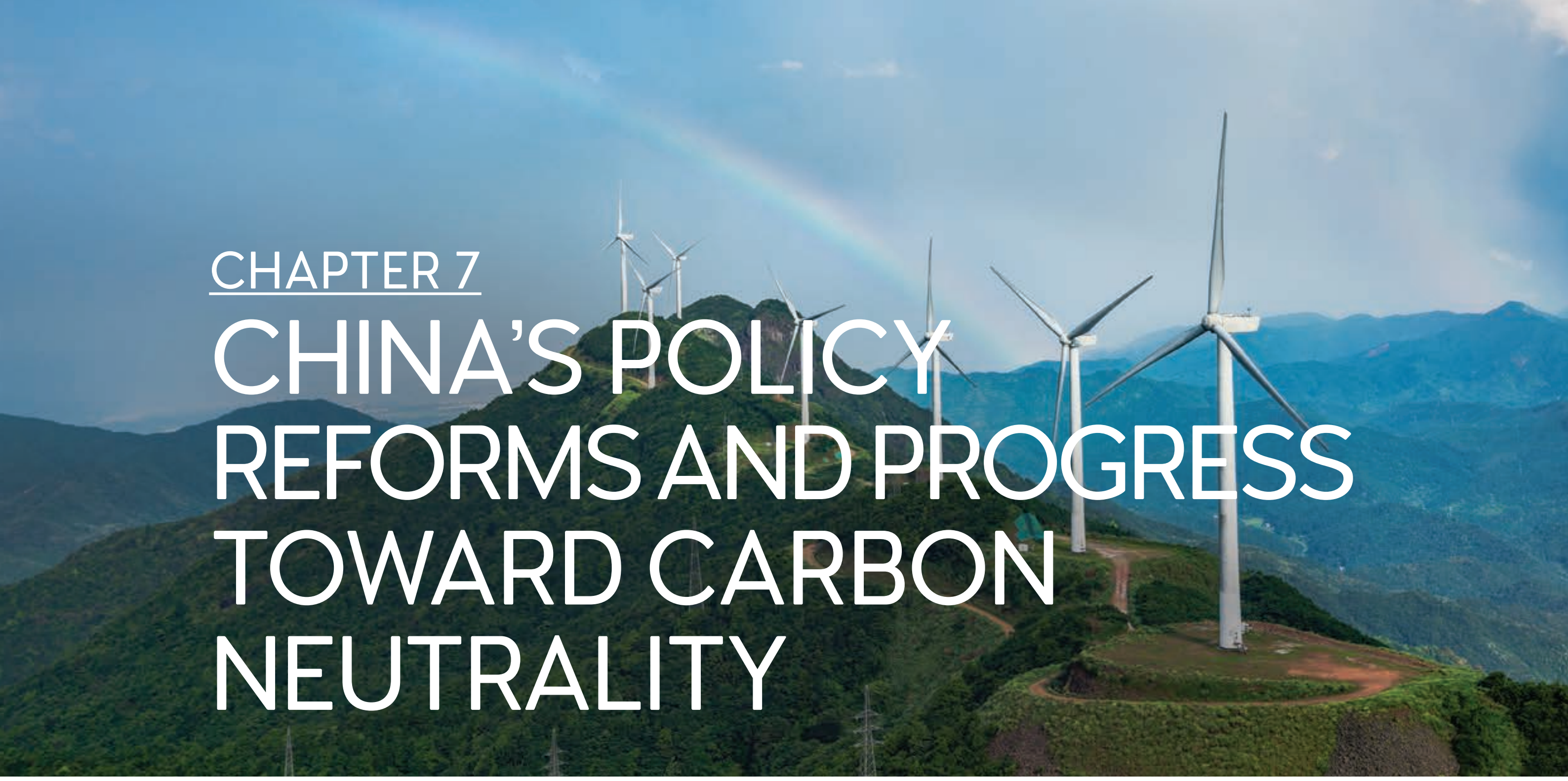
There are different models for how such coordination could be organized, but efforts in the net-zero space are coalescing around so-called country platforms (Carney, 2021). Central to these governance mechanisms is that they are country-owned, and they do place significant demand on state capacity. Many less developed countries will require strong support from their development partners.

Table 2: Assessing Public Policies to Support Net-Zero Technologies

	Economic Effect			
Policy Types	**Maintaining Technology Neutrality**	**Driving Resource Reallocation**	**Building Local Capacity and Resilience**	**Ensuring Fiscal Sustainability**
Carbon pricing	Yes	Yes	Uncertain impact	Yes
Government support for R&D	Unlikely	Uncertain impact	Likely positive impact	Likely negative impact
Market design and regulations	Unlikely	Yes	Uncertain impact	Neutral impact
Inward investment promotion and tax credits	Unlikely	Yes	Likely positive impact	Uncertain impact

R&D = research and development.

Sources: AIIB Staff estimates



CHAPTER 7

CHINA'S POLICY REFORMS AND PROGRESS TOWARD CARBON NEUTRALITY

China has made spectacular progress in economic growth and poverty reduction in the past four decades. Its per capita income rose from USD200 in 1978 to USD11,890 in 2021, transforming from a low to middle-income economy, with a sharp decline in poverty (World Bank; DRC, 2022c). The achievements are closely related to how the economy has been adapting and benefiting from the interaction between the state and the private sectors, transitioning from a centrally planned economy to one relying more on markets (World Bank, 2017a).

On the flipside, the growth model is energy-intensive, impacting both the climate and its local environments. EMDEs, including China, have lower historical cumulative emissions than those of other major economies. According to the Intergovernmental Panel on Climate Change, historical cumulative net anthropogenic carbon emissions in developing Eastern Asia, Europe and North America account for 12 percent, 16 percent, and 23 percent of global emissions, respectively. However, China is now the world's largest GHG emitter, accounting for 30 percent of global emissions.[46] China's carbon dioxide (CO_2) emissions reached 11.9 billion tons in 2021, above the pre-pandemic level. Facing the huge challenge of fundamentally changing its growth model, China has deployed administrative policy instruments, leveraging its direct control of SOEs. It has revised the regulatory framework to tap more into private sector resources and innovative capacity. It has launched a number of initiatives to increase the role of market forces, particularly in the energy sector, and through the development of carbon markets [see IEA (2016), IEA (2022a), Thieriot & Dominguez (2014), Wang et al., (2020)].

This chapter conducts a selective review of China's experiences in its transformation from a low- to middle-income country and in navigating the present green transition. First, the chapter shows that SOE reforms, such as privatization in the power sector in the 2000s, increased economic efficiency without adversely affecting the environment. As suggested by the literature, it further finds that SOE personnel and performance evaluation policy changes in 2010 were effective in prompting these companies to improve environmental performance, but mostly through introducing end-of-pipe technologies and less through production process innovation.

Second, this chapter zooms in on the role of private companies. It illustrates that private firms have played an important role in infrastructure investment through PPPs since 2014, particularly in environment-related sectors. PPPs and private participation were initially associated with local fiscal constraints but have become more correlated with institutional strength since the tightening of PPP rules in 2017.

[46] China's per capita emission is much lower and ranks at 28 globally.

Finally, this chapter assesses the impact of market-oriented reforms in the power sector and for carbon reduction. It finds that the unbundling of power monopoly in the power sector in 2002 improved allocative efficiency but had no impact on the environment. It shows that the emission trading system pilots in selective cities reduced carbon emissions through resource reallocation and imports of green equipment and raised climate awareness that may have profound implications for behavioral change. The pilots did not adversely affect city-level economic activities proxied by nighttime lights. However, the effect regarding green innovation is more subdued. To support markets and stimulate green innovation, a coordinated policy mix is much needed.

7.1 The Entrepreneurial State: Key to Efficiency and Environmental Performance

7.1.1 SOEs Dominate Infrastructure with SOE Reforms Core to Development

China's economy relies heavily on the public sector, sometimes referred to as the "China Puzzle." The most salient characteristic is the backbone feature of SOEs in the infrastructure and other strategic sectors.[47] During 2000-2020, 70 to 90 percent of publicly listed firms are SOEs in the utility and transportation sectors, accounting for over 90 percent of total assets (Figure 56). Over half of listed firms are SOEs in the construction sector as well, constituting 80 percent of total assets. One exception is the municipal and environmental infrastructure sector, in which the share of SOEs declined from 70 percent to 30 percent, in terms of both the number of firms and total assets. From this perspective, the state is considerably entrepreneurial and has significant influence on resource (re)allocation in China's economy.

Reforms of SOEs have been a core element of China's development process. Over the course of the reforms, a gradual and selective approach has been taken, distinguishing China from other formerly centrally planned economies. The process of SOE reforms could be broadly divided into four phases. In the initial phase (1978-1992), the government granted autonomy to SOEs through the contract management responsibility system and removed market entry barriers. In the second phase (1992-2003), a legal framework for the modern enterprise system was established, and privatization of SOEs was carried out. In the third phase (2003-2013), the government focused on the control of strategic industries and the institutional framework. In the current phase (2013-present), comprehensive reform was implemented under the "1+N" policy framework.[48,49]

Governance of SOEs in China has been significantly transformed as a result. With the ideology of "grasping the large, letting go of the small," the economically viable SOEs were commercialized and corporatized, while smaller ones and those with lower productivity were shut down or privatized (Hsieh & Song, 2015). A large share of the SOEs, including those in infrastructure, have been publicly listed, enhancing transparency and improving professionalism of management. Over the course of the reforms, these entities have come closer to enterprises facing market-based incentives, especially through mixed ownership and privatization.

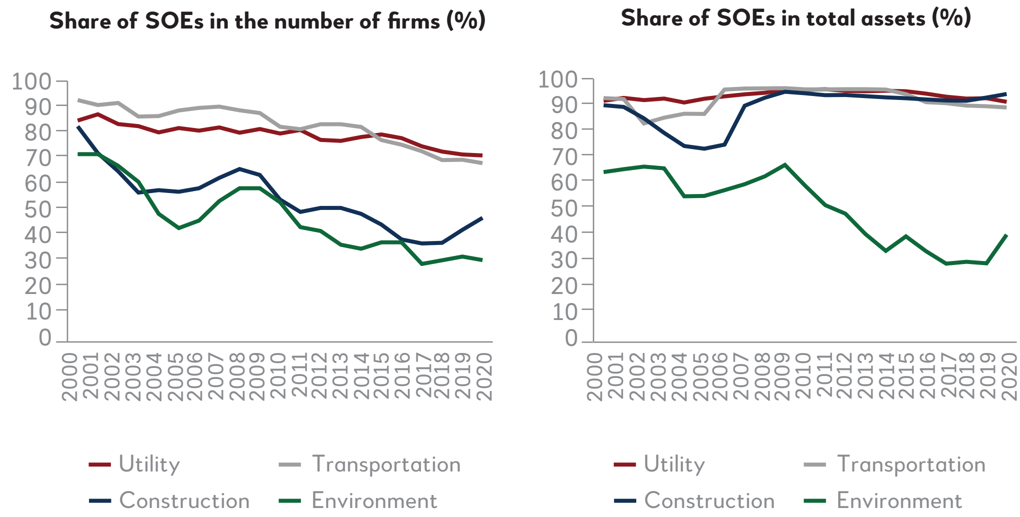
The state has removed itself from directly managing the day-to-day operations of SOEs through line ministries to indirectly supervising assets with designated public entities, i.e., State-owned Assets Supervision and Administration Commission (SASAC) and Ministry of Finance (MOF). More recently, a three-tier management system has been envisaged, with the newly formed or restructured capital investment and operation companies as the middle tier between the public entities and SOEs, further preventing the state from direct intervention in the daily businesses of SOEs.

[47] Following the SOE definition made by China's National Bureau of Statistics (NBS) in 2003 and then modified by the State-owned Assets Supervision and Administration Commission (SASAC) and the MOF in 2016, SOEs in this chapter refer to both state-owned and state-controlled enterprises (NBS, Decree 44; SASAC and MOF, Decree 32). The former refers to those whose capital is wholly owned by the state. The latter are those in which the state has absolute (equity share less than 100 percent but no less than 50 percent) or relative control (largest shareholder, though below 50 percent). State can refer to governments, public institutions and SOEs, and the equity share takes both direct and indirect ownership into account.

[48] Key measures include classifying SOEs into public and commercial categories and evaluating accordingly, promoting the mixed ownership reform, restructuring the institutional framework of supervision and strengthening supervision to avoid losses of state assets, enhancing Communist Party leadership and corporate governance and consolidating SOEs by integrations and mergers and acquisitions.

[49] See (Song, 2018) for a detailed introduction on the process of SOE reforms in China.

Figure 56: Publicly Listed State-Owned Enterprises in Infrastructure (2000-2020)



Data source: Chinese Research Data Services Platform database and AIIB staff estimates.

Despite the reforms, SOEs remain dominant in infrastructure (Figure 56). By contrast, SOEs became less dominant in non-infrastructure sectors, with the share of SOEs in the number of publicly listed firms decreasing from 84 percent to 26 percent over 2000-2020 and that in total assets from 80 percent to 40 percent.

7.1.2 Privatization Improved Allocative Efficiency with No Environmental Impact

Tremendous improvement on resource allocation in China has been documented as the result of SOE reforms. Most notably, economic efficiency of SOEs has increased, reflected in greater profitability, higher labor and total factor productivity and more innovation. SOE reforms are estimated to account for 20 percent of total factor productivity growth from 1998 to 2007. The productivity gains are found to be significant in both short and long terms [see Bai et al. (2009), Huang & Wang (2011), Zhang (2014), Hsieh & Song (2015), Chen et al. (2021)].

In the power sector, SOE reform initially fell behind the other sectors. However, chronic electricity shortage prompted the government to open the sector, following the broad SOE reform trend. Among various instruments, a critical step is to partially privatize SOEs in power generation and their subsidiaries through initial public offerings and other approaches. For example, the first listing was Shenzhen Energy on the Shenzhen Stock Exchange in 1993 (World Bank, 2000).

However, unlike in manufacturing sectors, the impact of privatization in the infrastructure sectors has not been systematically evaluated.[50] To shed some light on this question, a comparison of the performance of SOEs in electricity generation before and after their privatization is conducted as part of the background research undertaken for this report (Appendix 3). Note that, most ownership changes led to partial privatization.

The reformed SOEs in power generation enjoyed significant efficiency gains, even with partial privatization, and the state holding the controlling ownership (Figure 57). Out of around 1,500 SOEs and their subsidiaries in the power generation sector in 1998, 13 percent were (partially) privatized by 2013. The net profit margin rate increased by 7.1 percentage points, labor productivity increased by 21 percent, leverage decreased by 6.7 percentage points, and the ratio between administrative expenses and sales also fell

50 A few exceptions are studies on SOE reforms in the water utility sector, such as (Jiang & Zheng, 2014) and (Li, 2018).

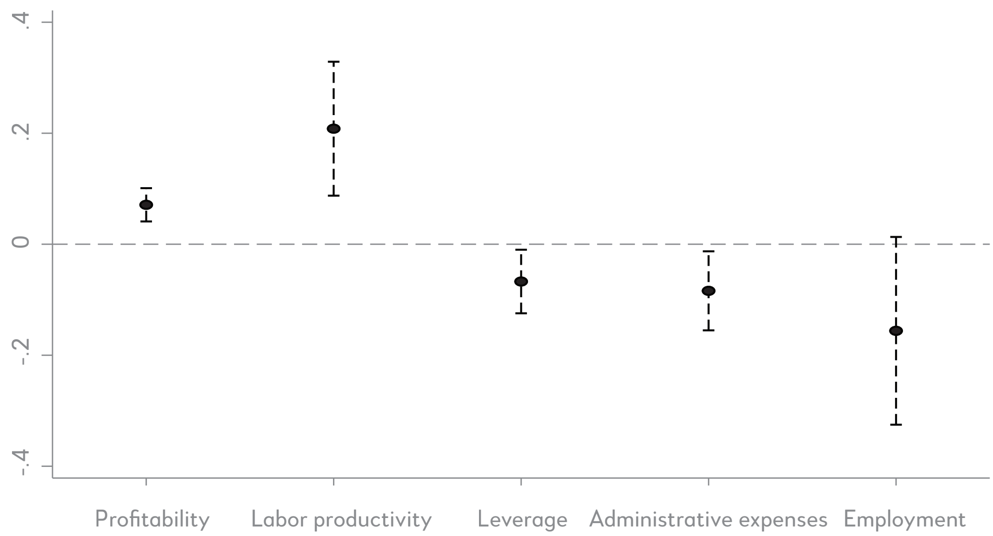
by 8.4 percentage points. These results are highly consistent with those that have been documented for non-infrastructure sectors.

The improvement in efficiency could be attributed to two main reasons. The introduction of private capital could result in greater transparency and "harder" budget constraints, prompting the government to make more informed and market-based decisions. There has been evidence that privatization has reduced differences between SOEs and non-SOEs in obtaining bank loans in China (Liu, Wang, & Zhu, 2021), indicating tighter financial constraints of privatized SOEs. Additionally, private investors could bring technical expertise and create better corporate governance practices, as suggested by reduced administrative expenses.

A concern over the partial privatization and divestiture of SOEs is whether they will shed their social responsibilities in the pursuit of efficiency. The answer is not uniform, depending on the specific type of social responsibilities under consideration. Regarding employment and associated social services, the evidence varies across studies, depending on industries and time periods.[51] In the power generation sector, partial privatization indeed reduced employment of SOEs by around 15 percent, suggesting surplus labor was a serious problem in these SOEs before privatization in this sector (Figure 57).

The effects of privatization tend to be ambiguous for green investment. The introduction of private ownership with hard budget constraints could generate pressure to cut down costs, i.e., incentives to not comply with environmental regulations. On the other hand, if the regulations are effectively implemented, privatization may lead a firm to focus on long-term cost effectiveness and improve the adoption of greener technology. The evidence on the relationship between ownership and environmental performance is indeed mixed for Chinese firms. Some studies find that state ownership has a positive effect on the corporate environmental responsibility (CER) of manufacturing firms, as SOEs are more likely to devote resources to CER-related activities (Dong, Dong, & Lv, 2022). There are also studies that show that private firms have less carbon emissions than SOEs (Anderson, Opper, & Khalid, 2018).

Figure 57: Impact of Privatization in Power Generation



Notes: The dots represent the point estimates of the impact of privatization, and the dashed lines are the 95 percent confidence intervals. Profitability refers to the ratio between net profits and sales. Labor productivity refers to the logarithm of the ratio between sales and employment. Leverage refers to the ratio between liability and assets. Administrative expenses are rescaled by dividing by sales. Employment is in logarithm. The estimations follow the methodology by Callaway & Sant'Anna (2021) and control for other firm characteristics and city characteristics.

Data source: AIIB staff estimates.

[51] Some studies find little impact of privatization on employment such as Bai et al., (2009) and Li (2018). Others, such as Gong et al. (2007), Jiang & Zheng (2014) and Chen et al. (2021) show the resulted employment downsizing.

However, the effect of privatization on environmental performance has not been directly assessed for Chinese firms. To fill this gap in the literature, the background research undertaken for this report expands the analysis of privatization in power generation to firm-level environmental performance (Appendix 3).

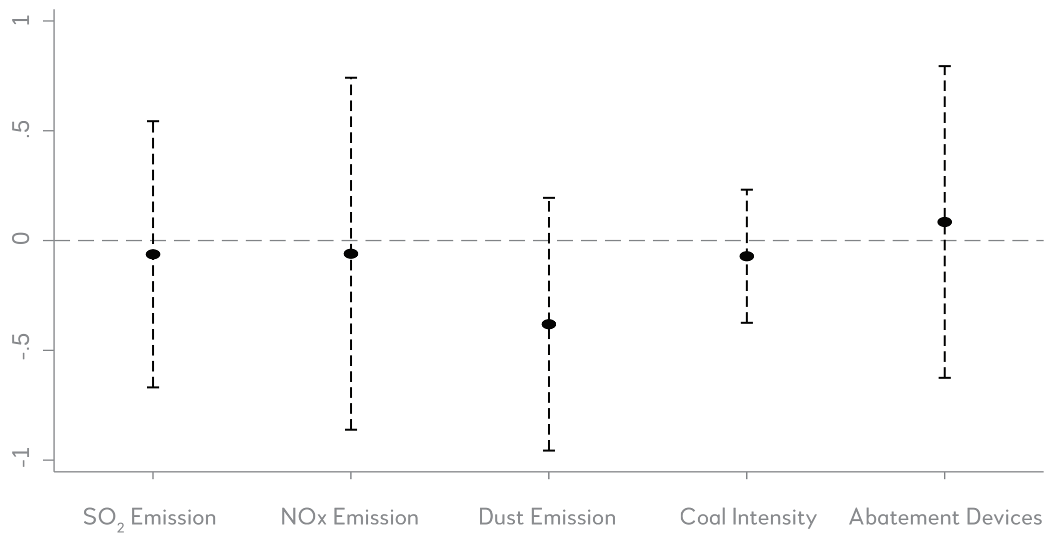
Privatization in power generation did not lead to more pollution nor did it increase energy intensity (Figure 58). Emissions of sulfur dioxide (SO_2), nitrogen oxides (NOx) and dust did not increase after partial privatization, compared with their SOE peers with no ownership change. Their coal intensity and the number of air pollution abatement devices did not change as well. This may be because these SOEs were only partially privatized, and they are still under the relatively close control of the government, whose goal is to maximize social welfare and pursue sustainable development particularly when environmental issues have become an important concern in China.

7.1.3 SOE Personnel and Evaluation Policies Enhanced Environmental Performance

The above finding also begs the question: what can prompt SOEs to do more for the green transition. The literature has suggested that the government has at its disposal distinctive tools to "push" SOEs toward green actions. These tools are more direct than the legislative, regulatory, and even financial instruments largely used to influence private sector behavior. For example, the government can issue directives to SOEs through the board of directors. It can appoint and remove senior executives based on their capability to implement green transition and request SOEs to adopt green personnel and evaluation policies [see IEA (2016), Benoit et al. (2022)].

Indeed, China has been actively using these administrative policy type of tools, notwithstanding the broad reform trend toward more independent and professional SOE management. In 2021, for example, the government revised its evaluation

Figure 58: Impact of Privatization in Power Generation on Environmental Performance



NOx = nitrogen oxides, SO_2 = sulfur dioxide.

Notes: The dots represent the point estimates of the impact of privatization, and the dashed lines are the 95 percent confidence intervals. All variables are in logarithm. The estimations follow the methodology by Callaway & Sant'Anna (2021) and control for other firm characteristics and city characteristics.

Data source: AIIB staff estimates.

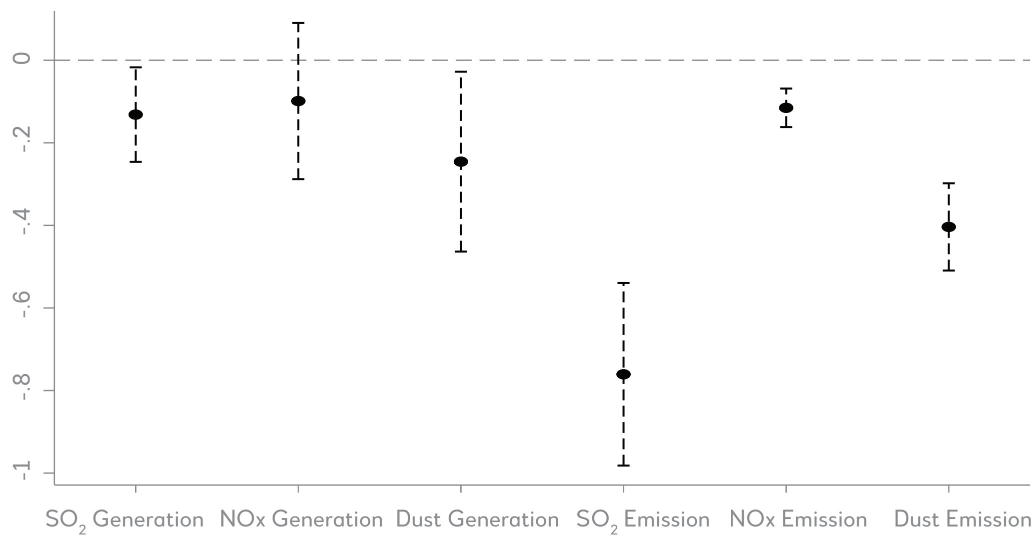
framework of SOEs to promote carbon neutrality (SASAC, Decree 93). In particular, carbon intensity reduction targets are included in the performance appraisals of SOEs' heads who have to report the completeness of these targets to the government every year.

The background research for this chapter assesses a similar policy initiative implemented in 2010 and linked environmental performance indicators with SOE personnel and evaluation policies (SASAC, Decree 23). This is the first time that energy saving and emission reduction in main pollutants were considered in the evaluation formula. The evaluation scores affect the remuneration, promotion and demotion of senior executives of SOEs. Like the analysis on privatization, the background research focuses on the power generation sector (Appendix 3).

The green personnel and evaluation policies did reduce both air pollution generation and emission by SOEs in power generation (Figure 59). The pollution generation reduction was significant for SO_2 and dust but not for NOx. Meanwhile, emissions of SO_2, NOx and dust dropped in much larger magnitudes, suggesting the adoption of end-of-pipe abatement devices. These findings provide a look ahead for the 2021 policy that includes carbon emission reduction in the SOE evaluation framework. SOEs are expected to likely respond in a similar manner to reduce both the generated and emitted CO_2.

However, direct administrative policies would have their limitations. As the ownership becomes increasingly mixed, and the state's remaining control over SOEs is weakened, the effectiveness of administrative policies could be diminished. Further, as SOE emissions constitute half of the national emissions, the private sector is also responsible.[52] Thus, other tools are needed to motivate the private sector to participate in the national campaign toward green transition. Finally, administrative policies, without a uniform carbon price across firms, often do not achieve allocative efficiency in terms of the economy adopting least cost abatements, and are also insufficient to spur green innovations.

Figure 59: Impact of Green Personnel and Evaluation in Power Generation



NOx = nitrogen oxides, SO_2 = sulfur dioxide.

Notes: The dots represent the point estimates of the impact of green personnel and evaluation policies, and the dashed lines are the 95 percent confidence intervals. All variables are in logarithm. The estimations control for other firm characteristics in the previous period, city characteristics and firm and year fixed effects.

Data source: AIIB staff estimates.

[52] In 2017, China's SOEs accounted for about half of the country's total GHG emissions.

7.2 Dynamic Private Players Rising through Environmental PPPs

7.2.1 PPP Policy Changes and PPP Growth

The flipside of China's reliance on SOEs is the relatively smaller role played by the private sector, particularly in infrastructure investment. In general, private firms have higher efficiency and innovative capacity. For example, in power generation, partial privatization of SOEs has seen efficiency gains, as documented in the previous section. In the transportation and environmental sectors, private companies register higher returns and apply for more patents than SOEs among publicly listed firms (Table 3). The picture is not uniform. In the construction sector, SOEs demonstrate stronger innovative capacity.

The efficiency gap between SOEs and private firms in most infrastructure sectors suggests that it could be welfare-enhancing to "pull" private capital toward directly investing in infrastructure in China. A PPP is highly relevant in this regard. The concept of PPPs in China differs from the more standard definition. The "private" partner is defined as "social" entities, encompassing private firms, foreign firms and SOEs in China.[53] The only requirement is that the social entities are not SOEs affiliated with the corresponding local government that initiates the project (MOF, Decree 113). The inclusion of SOEs could be seen as a practical approach: recognizing the status quo of China's infrastructure investment landscape (i.e., SOE dominance in most of the infrastructure sectors and the strong innovative capacity of construction SOEs) but signaling the future direction of increasing private sector participation.

Private sector participation can range across a full spectrum. Because of the large sunk costs, limited transferability and low contractability of quality in many infrastructure sectors, PPPs have gained considerable popularity across countries in their provision since the 1990s [see Engel et al., (2014), Fabre & Straub (2022)]. In China, PPPs emerged around the similar time, but the adoption had been through a bottom-up fashion driven by local governments.

The central government has taken more concerted efforts to set up the legal framework and supporting institutions for PPPs since 2014. These initiatives frequently emphasized attracting the private sector to participate in PPPs.[54] Several

Table 3: Efficiency of SOEs and Private Firms, 2000-2020

Sector	Ownership	ROA (%)	ROE (%)	Patent
Transportation	SOE	4	8	3
	Private	6	12	10
Environment	SOE	3	6	4
	Private	3	8	9
Construction	SOE	2	10	110
	Private	3	7	14

ROA = ratio between net profits and total assets, ROE = ratio between net profits and equity, SOE = state-owned enterprise.

Notes: The table reports the average performance across SOEs or across private firms. Patent refers to counts of patents registered in the China National Intellectual Property Administration.

Data source: Chinese Research Data Services Platform database and AIIB staff estimates.

53 In China, the official definition of PPPs was proposed for the first time in 2014, that is, "the collaboration between the government and social capital" (MOF, Decree 76). In this chapter, the PPP data is extracted from the National PPP Platform maintained by China's MOF, which covers all PPPs that conform to China's official definition. See Appendix 3 for details.

54 In 2014, following the new Budget Law, the central government formally proposed the definition and framework for PPP and actively promoted its adoption (State Council, Decree 43 and Decree 60; MOF, Decree 76). The PPP Center was also established under the MOF to regulate and supervise the PPP projects and to disclose their contract information through the National PPP Platform. Various policies were launched to motivate the participation of social capital. For example, Decree 42 issued by the State Council in 2015, Decree 90 by MOF in 2016, Decree 1744 by NDRC in 2016, and Decree 10 by MOF in 2019.

facilitating institutions have been set up, such as the National PPP Center and National PPP Fund. Province-initiated PPP centers and PPP funds were established as well. In 2017, however, the central government started to strengthen the PPP regulation to cope with concerns with fiscal risks and project qualities. Using PPP projects to borrow money by local governments were prohibited and underqualified PPP projects were terminated (MOF, Decree 50 and Decree 92).[55]

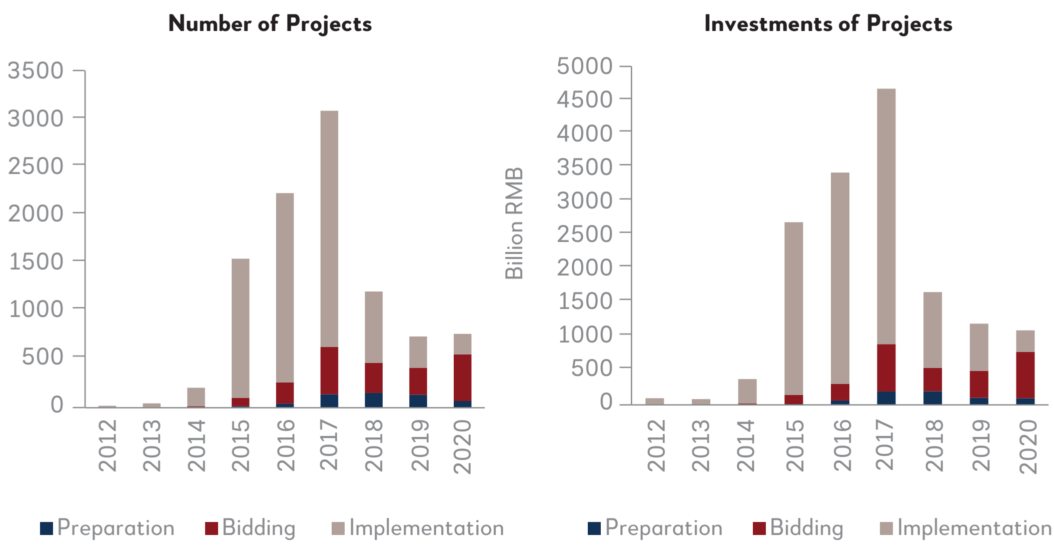
These important changes in PPP regulations and institutions profoundly impacted PPPs. By 2020, 9,882 PPP projects were initiated, 75 percent of which were implemented (Figure 60).[56] Over 2014-2017, PPPs experienced sharp growth. The rapid expansion then stalled since 2018, following the tightening of PPP regulations. The number of PPPs fell by more than half to 1,220 in 2018 and then fluctuated below 800.

7.2.2 Private Sponsors Play an Important Role in Environmental PPPs

The literature on China's PPPs has traditionally emphasized the importance of SOEs as the social partner and downplayed the role of private players [Zhou (2016), Tan & Zhao (2019)]. A unique database on the ownership of PPP project sponsors was compiled as part of the background work for this report (Appendix 3) to shed more light on this topic. The new database focuses on the environmental PPP projects, including rail transit, ecological and environmental protection, urban development (e.g., urban greening and sponge city), energy, and science and technology (e.g., intelligent city and IT networks) to explore the role of PPPs in transition toward carbon neutrality and environmental protection.

According to the analysis using this new database, private project sponsors have played an important role in environmental infrastructure investment through PPPs since 2014.[57] From the project perspective, the

Figure 60: PPPs in China (2012-2020)



Data source: National PPP Platform and AIIB staff estimates.

55 For example, PPP projects that did not pass the evaluations on value for money or fiscal affordability were cancelled. The risk control of central SOEs in PPPs was strengthened as well (SASAC, Decree 192).

56 These PPPs cover a broad range of sectors such as transportation, municipal works, urban development, ecological and environmental protection, energy, science and technology, affordable housing, education and healthcare.

57 A total of 1,129 environmental PPPs were recorded over 2014-2020, with 2,346 project sponsors (or social partners). Of these sponsors, 31 percent are private partners and 66 percent are SOEs. The vast majority of private sponsors are domestic and very few are foreign firms (one percent of total sponsors), in contrast with the situation in the 1980s and 1990s when foreign firms actively participated in China's build-operate-transfer (BOT) projects.

PPPs can be classified into three types by sponsor ownership: only private sponsors ("pure private sponsor"), both private and SOE sponsors ("joint private-SOE sponsor"), and solely SOE sponsors ("pure SOE sponsor"). Around 46 percent of environmental PPPs have private sponsors, accounting for 24 percent of total capital investments (Figure 61). Most notably, nearly half of these projects are joint private-SOE sponsor projects.

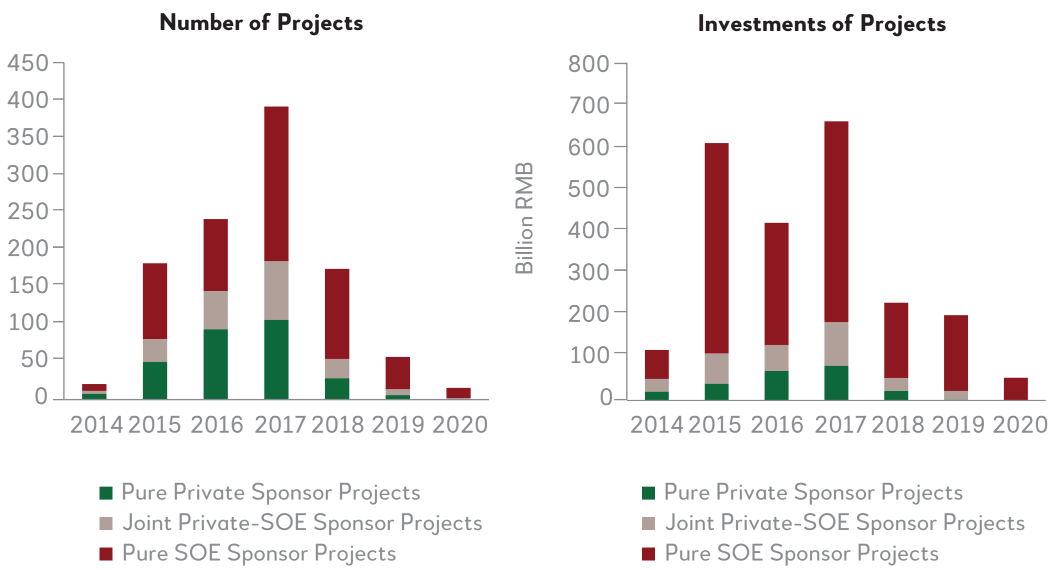
In these joint private-SOE sponsor projects, private firms work with SOEs, and some set up joint ventures—also known as special purpose vehicles. This could be another way to achieve mixed ownership in infrastructure sectors on top of the ongoing SOE reform. The collaboration between the two sectors could complement each other's strengths: private players may leverage SOEs' scale advantage, experiences in PPPs, and relatively easier access to finance, while SOEs may leverage the efficiency and innovative capacity of private firms.

The growth of private sponsor projects follows the overall trend of PPPs which is largely affected by the central government's PPP regulations (Figure 61). In the high-growth period of PPPs between 2014 and 2017, private sponsor projects grew in step with the pure SOE sponsor projects. However, the share of private participation through PPPs declined sharply on top of the overall PPP contraction after the central government tightened the PPP regulations in 2017 due to fiscal risks and project quality concerns. These rises and falls suggest that the involvement of the private sector as sponsors in PPPs were initially used to a large extent to fill the gap in financing infrastructure faced by local governments when local government financing vehicles were restricted.

Private sponsor projects have become prevalent in certain sectors (Figure 62). Private sponsor projects account for 65 percent in the science and technology sector and nearly 50 percent of PPP capital investments in the energy sector. This is likely driven by the private sector's advantage in efficiency and innovation. Private sponsor projects also make up a significant portion of urban development PPPs as well as in ecological and environmental protection PPPs. This is consistent with the overall trend of SOE pulling back from the municipal and ecological infrastructure sector and private players becoming more prominent.

Most private sponsor projects are initiated by county-level governments rather than by city- and province-level governments (Figure 63). Private sponsor projects account for 38 percent of PPP capital investments at the county level compared with 15 percent at the city level and nearly none at the provincial level. This is consistent with the rising role of private investors in urban and ecological infrastructure PPPs. This could also be because the county-level PPPs are usually smaller and entry barriers are lower.

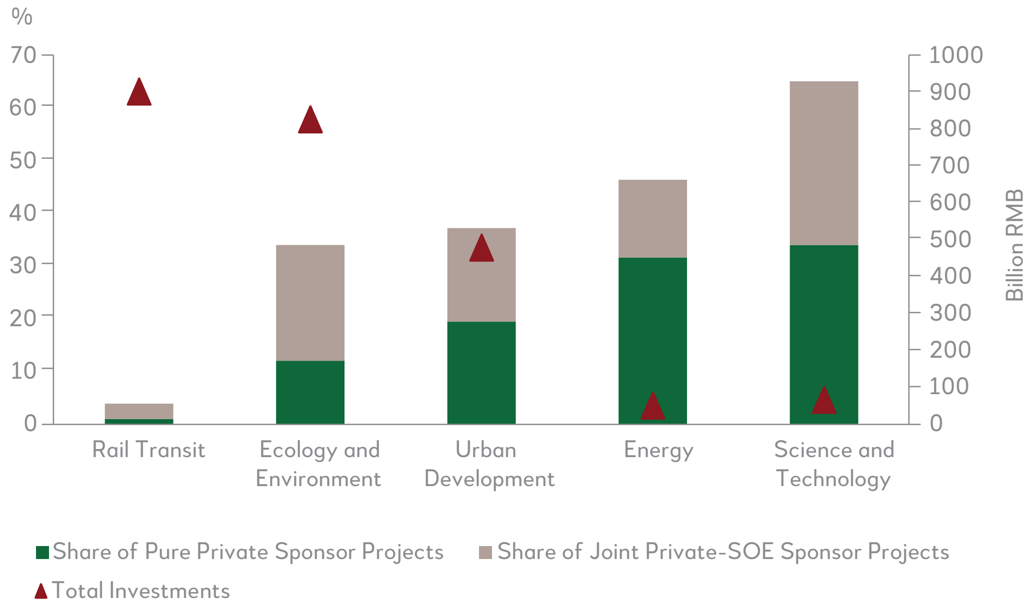
Figure 61: Ownership Types of Environmental PPPs in China (2014-2020)



PPP = public-private partnership, SOE = state-owned enterprise.

Data source: National PPP Platform and AIIB staff estimates.

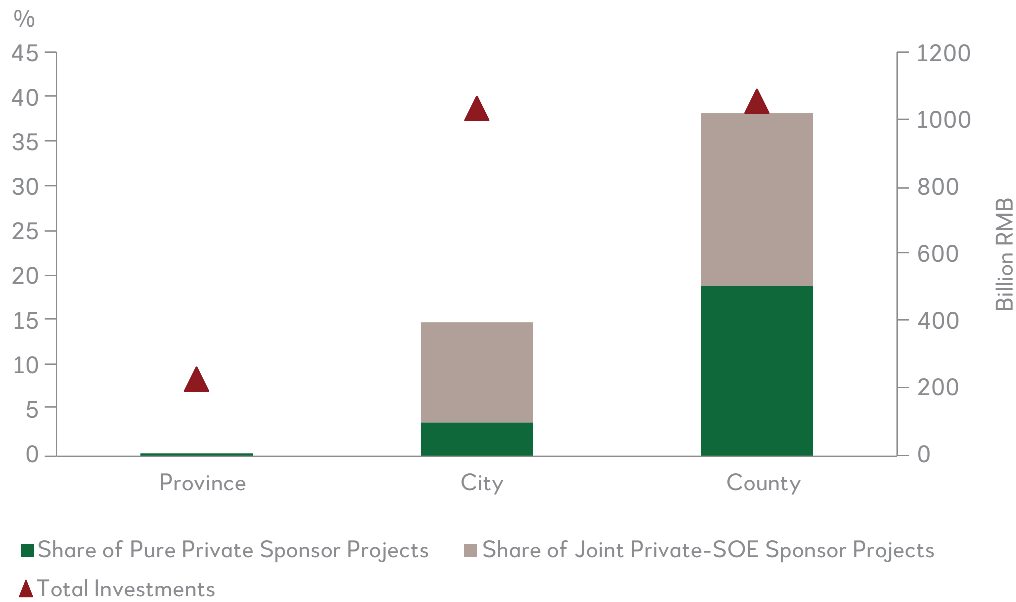
Figure 62: Distribution of Private Projects by Sector, 2014-2020



SOE = state-owned enterprise.

Data source: National PPP Platform and AIIB staff estimates.

Figure 63: Distribution of Private Projects by Level of Government, 2014-2020



Data source: National PPP Platform and AIIB staff estimates.

7.2.3 PPPs Were Correlated with Fiscal Constraints but Have Become Associated with Institution Strengths

PPP contracts are complex undertaking, requiring high government capacity to guard public interests. From the private sector's point of view, a strong regulatory and institutional environment is critical, as it can reduce investment uncertainty and risks. For example, effective property rights protection is a pre-requisite to mitigating hold-ups by governments [see Banerjee et al. (2006), Hammami et al. (2006), Panayides et al. (2015), Casady et al. (2020)].

In China, the geographical distribution of PPPs, particularly that of private sponsor projects in environment-related sectors, is associated with local fiscal capacity and institutional characteristics. Moreover, the relationship witnessed important changes after the central government implemented stricter PPP regulations in 2017 (Figure 64).

Between 2014 and 2017, the capital investment of PPPs was highly correlated with province-level infrastructure demand and negatively correlated with fiscal capacity. However, it was not associated with the strength of the regulatory system measured by the marketization index at the province level (Figure 64).[58]

Additionally, the average share of private sponsors' investments in the corresponding environmental PPP projects was not correlated with the local private sector development. These findings indicate that before 2017, local governments primarily used PPPs to bypass fiscal constraints while meeting rising infrastructure demand. Private participation was not mainly driven by market factors. The role of market-based institutions was subdued.

However, after 2017, when the central government tightened PPP rules, the total PPP investment was no longer correlated with local fiscal capacity, while the correlation with the strength of the regulatory system became significant. It suggests that capital mobilization through PPPs becomes more dependent on regulatory quality or institutional strength and less on fiscal needs. At the same time, the average share of private sponsors' investments in the corresponding environmental PPP projects became positively correlated with local private sector development, indicating improved resource allocation through PPPs, and better leverage of the private sector's strength (Figure 64).[59]

In general, PPPs themselves do not create gains in the fiscal space in present value and may at best postpone expenditures by backloading payments. The real gains come only when private participation brings efficiency gains [see Engel et al. (2013), Engel et al. (2020), Fabre & Straub (2022)]. It is thus reassuring to see that PPPs in China have become more affected by the local regulatory quality and institutional strength and less by fiscal considerations after the central government policies reemphasized the efficiency and quality of PPPs.

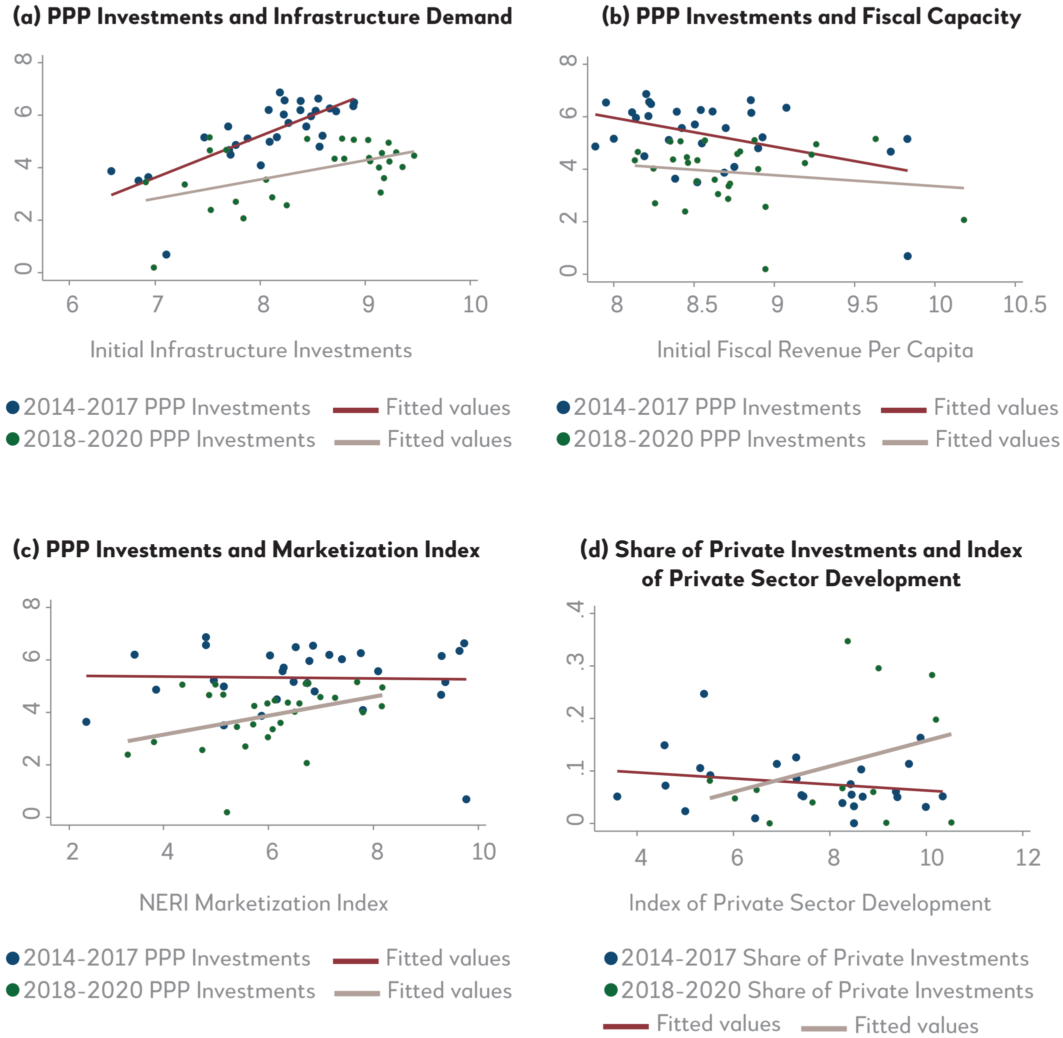
In China, the PPP contract is generally designed before the bidding process and the involvement of sponsors. On the positive side, similarities in contract design suggest that local governments do not discriminate against private sponsors in terms of differentiated contract terms, which the central government requires (MOF, Decree 90). However, contract design could have considered the private sector's preferences more to stimulate private participation. For example, compared to BOT, build-own-operate (BOO) would give private partners more controlling rights and, hence, incentivize them to invest [see Hammami et al. (2006), Zhang (2014), Wang et al. (2018)]. Yet, BOO is seldomly used in China's environmental PPPs. BOO accounts for two percent of private sponsor projects and one percent of pure SOE sponsor projects.

Despite the similarities in contract design, private sponsor projects are smaller in investment size. The average size of a pure private sponsor project is RMB815 million, which is less than 30 percent of an average pure SOE sponsor project (RMB2,960 million). The average size of a joint private-SOE sponsor project is larger at RMB1,605 million but is still just over half of an average SOE-sponsored one. The reasons behind the smaller size of private sponsor projects are multifaceted. Larger projects have greater sunk costs and risks, especially in the implementation stage. The private sector may not have the risk appetite unless under a conducive regulatory and institutional environment and with a favorable contract design to help reduce risks. The private sector also has fewer assets and probably harder access to finance.

[58] The marketization index refers to the province-level index developed by the National Economic Research Institute (NERI), including five subindexes that reflect the progress of marketization from different aspects: the relationship between government and market, development of the private sector, development of the product markets, development of the factor markets and development of market intermediaries and legal environment. The marketization index and its subindexes are from Wang et al. (2016) and Wang et al. (2021).

[59] However, it is also worth noting that the scope of private sponsor projects did not change, as illustrated by the lack of correlation between the share of private sponsor projects in environmental PPPs and local private sector development.

Figure 64: Relationship Between PPPs and Provincial Characteristics, 2014-2020



NERI = National Economic Research Institute, PPP = public-private partnership.

Notes:

1. For Figure 64(a), 64(b), and 64(c), the y-axis measures the capital investment of all PPPs in logarithm.
2. For Figure 64(d), the y-axis is the share of private investments, calculated as the average capital investment share by private sponsors in the corresponding environmental PPP projects.
3. Regarding the x-axis, in Figure 64(a), infrastructure demand is measured by the infrastructure investments in the initial year (i.e., 2014 for the period of 2014-2017, and 2018 for the period of 2018-2020)(in logarithm); in Figure 64(b), fiscal capacity refers to the fiscal revenue per capita in the initial year (in logarithm); in Figure 64(c), the NERI marketization index in 2014 and 2018 is used; in Figure 64(d), the subindex on private sector development of the NERI marketization index in 2014 and 2018 is used.

Data source: National PPP Platform, Wang et al. (2016) and Wang et al. (2021) and AIIB staff estimates.

Overall, well-designed PPPs with private sponsors and strong institutions could bring efficiency gains and catalyze sector reform while financing infrastructure demand [see ADB (2008), World Bank (2017b)]. The trajectory of China's PPP practices leads in the right direction. Private sponsors play an important role in environmental PPPs. These all indicate great potential for PPPs to be leveraged in China's transition toward carbon neutrality.

Some challenges ahead are to be addressed. It is not only about PPP investments in carbon-related and environmental sectors. All PPPs should be consistent with carbon reduction and climate resilience. As such, carbon and resilience indicators should be included in the value for money framework and projects' performance on carbon emissions should be carefully evaluated. Regulatory and institutional quality affects private sector participation in PPPs, and the subsequent implementation and service delivery.

Lifecycle governance is needed, which may imply new and deeper policy and institutional changes to achieve efficiency improvements and better value for money. While PPPs are less associated with local fiscal performance after 2017, most are funded by Viability Gap Funding or the government. These future obligations to pay are kept off the government's balance sheet, less transparent than direct borrowing and increasing governments' contingent liabilities [see Tan & Zhao (2019), Ahmad et al. (2018)].

7.3 Achieving Carbon Neutrality: Coordinated Market and Planning Instruments

7.3.1 Power Sector Reforms Increased Efficiency and Did Not Affect Environment

It almost goes without saying that China's 40-year remarkable economic growth has relied on two wheels of the drive: planning and markets. Market mechanisms provide a level playing field to all actors in comparison with control over SOEs and contractual arrangements with specific private players. At the same time, the government can still rely on regulatory and fiscal tools to achieve social objectives. Understandably, the exact mix of planning and markets varies across sectors throughout China's development. In the case of infrastructure, the public goods nature, network effects, and the complex political economy have titled the balance against market mechanisms. Utilities and other infrastructure sectors have not been fully liberalized till today. However, even in these sectors, considerable progress has been made toward competition neutrality. In many cases, "perceived" modest steps strongly impact efficiency and, hence, resource allocation.

The power sector is a case in point. China has gradually promoted market-oriented reforms and increased competition in the sector. Power generation was first opened to local SOEs and independent power producers (IPPs) in 1985, followed by commercialization and corporatization of SOE power plants and transmission/distribution subsidiaries starting in 1997. Unbundling was another milestone reform. In 2002, one fully integrated central SOE was split into five power generation companies and two transmission/distribution companies (State Council, Decree 5). It marked the vertical and horizontal separation of the supply chain in China, setting the foundation for the sector's market structure. A new round of deeper reforms has been initiated in 2015.[60] Regulations on power pricing have been further relaxed, and provincial and regional power markets have been established, including wholesale and spot markets. A nationwide power market has been proposed to be established by 2030 to optimize resource allocations and support renewables further (National Development and Reform Commission, National Energy Administration, Decree 118).

These market-oriented reforms have significantly increased competition. Measured by the Herfindahl-Hirschman Index, the market concentration of China's power sector (below 0.1) was lower than the average for OECD and G20 countries (around 0.35) by 2014 (Prag et al. (2018)).[61] According to the power sector reform index constructed by the World Bank, China's reforms reached 76 out of the full score of 100 by 2015, matching the median score for 22 OECD countries (77) and more than doubling the median score for 88 developing countries (37) [see Foster et al. (2017), Foster & Rana (2020)].

To further understand the impact of these reforms, the 2002 unbundling reform was assessed as part of the background research for this report. Although the reform aimed at breaking an SOE monopoly

[60] The aim of these reforms is to enhance the market's role in power pricing and power trading, and gradually reduce the role of administrative power planning and dispatch. Specific measures include relaxing regulations on on-grid prices and sales prices, establishing a separate and transparent transmission and distribution tariff, building power trading markets such as wholesale markets and spot markets, among others. Also, renewable power generation and its integration to grids are emphasized. See Decree 9 issued by the Central Committee of Communist Party of China and the State Council in 2015 for details.

[61] The Herfindahl-Hirschman Index is measured on a 0-1 scale. The lower the index, the lower the market concentration.

and promoting competition, studies have diverse views on its impact on efficiency. Some doubted its effectiveness in competition and efficiency improvements (Wang & Chen, 2012). Others found that it resulted in lower inputs by SOE power plants and their subsidiaries for given outputs, and that new SOE entrants closed the productivity gap with private plants [see Du et al. (2009), Gao & Van (2014), Ma & Zhao (2015)]. Additionally, the literature has not paid attention to the impact of the unbundling reform on energy efficiency and pollution, even though the power generation sector (particularly thermal power plants) is energy-intensive and one of the major sources of air pollution. The background research for this report thus evaluates how the unbundling affected SOE power generators' economic efficiency, energy efficiency and environmental performance.

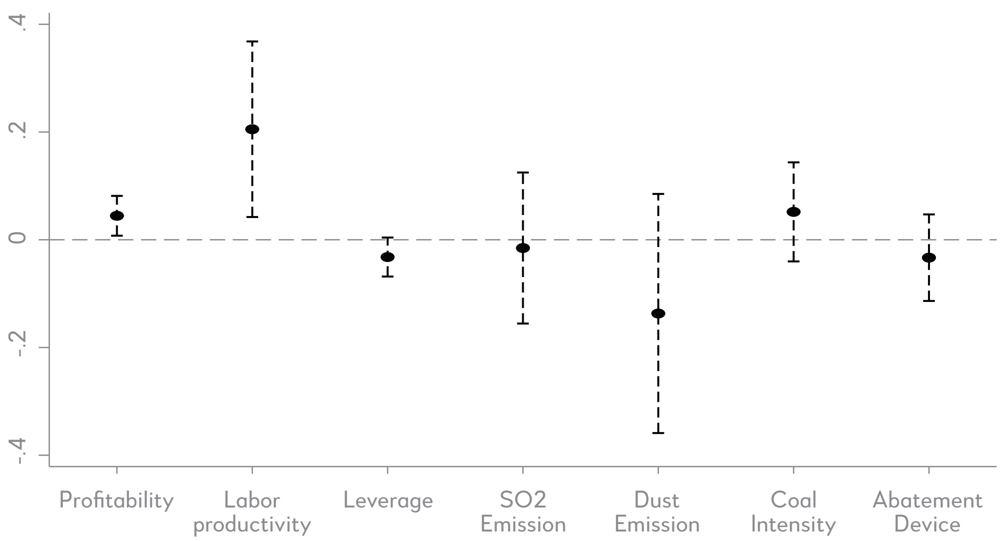
Consistent with the broad measure of market competition and reform progress, unbundling is found to significantly improve the economic efficiency of power generation (Figure 65). Compared to private plants, the profitability and labor productivity of unbundled SOE power plants significantly increased, and their leverage decreased simultaneously.

However, the unbundling reform did not affect energy efficiency and pollution (Figure 65). Emissions of major air pollutants such as SO_2 and dust, coal intensity, and installations of air pollution treatment equipment did not change after the reform. Market-oriented reforms such as this do not adversely affect environmental performance. However, these reforms alone may not generate environmental gains, either. Therefore, more tools are needed, such as regulations, incentives and personnel and evaluation policies, for environmental protection and carbon neutrality.

7.3.2 Emission Trading System Pilots Reduced Carbon Emission and Increased Green Investments

China has followed the same approach to tackle decarbonization, combining planning with market mechanisms. Regarding market-based incentives, China operates the biggest nationwide carbon emissions trading system (ETS), currently focusing on the power sector and covering 40 percent of annual national CO_2 emissions. It started operating

Figure 65: Impact of Power Sector Unbundling on Economic and Environmental Performance



SO_2 = sulfur dioxide.

Notes: The dots represent the point estimates of the impact of unbundling, and the dashed lines are the 95 percent confidence intervals. Profitability refers to the ratio between net profits and sales. Labor productivity refers to the logarithm of the ratio between sales and employment. Leverage refers to the ratio between liability and assets. All environmental variables are in logarithms. The estimations control for other firm characteristics in the previous period, city characteristics, and firm and year fixed effects.

Data source: AIIB staff estimates.

in July 2021 and builds on regional carbon market pilots (Box D). There have been concerns that ETS will not work as effectively in China as in other economies with liberalized power markets. In 2013, an IEA simulation suggested that an ETS with a moderate carbon price can reduce emissions even in China's regulated system, as long as generators are allowed flexibility to optimize production within their own generation portfolios (IEA, 2016).

The ongoing market-oriented reforms in the power sector are expected to complement and strengthen the effectiveness of the ETS. On the supply side, for example, the role of administrative dispatch will be diminished overtime, and the economic dispatch would favor generators with lower costs and lower emissions in the carbon pricing context. On the demand side, the deregulation of on-grid tariffs and consumer prices would allow some cost pass-through and thus reinforce the emission reduction incentives for generators.

To shed more light on the impact of ETS in China, the background research for this report assesses the ETS pilots from multiple aspects. They include CO_2 emissions, economic activities, green innovation, imports of environmental-friendly technologies and equipment and public awareness on carbon-related issues. All these measures on outcomes are aggregated to the city level. Compared with the literature, the background research covers more topics and employs more granular data with broader coverage (Appendix 3).

The operation of ETS pilots led to a significant reduction in CO_2 emission (Figure 66), consistent with the previous studies looking at province and power plant level evidence [see Gao et al. (2020), Cao et al. (2021)]. At the same time, the intensity of nighttime lights did not change in the ETS cities after ETS was in operation. It suggests that ETSs had no significant effect on economic activities at the city level.

The effects of the introduction of green technology are mixed. The impact on green patent applications is not significant, except for the last year of the sample (Figure 66). Even then, the positive impact disappears when controlling for city-level R&D intensity (measured as public R&D expenditure as a share of city GDP). It indicates that the strength of the ETS on green innovation is relatively weak compared to incentives offered by government R&D support. Meanwhile, imports of environmental technologies and equipment increased after ETS was in operation, suggesting that the regulated firms in the ETS cities may turn to import green technologies (particularly the end-of-pipe technologies) to cope with the market forces.

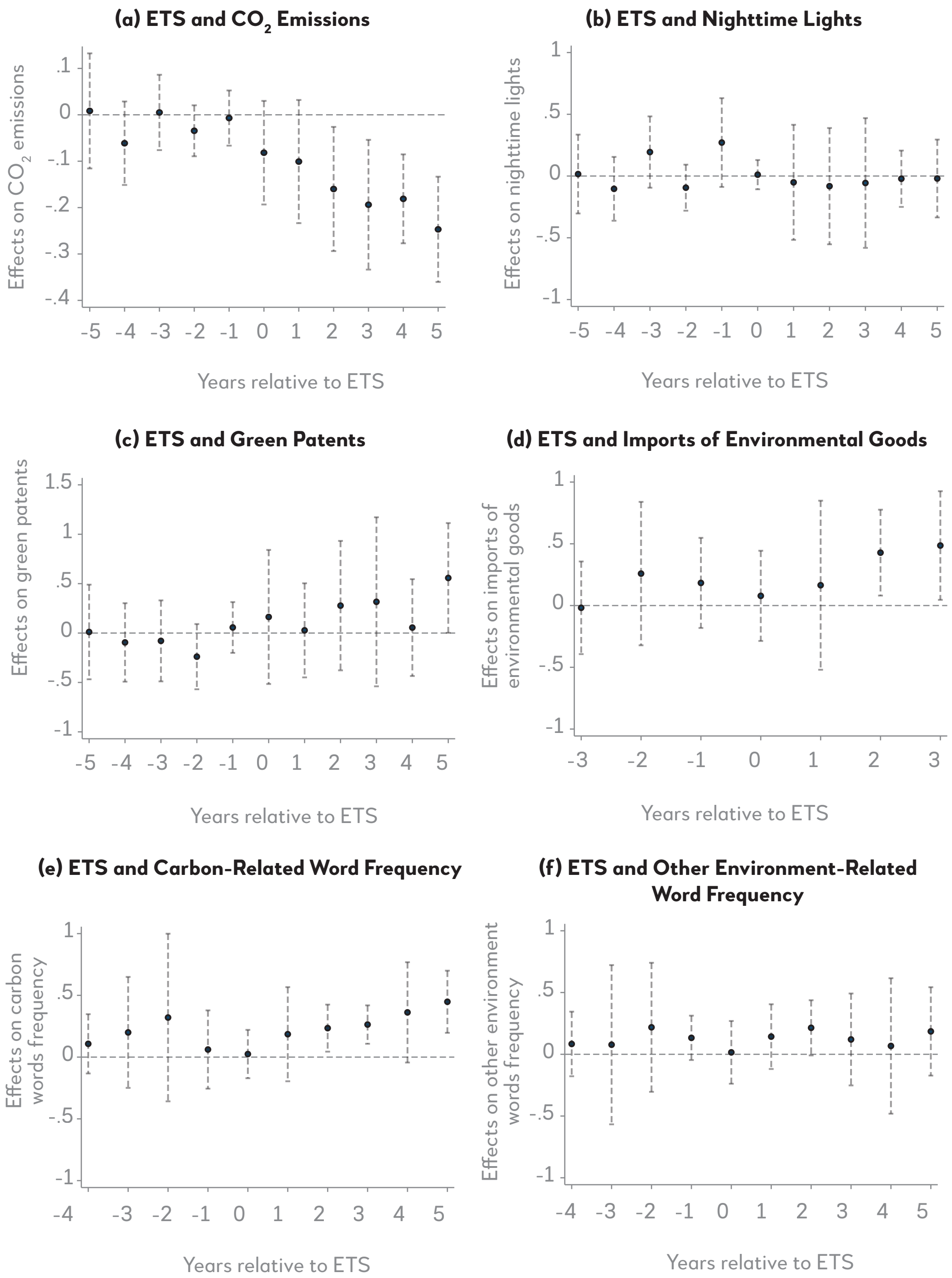
Two factors, taken together, may have contributed to the emission reduction following ETS pilots. One is the resource reallocation effect. The ETS may induce resource reallocations between heavy-emitting and low-emitting entities, reducing the heavy-emitting entities' economic activities while increasing those of the low-emitting ones. In the short term, resource transfer may primarily happen within cities, and that is why the city-level aggregated economic activities remain unchanged. This is in line with a study on the power sector (Cao, Ho, Ma, & Teng, 2021). The other factor is the imported green technologies, which could be adopted to reduce emissions without significantly changing economic activities as their costs are relatively lower than innovation.

Interestingly, the search frequencies of carbon-related words gradually increased after the ETS operation. These include CO_2, global warming, the greenhouse effect, sustainability, clean energy, and environmental protection (Figure 66). In contrast, the search frequencies of other environment-related words, such as SO_2, PM2.5, smog, haze, acid rain, water protection, and water pollution, did not increase. It indicates that the ETS raised public awareness of carbon emission issues, which may impact people's behavior toward carbon neutrality.

7.3.3 Coordinated Policy Mix Needed for Green Markets and Innovation

The development and introduction of low-carbon technologies ultimately drive the transformation toward carbon neutrality. However, markets such as ETS alone are likely insufficient to stimulate innovation. In particular, green innovation is subject to double externalities. Market instruments, such as ETS, can mitigate the climate-related externalities but may not be sufficient to address the innovation externality. Government support, such as R&D subsidies, is justified in this context to support market instruments.

Figure 66: Impact of Emission Trading System Pilots



CO_2 = carbon dioxide, ETS = emissions trading system.

Notes: The figures present the point estimates of the impact of ETS pilots before and after the implementation and the 95 percent confidence intervals. All outcome variables are aggregated to the city level (in logarithm). For analyses of CO_2 emission, nighttime lights and innovation, all the cities in China are covered over 2007-2019. For import, the period is 2010-2017. For keyword search frequencies, large cities are considered, as they have better access to the internet and similar internet user preferences. The estimations follow Callaway & Sant'Anna (2021) methodology and control for other city characteristics.

Data source: AIIB staff estimates.

Box D: Emission Trading System and Renewable Promotion

To reduce greenhouse gas emissions through market mechanisms, China's central government proposed to establish carbon emission trading system (ETS) pilots in seven regions in 2011, including Beijing, Tianjin, Shanghai, Chongqing, Hubei, Shenzhen and other cities in Guangdong (NDRC, Decree 2601). These pilots started operations in 2013 and 2014. Fujian also initiated ETS in 2016. The covered industries vary across these ETS pilots but all covered the power sector and energy-intensive manufacturing sectors such as iron and steel, cement, and petrochemicals. Some pilots (e.g., Shenzhen and Shanghai) also include transportation, construction, and some service sectors.

China's national ETS was launched in 2017 (NDRC, Decree 2191) and came into operation in 2021. The national ETS covers only the power sector but is expected to expand to seven other energy-intensive sectors, including petrochemicals, chemicals, building materials, iron and steel, nonferrous metals, paper, and domestic aviation. Power companies covered by regional ETS pilots have been integrated into the national ETS. The regional pilots continue to operate parallel to the national market and will gradually merge into the national ETS when the national market expands to more sectors.

The first compliance period of the national ETS covered around 2,000 power companies and ended in December 2021 with a 99.5 percent compliance rate. The carbon prices were around RMB40-60/tCO_2. The national ETS adopts an intensity-based allowance allocation approach, where emission allowances are allocated to power companies according to their output level and the predetermined CO_2 emission intensity benchmarks that differ by fuel, technology and size of firms. These allowances are allocated for free.

In 2005, China launched the Renewable Energy Law, which set the legal foundation for renewable development. It proposed to set up the Renewable Energy Development Fund, encouraged renewable power generation, and imposed obligations on power grid companies. In particular, it required that the grid operators purchase all of the renewable power that meets the technical standards of grids and should invest in grid construction and upgrade to integrate more renewable power.

In 2006, China introduced feed-in tariffs (FIT) to provide financial incentives for renewable power generation (NDRC, Decree 7). It mainly promoted renewable growth but obstacles became evident later on. A subsidy deficit was not sustainable and grid integration difficulties caused renewables curtailment issues. In this case, more recently, FIT was gradually phased out (NDRC, Decree 833). At the same time, China introduced a renewable portfolio standards (RPS) scheme in 2016 and then improved it in 2019 (NDRC, Decree 625). The RPS sets annual targets on shares of total renewables and non-hydro renewables in electricity consumption for each province to make use of the installed renewable capacity and minimize curtailment.

As a complementary measure of RPS, China introduced a voluntary green certificate system in 2017, which set up a market for the "greenness" (NDRC, NEA, Decree 132). It helps track RPS compliance and gives the RPS entities another option to meet their targets, i.e., certificate purchase. Also, in 2021, China piloted the green power trading, which allows renewable power to be traded as a distinct product in the wholesale market.

tCO_2 = ton of carbon dioxide.

Sources: IEA (2022a) and official documents of the Government of China.

In China, public R&D spending for energy innovation has increased significantly from about USD7.3 billion in 2015 to USD8.4 billion in 2020. It is now the second-largest energy R&D spender in absolute terms after the US. However, among the public energy R&D budgets, the share of renewables and other low-carbon budgets was around 50 percent in 2020; and the rest were allocated to fossil fuel-related energy technologies. By contrast, over 90 percent of public spending on energy R&D flows into low-carbon fields in the US and the EU (IEA, 2022b).

To catch up, China's government set up a 7 percent annual growth target on energy R&D spending in the recent 14th Five-Year Plan (FYP), and pointed out the key technology fields, including renewable energy power generation and comprehensive utilization, advanced power grids for renewable power integration and power storage, safe and efficient nuclear energy, green and efficient development and utilization of fossil energy, as well as digital and smart energy system.

The central government has also specified the national targets on CO_2 emission intensity and renewables in the long-term development plans since the 12th FYP. These targets are followed by provincial-level targets and pledges.

These top-down target-based policies are found to be effective in reducing emissions as well [see Li et al. (2021), Liu et al. (2021)]. On the one hand, local governments usually take extra steps to provide conducive policy and market environment. On the other hand, firms can form expectations of future environmental policies and regulatory stringency.

On top of emission and renewable targets, China has offered incentives and implemented other promotion schemes for carbon reduction. For example, to increase renewable power installation and integration in the grid, feed-in tariffs (FIT) and renewable portfolio standards (RPS) have been applied (Box D). Renewable electricity investment and capacity installation have increased drastically since the late 2000s. It indicates the effectiveness of these incentives. The share of wind and solar power in total power generation investments increased from 16 percent to 53 percent from 2008 to 2021. Their share in newly installed capacity also grew from 5 percent to 58 percent during the same period.

Market mechanisms are effective in reducing carbon emissions, but more measures need to be taken to achieve carbon neutrality. The design of the national ETS could be improved by expanding sector coverage, increasing carbon prices to send stronger signals, and introducing an auction scheme in allowance allocations. Transitioning from the current intensity-based ETS with a relative emission reduction target to a cap-and-trade scheme with an absolute cap would also enhance its control over the absolute amount of total carbon emissions. Strengthening government R&D support for low-carbon innovation is critical. There should be an increase in R&D subsidies allocated to renewables and other low-carbon technologies rather than fossil fuel ones. Accelerating the transformation from innovation to commercial applications will be a challenge.

Administrative policies, market mechanisms, and policy initiatives in different sectors, should reinforce each other on the path toward carbon neutrality. For example, to increase the effectiveness of the ETS, power sector reform needs to speed up to replace administrative dispatch with economic dispatch. Additionally, on top of RPS, more instruments are needed to integrate renewables better in the entire supply chain.

CHAPTER 8

INDIA'S TRANSITION TO NET ZERO: ROLE OF THE STATE AND THE PRIVATE SECTOR

India significantly enhanced its Paris commitments at the COP26 to achieve net-zero emissions by 2070. Other major commitments reflected in India's nationally determined contribution (NDC) include (a) expanding non-fossil-fuel energy capacity to 50 percent of total installed capacity, and (b) reducing the carbon intensity of GDP by 45 percent by 2030.

Achieving a net-zero transition by 2070 would require decisive shifts across energy-producing and consuming sectors and associated infrastructure. Coal-based generation would have to be completely phased out and replaced with solar and wind-based generation, along with supporting infrastructure. The adoption of EVs will have to increase manifold along with a significant decline in fossil fuel intensity across the industrial and construction sectors.

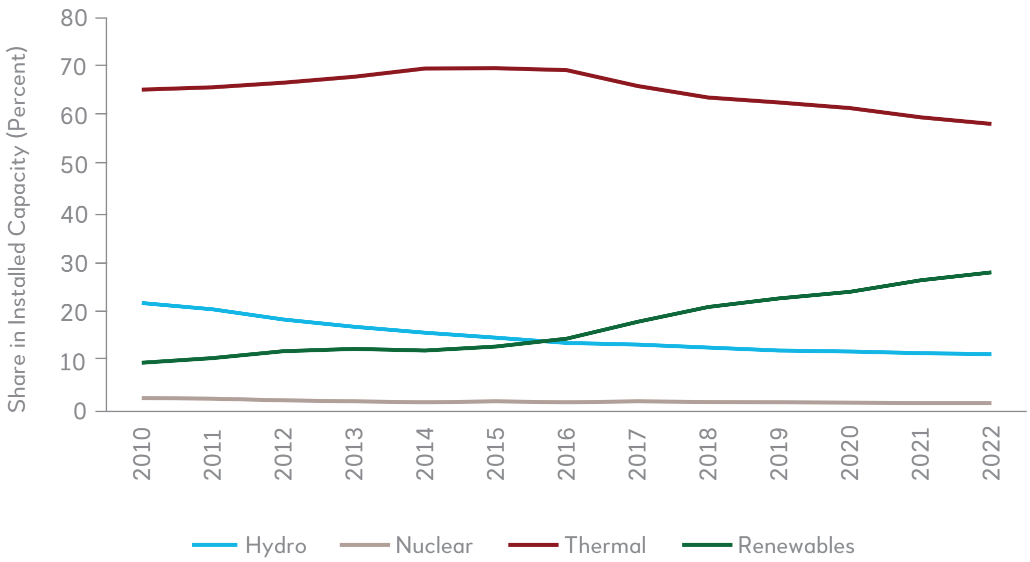
India's recent record is encouraging, making rapid progress toward the targets pledged during the 21st Conference of the Parties (COP21). In 2021, India achieved its target of 40 percent of installed capacity from non-fossil fuel energy, nine years ahead of schedule (Figure 67). Much of this has been driven by strong growth in solar generation (Figure 68). Similarly, by 2021, India had already reduced its emission intensity by 28 percent, compared to 2005, and is well-placed to achieve a 33 to 35 percent reduction by 2030.

The move toward decarbonization requires a significant shift away from the business-as-usual path. Challenges mainly lie on two fronts: first, bringing the actors together who adapt and evolve for the common cause, which will require moonshots toward innovations, technology, capacity building, etc.; second, developing the financial system to suit the immense investment needs during the transition process by facilitating innovative products and services. This chapter focuses on the roles of the two actors central to the transition process: (a) the private sector, including PPPs, and (b) the SOEs.

The private sector is playing a vital role in the decarbonization efforts. During the last decade, a decisive shift has been observed toward clean energy generation. Low-carbon transport like EVs, although at a nascent stage currently, has exhibited encouraging trends in recent years. The push toward low-carbon infrastructure is concentrated in only a few states. Participation of the lagging states is critical for India to meet its ambitious climate target.

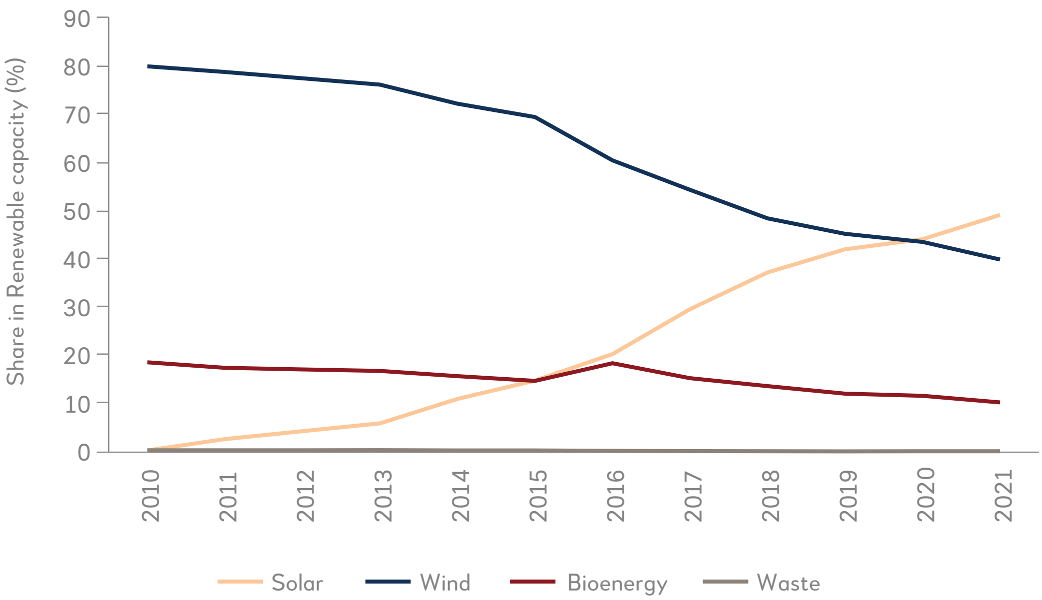
Decarbonization being a public good, SOEs will need to mitigate market failures. They can also be leaders in the transition process. However, the SOEs' weak financial health may be an impediment. The chapter finds that opportunities exist at the sectoral level for private and public sector players to learn and adopt best practices. At the same time, it is essential to safeguard the smaller enterprises during the transition process, as they remain vital sources of employment.

Figure 67: Share in Installed Capacity, 2010-2020



Data source: CEIC and AIIB staff estimates.

Figure 68: Share in Renewable Capacity, 2010-2020

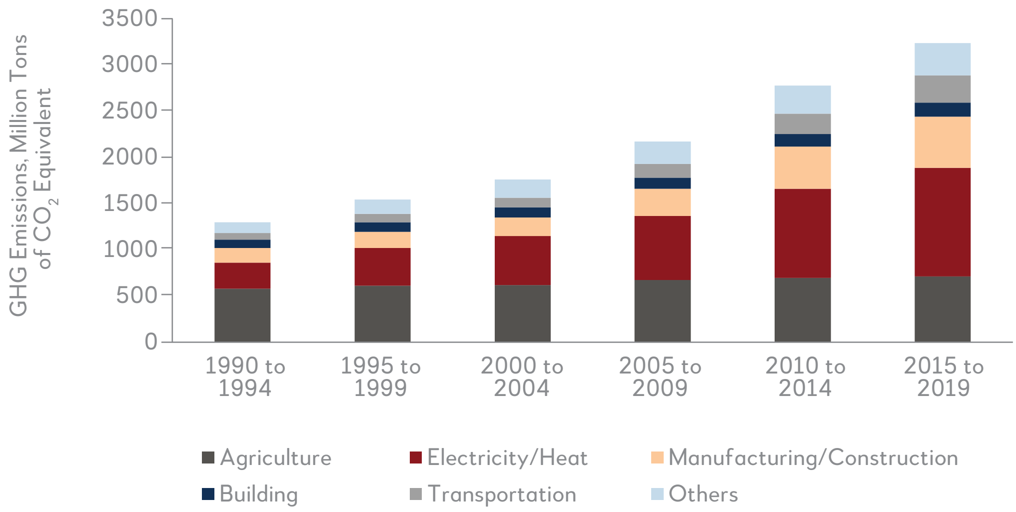


Data source: CEIC and AIIB staff estimates.

A sound financial infrastructure is a pre-condition to meet the large investment requirements.[62] Traditionally, the banking sector has been the primary source of finance for all sectors and is expected to play a leading role in the transition process. However, the magnitude of the estimated investments requires adopting new instruments and avenues to finance. The chapter evaluates the green financing space, which, although nascent, has evolved over the years. Policies focusing on developing the financial markets for green financing will be essential to achieving the transition.

[62] India would need USD10.4 trillion in infrastructure investment between 2020 and 2070 (Singh & Sidhu, 2021)., while India's NDCs point toward a financing requirement of USD 2.5 trillion between 2015 and 2030 (Ministry of Finance of India, 2020).

Figure 69: Greenhouse Gas Emissions across Key Sectors in India



CO_2 = carbon dioxide, GHG = greenhouse gas.

Data source: Climate Watch, and World Resource Institute.

The path toward net zero will have to align with the developmental needs of India. For example, agriculture contributes significantly to India's GHG emissions while supporting more than 40 percent of the workforce (Figure 69). Hence, a reduction in the GHG emission intensity of agriculture production will have to be accompanied by a rise in productivity. Similarly, the transition will have to be accompanied by steps to minimize the dislocation in the labor market as carbon-intensive industries such as coal and steel account for significant formal sector employment in India.

8.1 Private Sector Leading Decarbonization Efforts but More Needs to be Done

8.1.1 Recent Trends

Over the last two decades, private sector investment has emerged as an important channel for developing infrastructure. The share of the private sector in overall infrastructure investment increased steadily between 2007 and 2011 before dropping sharply from 2013 to 2017, owing to regulatory bottlenecks and financial sector distress (Figure 70) (Government of India, 2019).

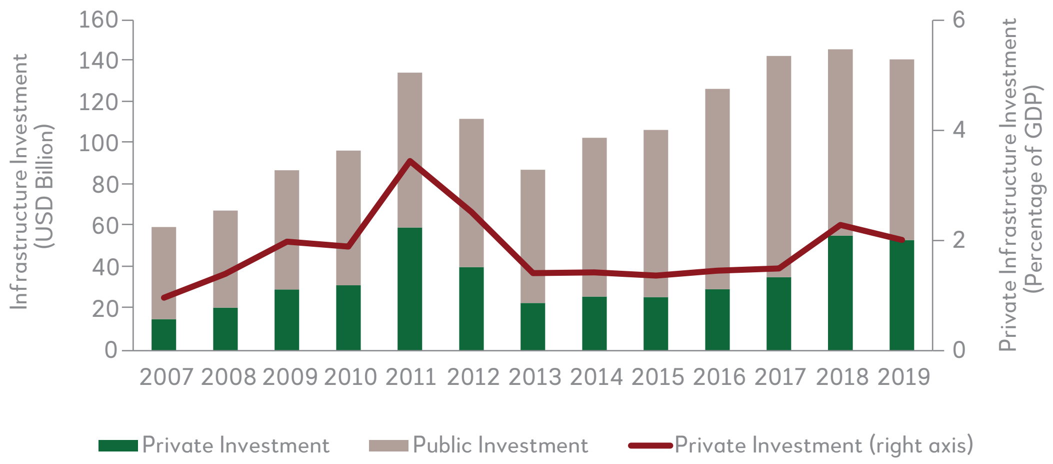
A bottom-up approach using project-level data also confirms the decline in private sector investments between 2013 and 2017 before a revival in recent years. However, a decomposition between PPP and non-PPP investments brings up some interesting trends.

First, PPP and non-PPP investments declined after 2010, but the drop was steeper for PPP investments (Figure 71). The slowdown in PPP investment was caused by distress in transport projects due to delays associated with land acquisition and environmental clearances, weak due diligence by developers, and unrealistic traffic projections (Singh, 2010).

Second, the post-2018 revival in private investment was driven by non-PPP investments, aided by government initiatives like modification in the concession structure, deferment of premium, and infusion of funds. The government also introduced asset monetization, implemented de-risked models like the hybrid annuity model, and introduced infrastructure investment trusts to attract private investment (CRISIL, 2019).

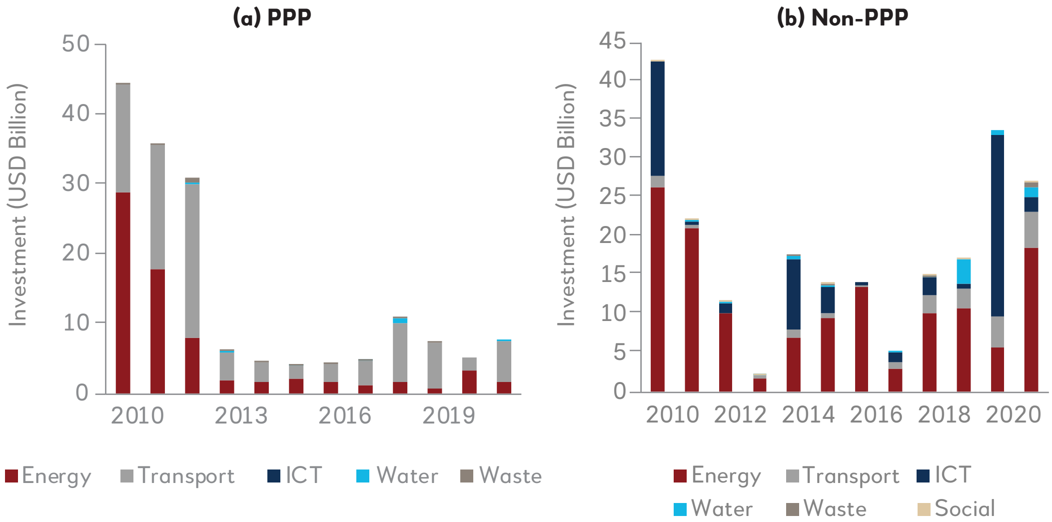
Third, non-PPP investment tends to be more diversified compared to PPP investment. The latter is overwhelmingly dominated by the transport and energy sectors, which account for 98.5 percent of total investment.

Figure 70: Public and Private Sector Investment in Infrastructure



Data source: National Infrastructure Volume Pipeline Volume 1 and AIIB staff estimates.

Figure 71: PPP and Non-PPP Infrastructure Investment



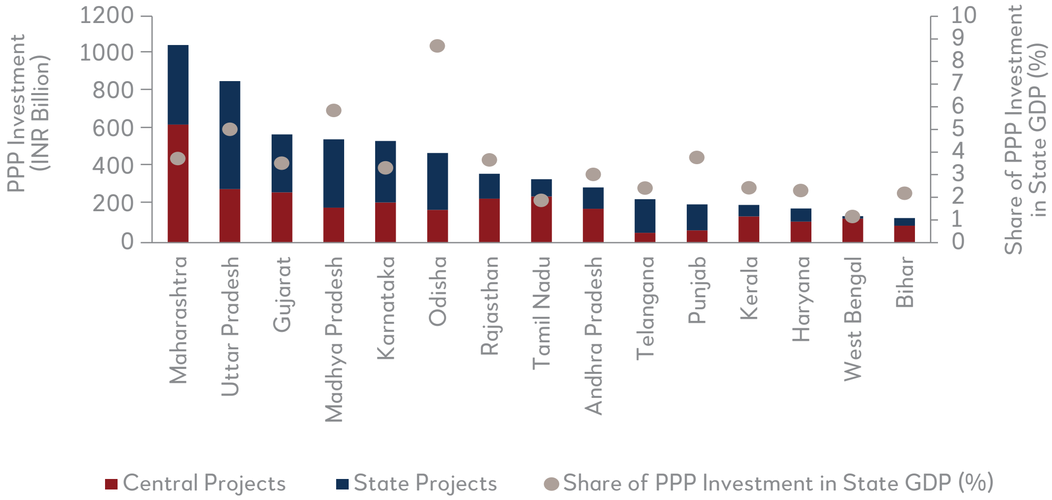
ICT = information and communication technology, PPP = public-private partnership.

Data source: World Bank PPI Database, IJGlobal Dataset and AIIB staff estimates.

India is one of the few Asian economies where subnational governments played a critical role in contracting out PPPs. Over the last two decades, state governments undertook USD120 billion, or 46 percent of overall PPP investment. Nearly 80 percent of this investment took place in the energy sector. In contrast, the transport sector accounts for nearly three-quarters of investment in federal government projects.

A granular analysis shows that large states like Maharashtra, Uttar Pradesh, Gujarat and Karnataka have attracted sizeable PPP investments (Figure 72). Recently, smaller states like Odisha and Punjab have enticed substantial PPP investments. Overall investment climate of the state has a strong bearing on the private player's decision to enter into a PPP. States with a better business environment are found to have a higher ratio of PPP investment relative to the size of the economy (Figure 73). Other factors impacting PPP investment include financial sector development and the rule of law (Kaur & Malik, 2020).

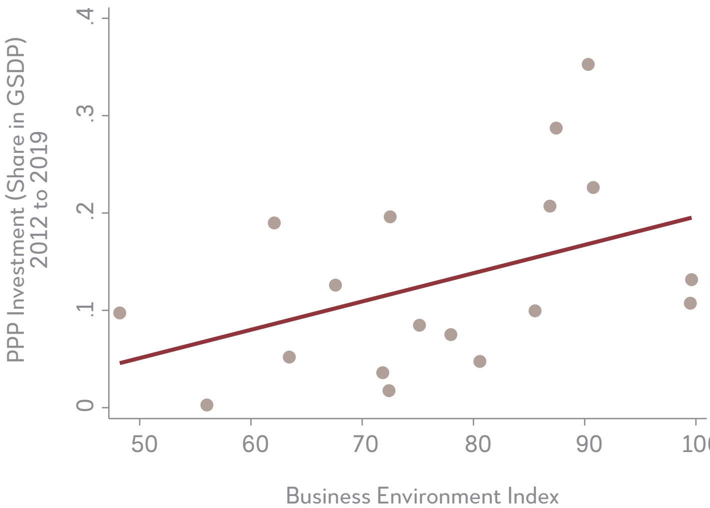
Figure 72: PPP Investment across Selected States



GDP = gross domestic product, PPP = public-private partnership.

Data source: PPPIndia database and AIIB staff estimates.

Figure 73: Business Environment and PPP Investment



GSDP = gross state domestic production, PPP = public-private partnership.

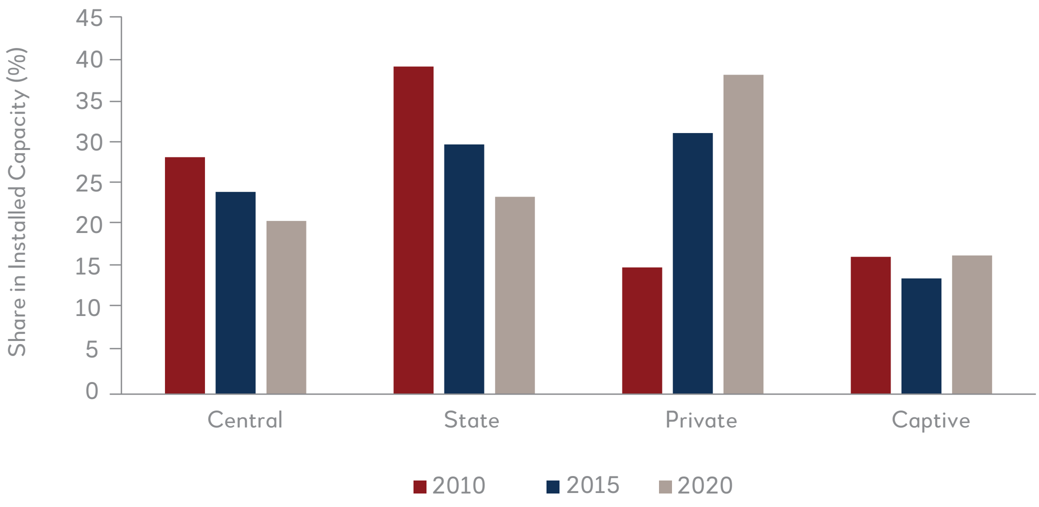
Data source: PPPIndia database, (NITI Aayog, 2021) and AIIB staff estimates.

8.1.2 Private Investment Showing Strong Shift Toward Renewable Power Generation

The private sector has been the vanguard of the shift toward renewable sources of electricity generation in India. Over the last decade, the share of the private sector in India's installed capacity for electricity generation more than doubled to 39 percent in 2020 (Figure 74). Much of the increase in private sector-installed capacity has been driven by renewables, where the sector accounts for more than 90 percent of the capacity (Figure 75).

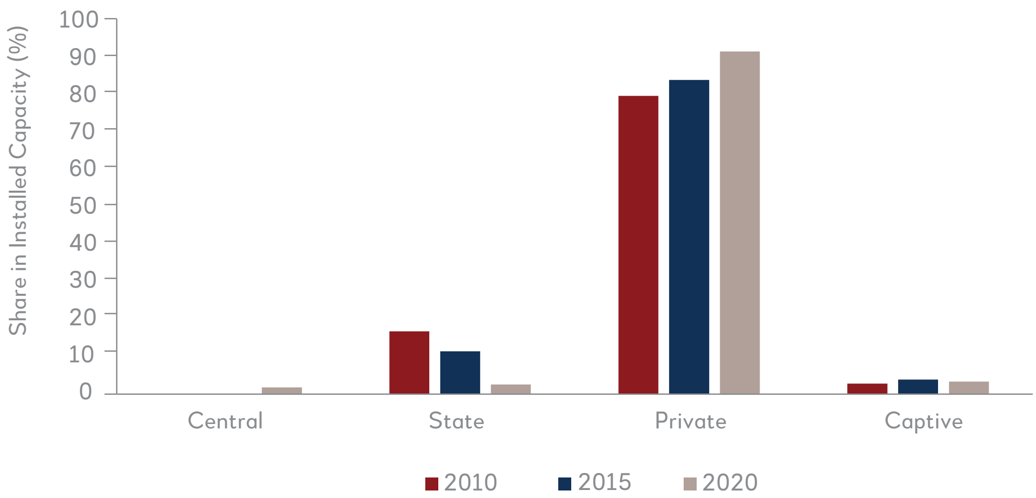
The rise in the private sector share in renewables resulted from a distinct shift in investment by the private sector—both PPP and non-PPP—during the last 10 years. Cumulatively, the private investment from 2012 to 2021 in conventional electricity generation was 20 percent higher than in renewables. However, the share of renewables in total electricity generation investment nearly doubled for PPPs and

Figure 74: Ownership of Total Installed Capacity



Data source: CEIC and AIIB staff estimates.

Figure 75: Ownership of Renewables Installed Capacity



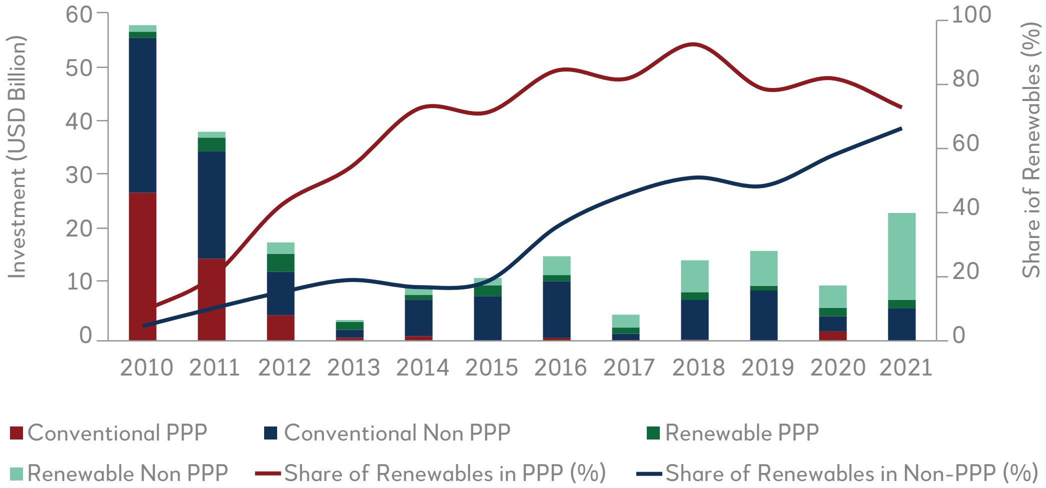
Data source: CEIC and AIIB staff estimates.

increased fourfold for non-PPPs during this period (Figure 76). Non-PPPs were the primary driver of renewable investment, accounting for nearly two-thirds of the total. A commensurate shift toward renewables was observed in new capacity additions. Again, the non-PPP segment accounted for more than 60 percent of the renewable capacity addition during this period.

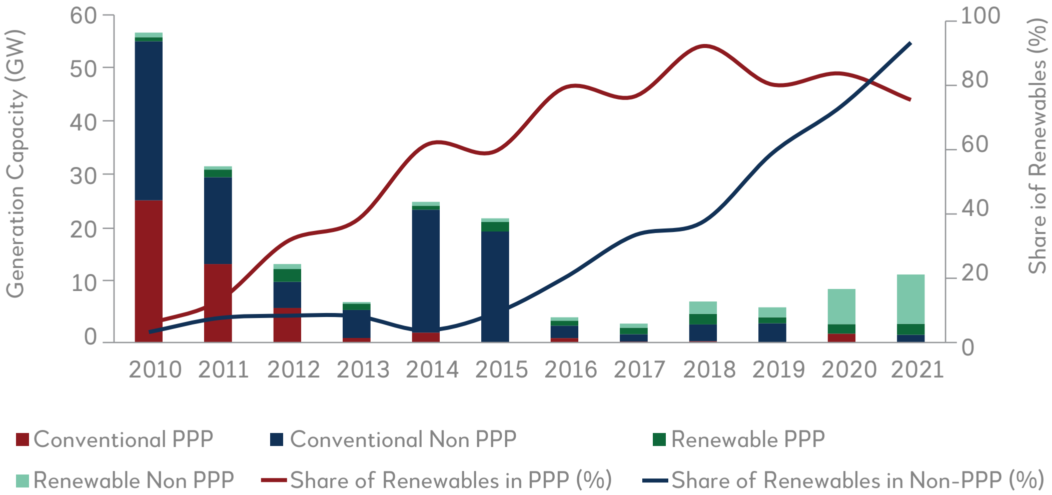
Within PPPs, projects tendered out by both federal and state governments aided the shift toward renewables. While federal government projects primarily focused on solar photovoltaic (PV) energy, state governments have tendered out a more diversified mix of projects involving onshore wind, small hydro and biomass energy. Tamil Nadu, Rajasthan, Gujarat, Maharashtra, Karnataka and Andhra Pradesh have emerged as the states with the most investment in renewables, primarily due to favorable geological conditions and supportive regulatory policies. Resource-deficit states can embrace renewable energy by procuring power from renewable energy-rich states, promoting grid connected solar rooftop projects and strengthening regulatory frameworks encompassing metering policy, tariff regulations and renewable energy obligations.

Figure 76: Private Sector Investment and Capacity Addition in Renewables

(a) Investment



(b) Capacity Addition



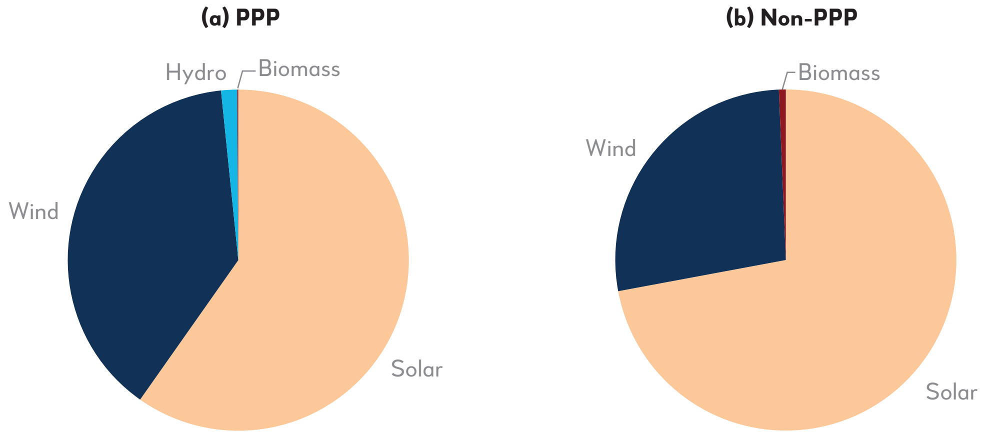
GW = Gigawatt, PPP = public-private partnership.

Data source: World Bank PPI Database, IJGlobal Dataset and AIIB staff estimates.

Solar and wind energy investments overwhelmingly account for total private sector renewable investments for both PPP and non-PPP segments (Figure 77). Several factors have contributed to raising the attractiveness of solar and wind projects in India, including rising fossil fuel prices, supportive government policy, the advent of new technology and lower risk. India, like many other emerging economies, witnessed a steady drop in the cost of renewable power since 2010, aided by low and falling equipment costs, including solar PV modules, availability of low-cost financing and declining operation and maintenance costs (IRENA, 2020). In 2019, India had one of the lowest levelized cost of energy (LCOE) for newly commissioned utility-scale solar PV and onshore wind projects (Figure 78).

The falling price of renewables has raised questions about the economic viability of thermal power projects. The plant load factor or capacity utilization of thermal plants declined from 75 percent in 2010 to 59 percent in 2021, making it more expensive to run existing plants. Adding more thermal capacity will further reduce the utilization rates of the existing plants. Thus the 34-gigawatt of coal capacity under construction and another 21-gigawatt pre-construction pipeline risk becoming stranded assets.

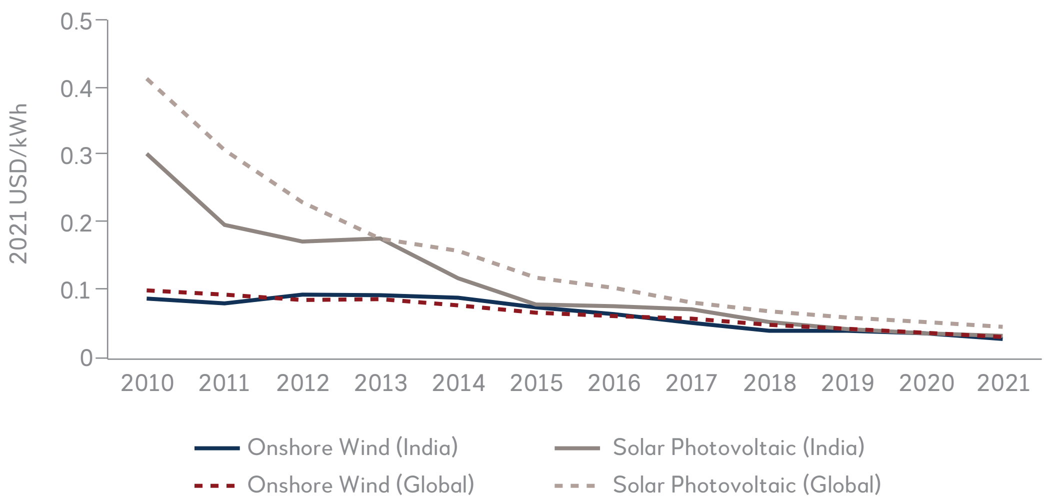
Figure 77: Renewable Energy Investments, 2012-2021



PPP = public-private partnership.

Data source: World Bank PPI Database, IJGlobal Dataset and AIIB staff estimates.

Figure 78: Weighted Average Levelized Cost of Energy of Newly Commissioned Projects



kWh = kilowatt-hour.

Data source: International Renewable Energy Agency.

8.1.3 Low-Carbon Transport at a Nascent Stage

The transport sector's share in India's GHG emissions has increased from 5.8 percent during 2000-2004 to 9.1 percent during 2015-2019 (Figure 69). With several major cities in India suffering from high air pollution, it is imperative to develop low-carbon transport infrastructures such as urban rail, metro and EVs, to shift traffic from carbon-intensive vehicles to cleaner sources.

Investment in the transport sector is dominated by PPPs, which account for more than three-quarters of private investment (Figure 79). Nearly 80 percent of the PPP investment in transport took place in the road sector, resulting in the building or upgrading of almost 29,000 kilometers of roads. By making it easier to travel on the streets, such investments can induce additional traffic, resulting in more GHG emissions in the medium-term. This can be offset by adopting more EVs on the road. With India increasingly shifting toward renewable power generation, EVs have the potential to reduce vehicular emissions significantly (Box E). Technological innovations and supportive policies by the federal and state governments have increased the attractiveness of EVs in India. However, deterrents remain in the form of high upfront costs and a lack of associated infrastructure that have dampened the enthusiasm for EVs.

Intracity rail or metro can also shift passengers away from more carbon-intensive transport. India has built or is in the process of building metro rail networks across 20 cities. However, only a few selected metro projects have attracted private sector interest in the form of PPPs. These tend to concentrate in cities that are important business centers like Mumbai, Hyderabad and Gurugram. Metro projects tend to be less attractive to the private sector due to weak financial return, driven by limits to raising farebox revenue. Consequently, such projects depend on some form of government support.

Encouragingly, several private sector players have outlined strategies and targets to combat energy transition risks. This will further provide an impetus for PPP projects designed in a low-carbon setting. As of December 2021, 64 Indian companies have announced science-based approved targets and commitments, with India ranking just behind large, advanced economies and China (SBTi, 2022).

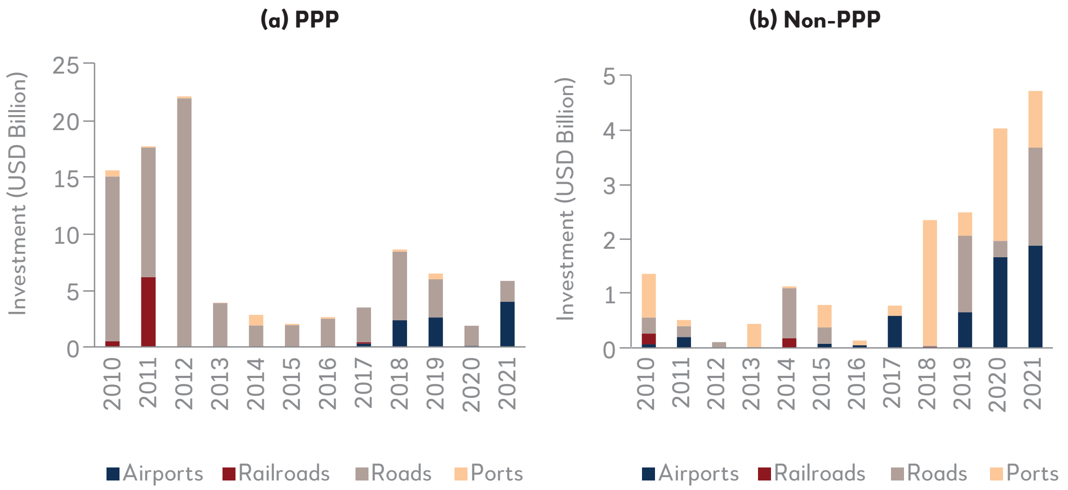
Similarly, according to a report (ABB, 2022), 63 percent of the surveyed Indian companies aim to achieve net-zero emissions within five years, resulting in India being ranked third behind China (71 percent) and Mexico (64 percent) and well ahead of many advanced economies. The SOEs are yet to make a decisive shift towards net-zero targets, despite some progress. The largest natural gas company has targeted to achieve net zero GHG emissions by 2035, while two natural gas companies have announced targets to achieve net-zero scope 1 and scope 2 emissions by 2040.

8.2 SOEs Yet to Provide Strategic Net Zero Push

8.2.1 Recent Trends

Although private sector participation in decarbonization has been encouraging, the public good characteristics of green infrastructure and decarbonization make it imperative for SOEs to actively participate in the transition process while nudging the right incentives for private sector participation. SOEs have been a critical driver of economic development across several economies, including India. SOEs serve broader developmental objectives and play an essential role in infrastructure sectors such as energy, transportation, and telecommunication where the potential market

Figure 79: Investment in Transport Infrastructure



PPP = public-private partnership.

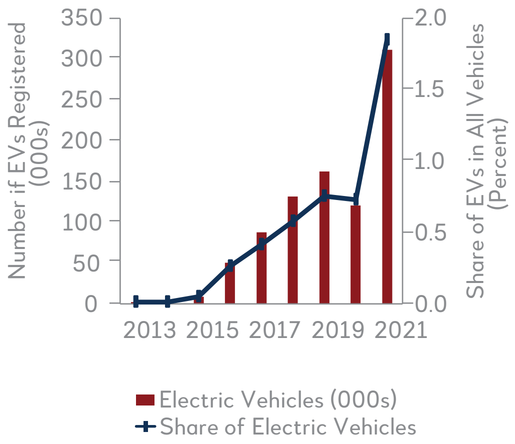
Data source: World Bank PPI Database, IJGlobal Database and AIIB staff estimates.

Box E: Opportunities and Challenges for Electric Vehicles

India has a fast-growing middle-income group. This is both a threat and an opportunity. The transport sector accounts for around 10 percent of India's emissions. Without sufficient decarbonization, there is a risk of many more emissions, in line with the growing affluence. The opportunity here is for an early push toward electric vehicles (EVs), thus setting the industry to sustainably grow. Increased use of EVs, together with renewable electricity generation, can substantially reduce greenhouse gas emissions.

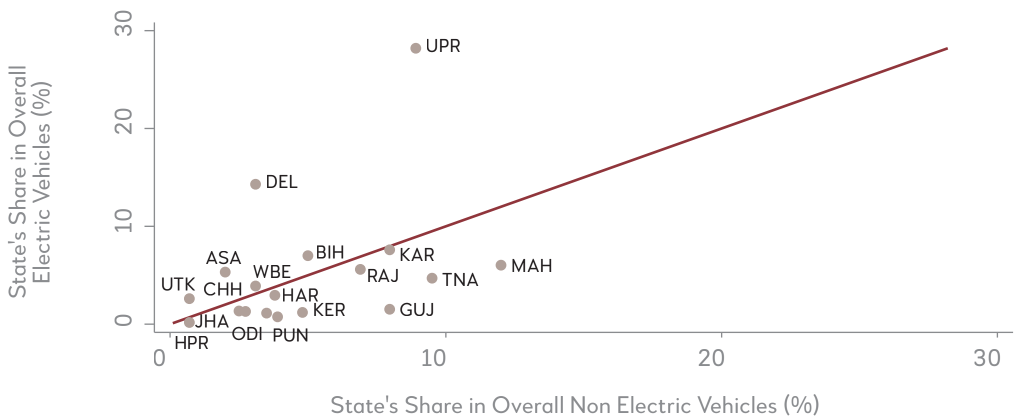
NITI Aayog (2019) outlines an ambitious target of electrifying 70 percent of all commercial cars, 30 percent of private cars, 40 percent of buses and 80 percent of two-wheeler and three-wheeler vehicles in India by 2030 with supportive policies. This is a daunting target, given current trends. Since 2013, nearly 1.1 million EVs have been registered in India. Although EV registrations have increased over the last decade, they still account for a meager 0.5 percent of total vehicles registered during this period (Figure E.1). More than 95 percent of the EVs are registered to belong to the two-wheeler and three-segments segments.

Figure E.1: Trends in Electric Vehicles Registrations



Data source: Vahan Database and AIIB staff estimates.

Figure E.2: Comparison of States in Electric and Non-Electric Vehicles



ASA = Assam, BIH = Bihar, CHH = Chhattisgarh, DEL = Delhi, GUJ = Gujarat, HAR = Haryana, HPR = Himachal Pradesh, JHA = Jharkhand, KAR = Karnataka, KER = Kerala, MAH= Maharashtra, ODI = Odisha, PUN = Punjab, RAJ = Rajasthan, TNA = Tamil Nadu, UPR = Uttar Pradesh, UTK = Uttarakhand, WBE = West Bengal.

Data source: Vahan Database and AIIB staff estimates.

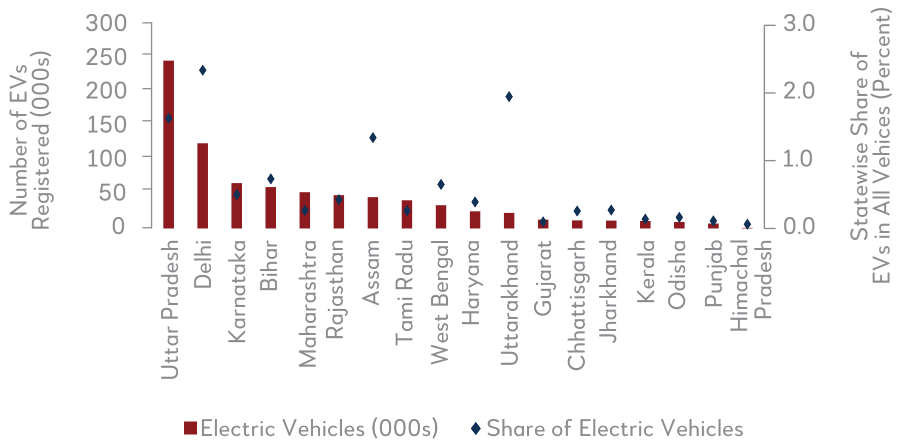
The uptake of EVs is concentrated across a few states. Uttar Pradesh, Delhi, Karnataka, Bihar, and Maharashtra accounted for 64 percent of EVs registered between 2013 and 2021 (Figure E.2). This is significantly higher than the share of these states in non-EV registrations. Supportive policies have led to EV uptake in Uttar Pradesh being three times higher than the national average, accounting for more than a quarter of the EV registration in India (Figure E.3). These include fiscal incentives, assistance for developing the charging infrastructure, and investment-related incentives.

Delhi has adopted a holistic policy framework to incentivize EVs to improve air quality. The measures encompass purchase incentives, scrapping incentives on the deregistration of old vehicles, road tax and license fee waivers, and reducing bureaucratic red tape. The government has adopted the concept of 'feebate' by imposing a surcharge on polluting vehicles to fund the purchase incentives.

continued on next page

Box E: *continued*

Figure E.3: Adoption of Electric Vehicles across Selected Indian States



Notes: Vehices (Percent) Vahan Database and AIIB staff estimates.

Data sources: Besley et al. (2021)

Currently, several factors impinge on the mass adoption of EVs in India. A significant barrier is the price of EVs, which remains 1.2 to 3 times higher than internal combustion engine (ICE) vehicles. Weak charging infrastructure (contributing to range anxiety) remains a major barrier. In some instances, EVs' safety standards have also affected the sentiment. Other constraining factors include financial barriers, operating costs, societal influence, and environmental awareness (Michael et al. (2022)).

The government has introduced an array of schemes to incentivize the adoption of EVs. The first phase of the Faster Adoption and Manufacturing of (Hybrid and) Electric Vehicles (FAME-I) scheme was introduced in 2015 and continued for four years with a two-year extension. It focused on demand creation by reducing the cost of purchasing vehicles. In addition, specific pilot projects in the areas of research and development and technology development and public charging infrastructure were sanctioned.

The project's second phase, FAME-II, will run from 2019 to 2024, with an allocation of INR100 billion and primarily focusing on increasing the demand incentives (86 percent of outlay) and strengthening the charging infrastructure (10 percent of outlay). To bolster the supply of EVs, the government introduced a production-linked incentive scheme in 2021, with an outlay of around INR260 billion. It proposes financial incentives of up to 18 percent over the next five years to boost domestic manufacturing of electric and hydrogen fuel cell vehicles and their components.

However, utilization of these schemes has remained muted. FAME-I utilized only 41 percent of the sanctioned INR8.95 billion while only 19 percent of funds allocated for FAME-II were disbursed till June 2022. Critical policy gaps inhibiting the faster adoption of EVs include (a) lack of incentive to switch from ICE vehicles to EVs like scrappage incentive, retro-fitment allowance for converting ICE vehicles to EVs and penalties on continued use of ICE vehicles; (b) lack of subsidy for private four-wheelers, which is a fast-growing segment; (c) stringent requirements on original equipment manufacturers related to recertification and indigenous components; and (d) lack of clarity on the choice between EVs and ICE vehicles with better emission standards.

Transitioning toward EVs would require significant scaling of the existing ecosystem given the different propulsion systems used in these vehicles, including an electric motor, a power controller, and a rechargeable battery. PPPs can play an essential role in strengthening EV infrastructure in certain areas. One such area is the charging infrastructure, where the state power distribution companies and private players can set up charging and battery swapping stations. The public sector can also guarantee to offset any shortfall in revenue for a predefined period to incentivize private players. Another area where PPP can play a valuable role relates to the procurement of electric buses with models differing based on ridership and operator capacity.

failure can occur due to high fixed costs, risky and long-term investment and underinvestment in externalities (Melecky, 2021).

SOEs have a strong presence in India. The share of SOE's income in GDP started rising in 2010, reaching a peak of 7.2 percent in 2015, before declining in recent years (Figure 80).[63] Non-infrastructure SOEs dominate, accounting for 61 percent of income and 71 percent of the companies.[64] Non-infrastructure SOEs are diverse, spreading across mining, manufacturing, and services sectors, such as oil and natural gas, coal, textiles, chemicals, electronics, and hotels.

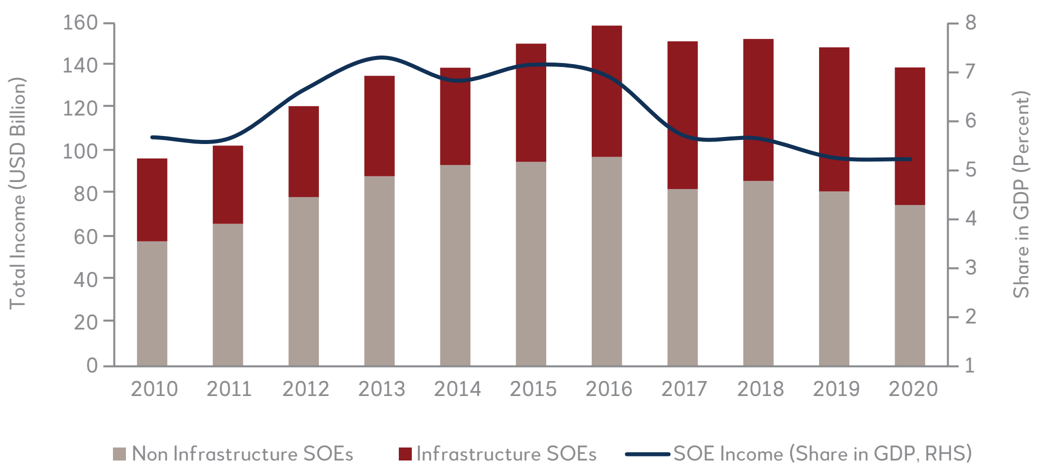
Capital expenditure by SOEs accounts for 6.5 percent of overall fixed capital formation. More than 40 percent of the SOE investment in the infrastructure sector, between 2010 and 2021, took place in the conventional energy sector, followed by the transport sector, which accounted for one-third of the investment (Figure 81). The transport sector has witnessed an uptick in investment by SOEs since 2018. Over the last decade, investment in renewable projects by SOEs has picked up; however, it accounted for only 3.5 percent of the total investment and 6.5 percent of the overall projects since 2017.

8.2.2 Weak Financial Health of SOEs Constraining Ability to Foster Decarbonization

The SOEs' participation in the greening process would depend on the firm's financial soundness and ability to lead from the front. The financial performance of the Indian SOEs is quite varied. Cumulatively, SOEs owned by the subnational governments faced a loss equivalent to 0.5 percent of GDP in 2017. On the other hand, federal government SOEs, also known as Central Public Sector Enterprises (CPSEs), remain profit-making at the aggregate level (Melecky, 2021).

Although nearly 30 percent of the CPSEs are loss-making, the losses are heavily concentrated, with the top 10 loss-making SOEs accounting for 87 percent of the losses. The loss-making SOEs are primarily in fossil fuel-intensive sectors such as aviation, petrochemicals, and petroleum. The financial performance of CPSEs has worsened in recent years with a decline in profits as a share of GDP (Figure 82). The weakening of SOE finances adds to the fiscal pressure as the government must step in to provide financial support. It also constrains them from undertaking investments that would help them

Figure 80: Income of SOEs



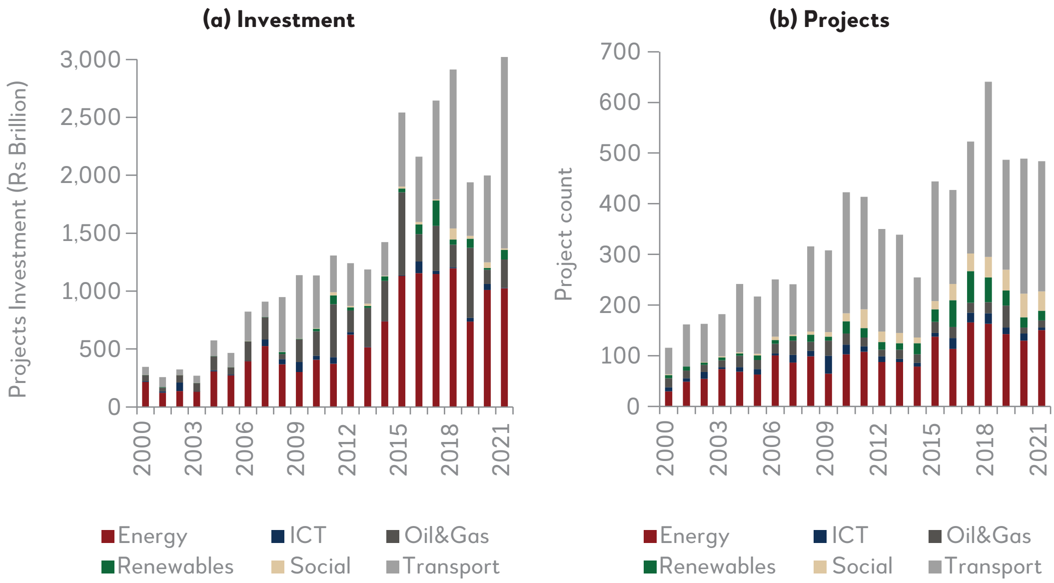
GDP = gross domestic product, SOE = state-owned enterprise.

Data source: CMIE Prowess Database and AIIB staff estimates.

63 Prowess database covers financial performance of companies from annual reports of companies, stock exchanges and regulators. Hence, it excludes some of the central and state SOEs that are not covered by these and may be an underestimate. According to GOI (2022), value added by public financial and nonfinancial corporations or SOEs accounts for 8.2 percent to 8.6 percent of India's gross value added in 2018-2019 and 2020-2021.

64 Staff calculations based on firm-level data from Prowess dx database.

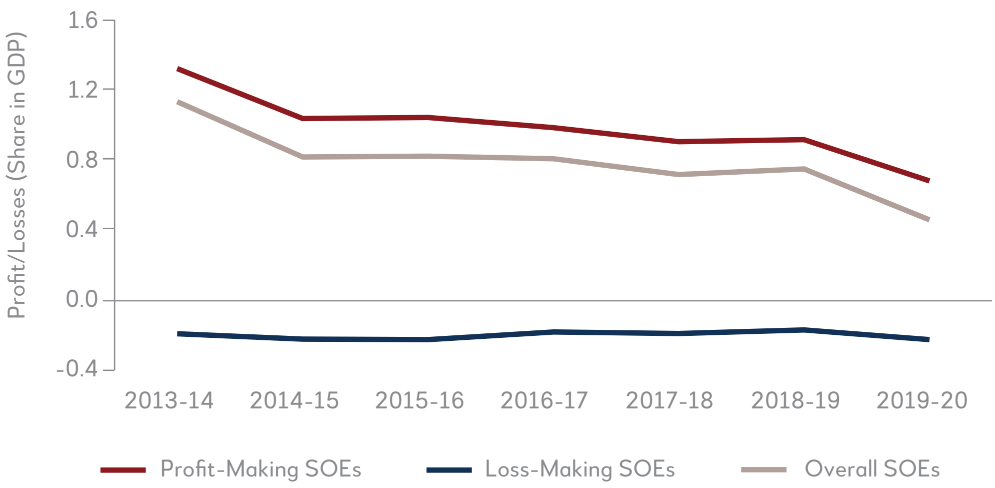
Figure 81: Infrastructure Capital Expenditure by SOEs



ICT = information and communication technology, SOE = state-owned enterprise.

Data source: CMIE Prowess Database and AIIB staff estimates.

Figure 82: Profits and Losses in Central SOEs



GDP = gross domestic product, SOE = state-owned enterprise.

Note: Data pertains to fiscal years which start from April 1 and end on March 31 of subsequent year.

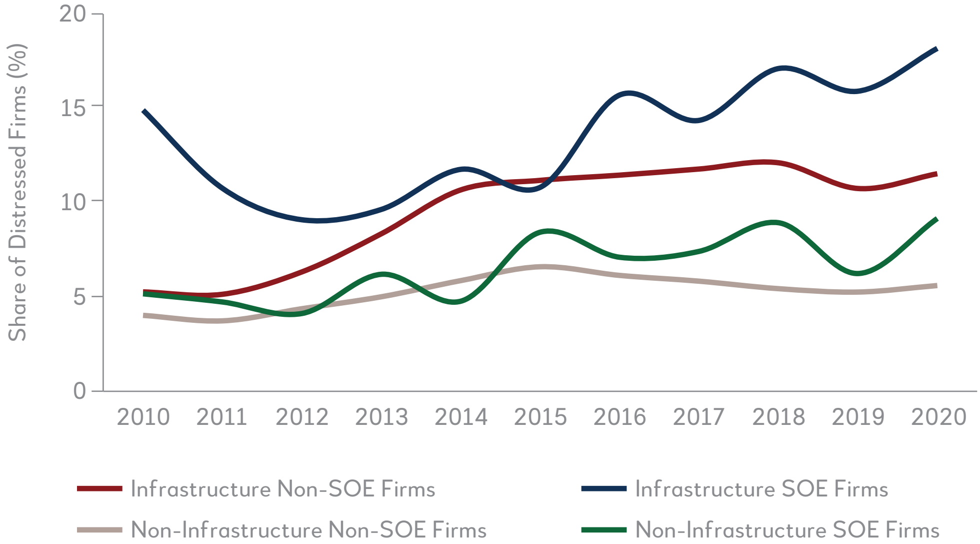
Data source: Public Enterprise Survey, Department of Public Enterprises Ministry of Finance Government of India and AIIB Staff estimates.

reduce their carbon footprints. This is especially the case in the petrochemical and petroleum sectors, which are inflexible in terms of technology and energy requirements and would require major rehaul to move forward on the decarbonization process.

The interest coverage ratio, an essential indicator of the extent of distress, shows that, on average, a higher proportion of infrastructure firms tend to be distressed compared to non-infrastructure firms among SOEs and non-SOEs (Figure 83).[65]

[65] Interest coverage ratio refers to the ratio of earnings before interest and taxes to interest payment.

Figure 83: Share of Distressed Firms



SOE = state-owned enterprise.

Note: Firms are considered distressed if their interest coverage ratio is less than one in that year.

Data source: CMIE Prowess Database and AIIB Staff estimates.

8.2.3 Investment in Pollution Abatement and Fossil Fuel Intensity

Reduction in industrial emissions would depend on how different industries invest in pollution control equipment and reduce their fossil-fuel usage, and within industries, how the SOEs are placed vis-a-vis the non-SOEs (Appendix 4).[66]

Table 4: Investment in Pollution Control Equipment

	SOE	NON-SOE
No	587 (86%)	48919 (94%)
Yes	94 (14%)	3283 (6%)
Total	681 (100%)	52202 (100%)

SOE = state-owned enterprise.

Notes: Figures in parentheses denote the shares.

Data source: Annual Survey of Industries (ASI, 2018-19) and AIIB staff estimates.

SOEs tend to perform better on pollution control, with 14 percent of the firms investing in pollution control equipment, while only 6 percent of non-SOEs invest in such equipment (Table 4). In terms of net assets, larger firms invest more in pollution control—a similar trend for both the SOEs and non-SOEs. Thus, investment in pollution control is not popular among smaller firms.

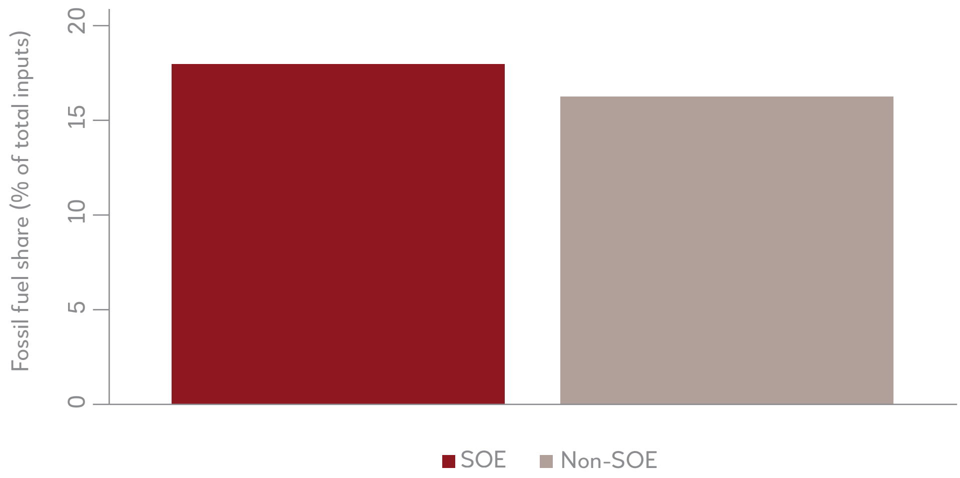
Fossil fuel intensity is measured as the total value of the fuel consumed for electricity as a share of the total input cost. Since around 60 percent of electricity in India is generated using coal, this share is used to adjust the contribution of electricity toward fossil fuels.[67] On average, fossil fuel intensity is more significant for SOEs than non-SOEs but marginally so (Figure 84). Further investigation also reveals that larger firms tend to perform better in terms of economizing the use of fossil fuels in the production process, and this trend is similar across both SOEs and non-SOEs (Figure 85).

Interestingly, and probably on expected lines, firms' investment in pollution-control equipment positively correlates with their fossil fuel intensity. This means fossil fuel-intensive sectors are investing more in such equipment, albeit the share of such firms is low.

[66] Pollution control equipment include machinery installed for pollution control and environment improvement like packed towers, carbon absorbers, fabric filters, catalytic reactors, etc.

[67] See Ghosh et al. (2022) for this approach.

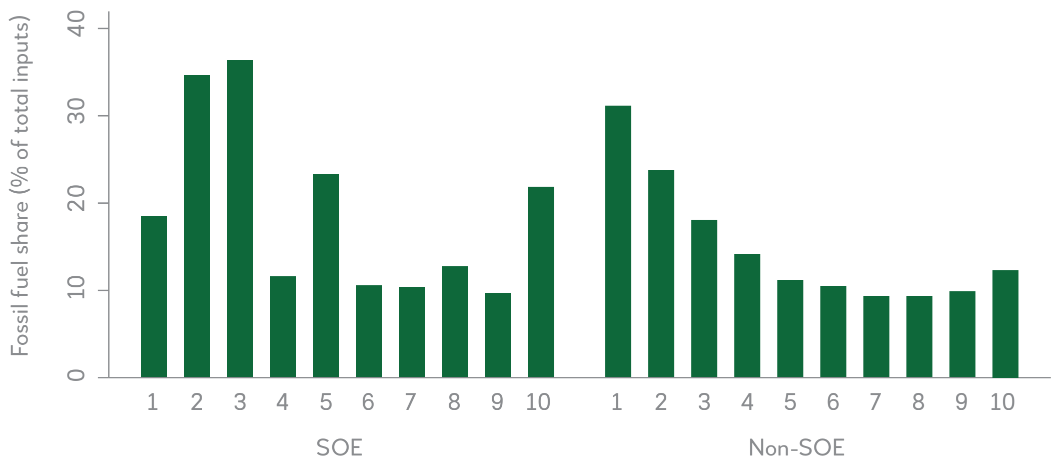
Figure 84: Fossil Fuel Intensity (SOE vs. Non-SOE), by Ownership



SOE = state-owned enterprise.

Data source: Annual Survey of Industries (ASI, 2018-2019) and AIIB staff estimates.

Figure 85: Fossil Fuel Intensity (SOE vs. Non-SOE), by Size Distribution



SOE = state-owned enterprise.

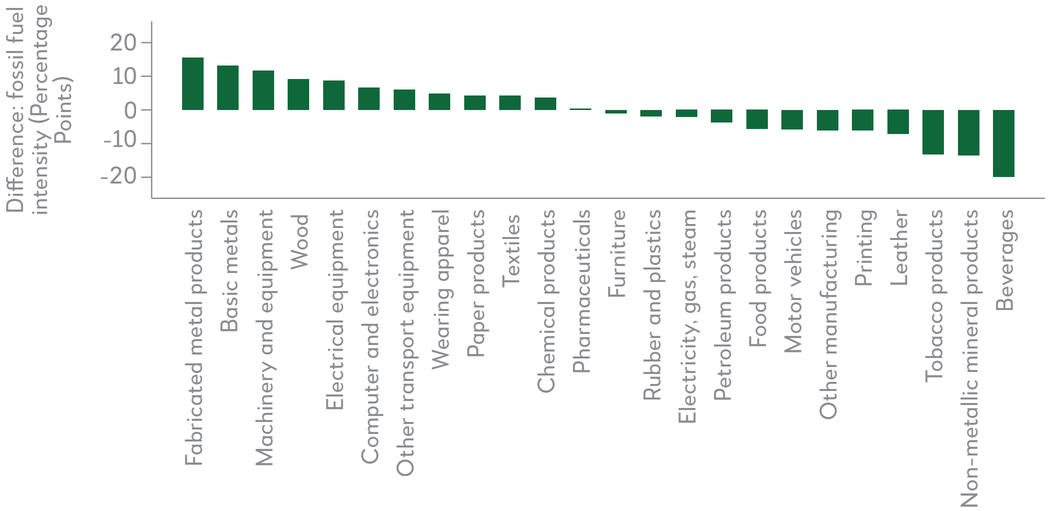
Note: The numbers on the X-axis denote the quantiles based on Net Assets. Firms in the higher (lower) quantiles are larger (smaller) in size in terms of Net Assets.

Data source: Annual Survey of Industries (ASI, 2018-2019) and AIIB staff estimates.

Although fossil fuel intensity is similar across SOEs and non-SOEs, interesting variations exist within sectors and across ownership. This highlights the differences in fossil fuel intensity for firms in the same sector that use similar production processes but differ in ownership and governance structure. Figure 86 evaluates the difference in fossil fuel intensity between SOEs and non-SOEs. A positive difference indicates that SOEs in a particular sector have higher fossil-fuel intensity compared to non-SOEs in the same sector. A negative difference indicates a lower fossil fuel intensity for SOEs compared to non-SOEs.

In sectors like metal products, machinery and equipment, and electrical equipment, non-SOEs perform better than SOEs. In contrast, in sectors like motor vehicles, leather, non-metallic mineral products, and food products, SOEs perform better than non-SOEs. This variation in fossil fuel intensity across ownership and within the same sectors highlights the opportunities for SOEs and

Figure 86: Fossil Fuel Intensity: Heterogeneity across Sectors and Ownership



SOE = state-owned enterprise.

Note: The y-axis denotes the difference in fossil fuel intensity between SOE and non-SOE firms. A positive (negative) difference means that SOE firms in that sector have a higher (lower) fossil fuel intensity than non-SOE firms.

Data source: Annual Survey of Industries (ASI, 2018-2019) and AIIB staff estimates.

non-SOEs to learn from each other and adopt the best practices for decarbonization in their production process.

8.2.4 The Transition Must be Inclusive

Given the magnitude of the investments required for the net-zero transition, an inclusive approach is necessary since smaller firms operating at low levels of productivity and with credit and liquidity constraints may find it challenging to adopt greener technologies at a pace matching the larger firms.

Larger non-SOEs are less fossil-fuel intensive after controlling for industry characteristics (Figure 87). Thus, incentives to move toward cleaner fuel alternatives must be directed toward smaller firms regardless of the sectors. For SOEs, there is no systematic correlation between firm size and fossil fuel intensity. Thus, more focus must be directed toward identifying the lagging sectors for SOEs.

As per the World Bank, micro, small, and medium-sized enterprises (MSMEs) worldwide represent 90 percent of business and employ about 50 percent of the workforce.[68] In India, these enterprises are structurally important and contribute about 30 percent to the GDP while employing around a third of the workforce.[69] Since these MSMEs operate on low capacity and scale, the transition toward net zero may require added finance and incentives for upgradation to reduce fossil fuel intensity.

The financial institutions would have to play a significant role in channeling finances toward MSMEs dedicated to their transition toward net zero. In August 2021, the Small Industries Development Bank of India announced the Swavalamban Challenge Fund, providing loans to MSMEs and new startups.

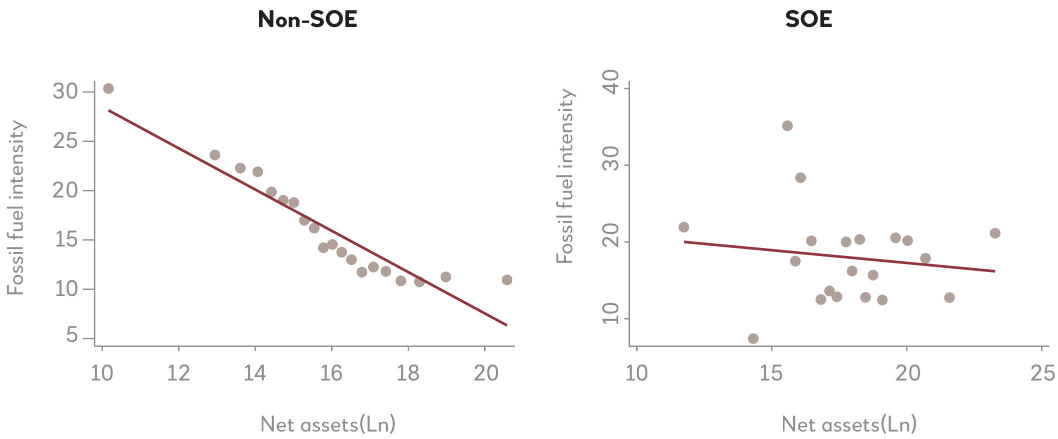
MSMEs can be supported across an array of nonfinancial areas, given the weak capacity of the sector. These could include access to trusted advisory services for technology transfer, conducting energy audits, providing required skilling and reskilling, and offering common hard infrastructure like lab-testing centers.

MSMEs are located at different stages of the supply chain. Thus, larger firms that source raw materials from these countries have a big role in channeling back their resources and ESG frameworks to

[68] See https://www.worldbank.org/en/topic/smefinance.

[69] See https://www.pib.gov.in/PressReleasePage.aspx?PRID=1744032; and https://www.cii.in/Sectors.aspx?enc=prvePUj2bdMtgTmvPwvisYH+5EnGjyGXO9hLECvTuNuXK6QP3tp4gPGuPr/xpT2f.

Figure 87: Relationship between Firm Size and Fossil Fuel Intensity



SOE = state-owned enterprise.

Note: Variables on the x-axis and y-axis are residualized by controlling for industry (2-digit) fixed effects that essentially control for any industry characteristics that remain constant across firms operating in the same industry.

Data source: Annual Survey of Industries (ASI, 2018-2019) and AIIB staff estimates.

downstream industries using incentives and financing schemes. Lastly, the industrial policies related to climate change must take note of the specific problems that the MSMEs may face to lay the ground for a smooth transition process.

8.3 Financing for Green Transition Remains at a Nascent Stage

8.3.1 Banks Remain Major Source while Foreign Direct Investments (FDIs) Gathered Pace

As discussed above, the financing needs for the transition to net zero are immense and will require several trillions of dollars over the next 50 years. This would entail identifying new sources of finance, including bank lending, bonds, and FDI.

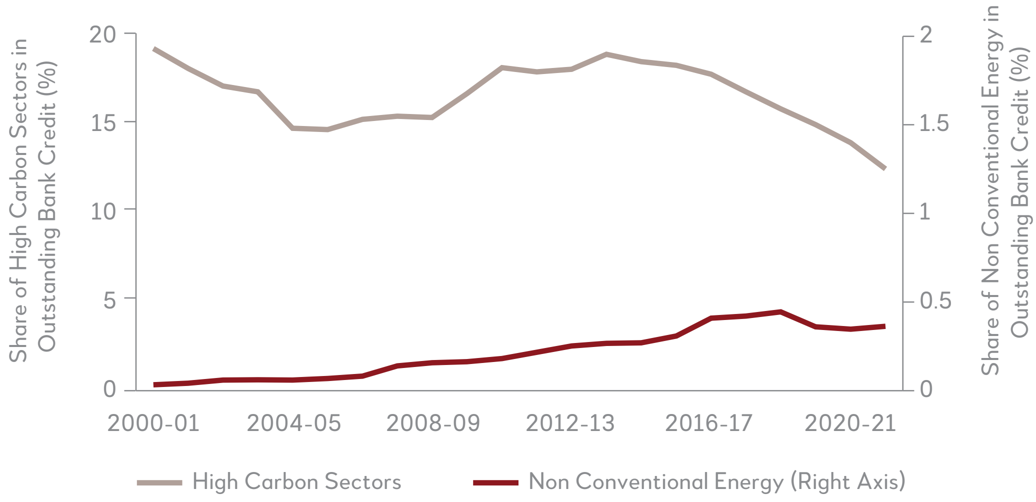
The banking sector has been the traditional source of finance for infrastructure projects. It has also financed some of the largest thermal energy projects. Cumulatively, Indian banks have provided USD156 billion between 2012 and 2019 in financing coal plants and ranked fourth globally (Oil Change International, 2021). Although, over the last decade, there has been some shift in banking lending to nonconventional energy, which primarily includes renewable energy, the banking sector remains heavily exposed to carbon-intensive sectors.[70] Despite a decline in the share of high carbon-intensive sectors since 2013, they continue to account for around 13 percent of the overall outstanding credit of the banking sector (Figure 88).[71] With innovations improving the economics of the renewable sector, many high-carbon investments run the risk of becoming stranded. On the other hand, despite growing at a healthy rate, credit to nonconventional energy accounts for less than 0.5 percent of outstanding credit.

Although state-owned banks remain the biggest lender to the renewable sector, private Indian banks have significantly increased their lending to the sector. They accounted for nearly 42 percent of the credit to this sector in fiscal year 2020-2021, compared to only 12.5 percent a decade back. To promote green lending, the Reserve Bank of India included the small renewable energy sector under its Priority Sector Lending (PSL) in 2015 and increased the limits in 2020. However, the uptake has been muted under this, with outstanding renewable sector credit being only a small fraction of overall PSL.

[70] Nonconventional energy sources include geothermal, wind, solar, tidal, biomass and small hydroelectric.

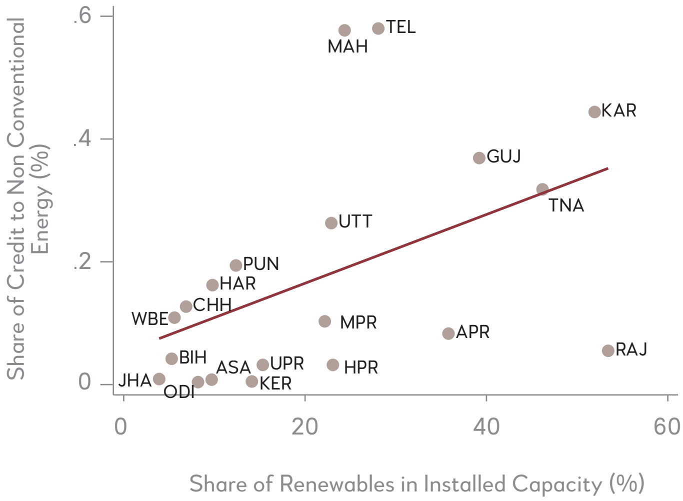
[71] High carbon-intensive sectors are defined according to the emission intensity and includes electricity production, petroleum, coal and nuclear fuels, iron and steel, non-ferrous metals, vehicles and transport equipment and cement. All these sectors have higher emission intensity than India's average emission intensity.

Figure 88: Credit to High Carbon and Nonconventional Energy Sector



Data source: CEIC and AIIB staff estimates.

Figure 89: Credit and Renewable Capacity across Selected Indian States



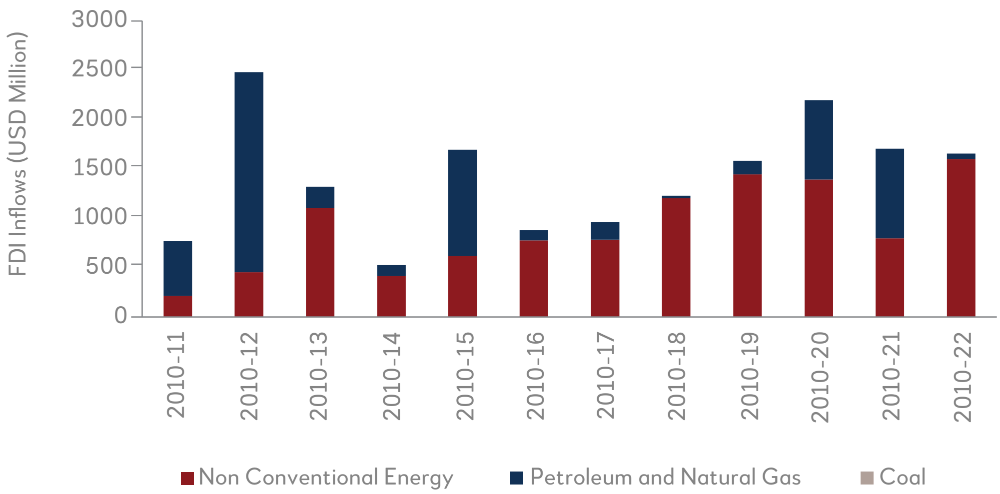
ASA = Assam, BIH = Bihar, CHH = Chhattisgarh, DEL = Delhi, GUJ = Gujarat, HAR = Haryana, HPR = Himachal Pradesh, JHA = Jharkhand, KAR = Karnataka, KER = Kerala, MAH= Maharashtra, ODI = Odisha, PUN = Punjab, RAJ = Rajasthan, TNA = Tamil Nadu, UPR = Uttar Pradesh, UTK = Uttarakhand, WBE = West Bengal.

Data source: CEIC and AIIB staff estimate.

Credit to the renewables sector across different Indian states strongly correlates with the share of the renewable sector in installed capacity (Figure 89). The relationship is likely to be bidirectional and mutually reinforcing. While easy access to credit will likely incentivize firms to invest in the renewable sector, higher demand for renewable investment due to other state-specific factors like policies, tariffs, and the health of power distribution companies would increase the need for bank credit.

FDI inflows into the nonconventional energy sector have also steadily increased since 2013-2014, barring a dip in fiscal year 2020-2021, owing to the pandemic (Figure 90). Liberal investment policies, including allowing 100 percent FDI in the renewable sector, improved economics of renewable energy, strong government support, and rising energy demand have made India an attractive destination for foreign investors.

Figure 90: Foreign Direct Investment Inflows in Key Energy Sectors in India



FDI = foreign direct investment.

Note: Data pertains to fiscal years which start from April 1 and end on March 31 of subsequent year.

Data source: Department for Promotion of Industry and Internal Trade, Ministry of Commerce and Industry, Government of India.

8.3.2 Green Bonds Emerging as an Important Financing Instrument

Green bonds are emerging as an important instrument in India to mobilize capital for climate action. Overall green bond issuance has reached USD8.9 billion since 2015 across 73 deals (Figure 91). Of these, nearly USD7.0 billion was issued in 2021 across 24 deals. An overwhelming majority of the issuance of the green bond (close to 90 percent) is related to the energy sector, with another 8 percent related to the transport sector. Nonfinancial corporates undertook the majority of the issuance, followed by SOEs.

Currently, among emerging markets, India ranks behind only China, in terms of green bond issuance. However, the gap remains significant, with China having issued nearly USD200 billion in green bonds since 2015. Moreover, the market for green bonds remains small in India, with green bonds accounting for only 0.7 percent of all the bonds issued since 2018 (Ghosh et al., 2021).

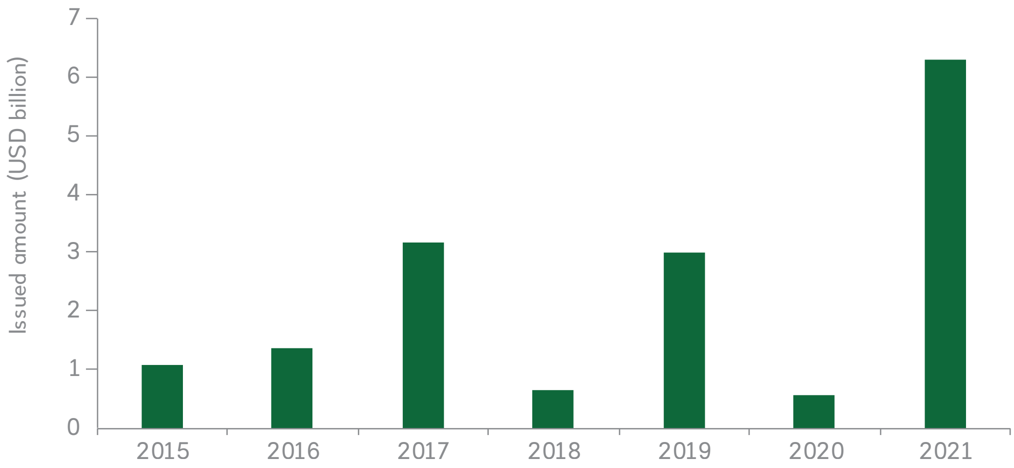
Supportive public policy has helped expand green bond issuance. For example, in June 2019, the India International Exchange launched a trading platform dedicated to green bonds in foreign currencies. Recently, in the Union Budget for 2022-2023, the government announced the issuance of sovereign green bonds dedicated to financing green infrastructure projects. As such, green bonds can be issued by any sovereign entity or corporates to deploy the proceeds toward environmentally sustainable projects. Entities in India started issuing green bonds in 2015.

High borrowing costs, driven by asymmetric information, higher risk perception, and other governance issues, remain crucial to fostering green bonds (Ghosh et al., 2021). However, recent deals have narrowed the difference. Comparing the yields of green and non-green bonds shows that non-green bonds are not necessarily cheaper from the issuer's perspective (Figure 92), as the pricing of bonds seems to be primarily driven by the issuer's financial health and credit ratings. This is also validated by recent findings [see Larcker & Watts (2020), Wu (2022)], although evidence from emerging markets is scarce. From a policy perspective, this insinuates that additional efforts to boost both issuer and investor confidence may be necessary to transform green bonds into an attractive financial instrument.

8.4 Conclusion

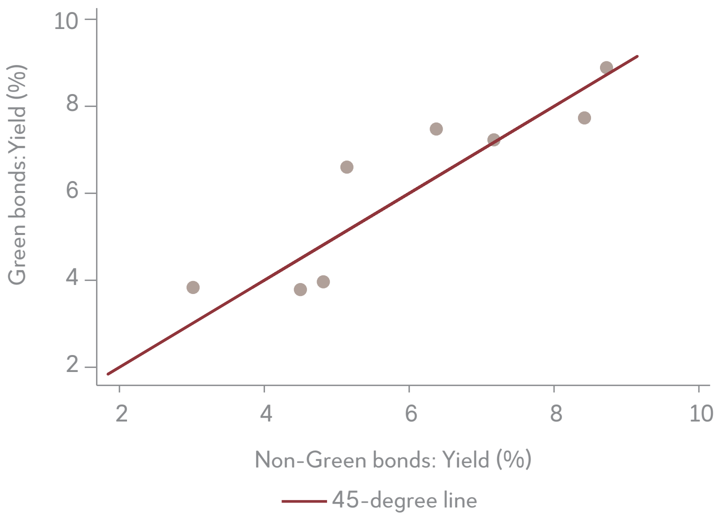
India will require several trillion dollars to achieve the formidable climate targets it has set for itself. Access to innovations and new technologies is also critical to develop viable renewable energy alternatives. Additional challenges involve managing an equitable

Figure 91: Green Bonds Issuance in India (2015-2021)



Data source: Refinitiv and AIIB staff estimates.

Figure 92: Comparison of Yields between Green and Non-green Bonds



Note: Each dot indicates the same company's yield of a green and non-green bond.

Data source: Refinitiv and AIIB staff estimates.

job transition and access to finance. India can move forward on these challenges by ensuring that key stakeholders ramp up their contribution toward this end.

The private sector has been spearheading power generation through renewable sources. However, more attention is required to clear the bottlenecks related to energy storage and charging infrastructure to enable renewable energy and EVs as viable options. SOEs, in line with their developmental objectives, will have to significantly augment their participation toward net zero. Engaging with the private sector toward adopting the best practices to reduce fossil fuel intensity is imperative for an effective participation in the transition process.

Finally, the financial system will be the backbone of this transition process. Availability of finance through new instruments and facilitating investor confidence will be vital to create a conducive investment climate for green financing.

CHAPTER 9
INDONESIA'S STATE AND PRIVATE SECTOR: UNDERPINNINGS FOR NET ZERO

Indonesia has achieved remarkable economic growth since the Asian Financial Crisis (AFC), becoming an upper-middle-income economy with a pre-pandemic reduction of poverty to 10 percent in 2020. The achievements come from effectively managing the interplay between the state and the private sectors and balancing the efficiency versus equity trade-off [see Kim & Summer (2021), ADB (2020), Nugroho (2020)].

With 1.7 billion tons a year, the country accounted for 3.5 percent of global CO_2 emissions in 2018. Its energy mix still relies heavily on coal-fired power technology, resulting in one of Asia's highest grid emission factors. As the largest archipelago, it is also among the most vulnerable countries to climate change with over 70 percent of the 250 million population living in coastal and flood-prone areas, and vulnerabilities exacerbated by significant infrastructure gaps. To transit into a more sustainable development model, Indonesia has launched a series of initiatives aiming to leverage SOEs, promote private sector participation, nurture market forces in the energy sector, and stimulate green innovation [see Hendriwardani et al. (2022), Oxford University (2020), ADB (2017a), ADB (2017b), Widjaja (2017), Ray & Ing (2016)].

This chapter selectively reviews Indonesia's experiences in managing growth and embarking on the net-zero transition. The chapter shows that SOEs remain prominent in infrastructure development. Recent reform to consolidate SOEs into sectoral holding companies have generated diverse impacts across firms and sectors. In construction, reformed SOEs significantly increased scales, but the performance of private firms deteriorated. In mining, the private firms improved, whereas the impact on SOEs was limited.

The chapter also discusses PPPs in Indonesia. The PPP framework reforms seemed to have prompted PPP growth but only in the short term. The energy sector still dominates PPPs, with most energy projects remaining fossil fuel-based while renewables continue to lag. Across provinces, the distribution of energy PPPs correlates more with local fiscal constraints than with the demand for private sector innovation to deliver the last mile connectivity.

Market-oriented instruments in the energy sector have become an important part of Indonesia's policy mix to meet efficiency, equity, and climate commitments. The chapter illustrates that power sector reforms have effectively reduced market barriers but not so much in stimulating renewable investment. Installed independent power producer (IPP) capacity has grown in tandem with reforms, especially since 2015. However, the importance of renewables in the total power mix has not been increasing except in off-grid power generation capacity.

Finally, this chapter finds that Indonesia may be falling behind global green innovation, measured by patent filing. Existing innovation in the country is driven more by foreign companies than domestic firms. Nevertheless, sectoral innovation data points to the importance of carbon capture, conservation, hydropower, recycling, and EVs, highlighting the potential of these sectors. The concentration of innovation in these areas is due to the confluence of market-pulling effects and government instruments. Recent EV innovation and the development EV supply chain look promising.

9.1 The Entrepreneurial State Dominant in Infrastructure

9.1.1 SOEs are a Prominent Part of Indonesia's Infrastructure Sector

Indonesia has used SOEs to develop infrastructure and promote strategic industries since its independence, which has its legal basis in the 1945 Constitution.[72] In infrastructure, SOEs accounted for about a third of total investment in 2020 (ADB, 2020). At the same time, the governance of SOEs has gone through several waves of reforms since the Asian Financial Crisis.[73] In 1997-2003, Indonesia experienced a "big bang" in privatization followed by partial privatization and shifting away from day-to-day management by the state. Between 2003-2012, right-sizing was the primary reform tool followed by piloting of state-owned holding companies (SOHCs) in 2012, which aims to consolidate SOEs into large conglomerates at the sector level. In 2014, a shift to modernizing SOEs, consolidating into SOHCs, and creation of "World Class Companies" came into effect while privatization effectively stopped. A dramatic scale up in state capital injections and asset revaluations also took place in 2015-2016.

Despite reforms and more private sector participation, SOEs remain dominant in infrastructure. Combining newly reported statistics on sectoral SOHCs by the MSOE and information on publicly listed firms sheds light on the importance of SOEs (Figure 93). The SOHCs account for nearly all assets in energy, oil and gas. In construction and in transport, the SOHCs stand slightly under 80 percent of assets.[74] In mineral and coal, 60-70 percent of assets belong to the SOHCs.

The SOHCs and SOEs exert control through extensive shareholding structures. For example, in transport or logistics, 12 major SOEs are under the direct purview of the SOHC. In energy, oil, and gas, three major SOEs constitute the SOHCs, with over 200 subsidiaries spanning up to six ownership levels. PT Perusahaan Listrik Negara (PLN), the power sector monopoly, reports 50 subsidiaries alone, nearly half of them controlled by PLN. Many of its subsidiaries participate in a range of activities, such as construction, manufacturing, and telecommunications.

9.1.2 SOE Consolidation into SOHCs Generated Mixed Effects

Resource allocation has improved in Indonesia even though SOE reforms are more modest than those undertaken by other countries. Most notably, partial privatization led to a significant performance boost in these companies. On average, the profitability of these SOEs improved over a longer horizon (after some initial short-term declines). Labor productivity and turnover increased in the short and long term. At the same time, the mode of privatization matters with more mixed results associated with privatization through the capital market [Astami et al. (2010), Bartel & Harrison (2005), Nahadi & Suzuki (2012), Rakhman (2018), Soejono & Heriyanto (2018), Sukmadilaga et al., (2014)].

Holding company reform is more recent; hence, empirical evidence of impact is limited. For example, in mining, the SOHC was established in 2017 with PT Inalum taking the group's helm. In construction, PT Semen Indonesia Investment Holding was first created in 2012 and formally recognized as the SOHC around 2017 or 2018, consisting of nine major construction SOEs. To date, there are 13 SOHCs in Indonesia. In principle, holding

[72] SOE defined as fully or partially owned (by central or local authorities) enterprise involved in commercial sector activities in pursuit of profits and/or national development objectives. See Chapter XIV Article 33 of the Indonesian Constitution (1945), SOE Law of 2003, and documentation from Ministry of SOEs for evolution of SOE definition in Indonesia.

[73] See Brazer & Daryanto (2019), Hermansjah et al. (2021), Khajar et al. (2019), Kim K. (2019).

[74] To be consistent with the nomenclature used in this chapter, infrastructure SOHC is referred to as construction SOHC.

Figure 93: Importance of SOHCs in Infrastructure (Share in Total Assets)

SOHC = state-owned holding company.

Data source: Government of Indonesia, Ministry of State-Owned Enterprises, ORBIS, and AIIB staff estimates.

company reform has been supported on the merits of synergies, and the ability to acquire greater debt. However, consolidation into SOHCs has also raised concerns over market concentration and efficiency loss together with practical challenges in coordination.

Firm performance before and after the SOHC consolidation in two sectors was compared as part of the background research undertaken for this report to shed light on the impact of holding company refrom. The two selected sectors are construction and mining, which formally formed SOHCs over the period. A difference-in-differences (DiD) approach is applied.[75]

In the construction sector, reformed SOEs significantly increased their scales of operation and enjoyed some efficiency gains following the consolidation (Table 5). Relative to private construction firms, these SOEs accumulated more assets, increased employment, and reported greater revenues after SOHC consolidation. Notably, their profitability, as measured by return to asset and labor productivity, was significantly higher than those of the private firms. Meanwhile, compared with SOEs in other unrestructured sectors (including ICT and accommodation), these reformed SOEs became less profitable and less productive despite enjoying larger scales of operation in assets, employment, and revenues. Private firms' performance deteriorated compared to private firms in other sectors, including lower revenues and decreased labor productivity.

In mining, SOHC consolidation did not significantly improve SOEs' performance, but there were no adverse effects either (Table 5, Panel b). It is the case when comparing private mining firms with peer SOEs in other sectors. Interestingly, the performance of private players in mining responded more positively to the reform. Compared with private players in other sectors, private mining companies increased employment and raised revenues after consolidation, and their profitability and labor productivity improved.

These results suggest the heterogeneous impact of holding company reform. As the case of the construction sector suggests, the consolidation can indeed tilt the market in favor of SOEs, leading to a concentration of resources and thus, market power. Such consolidation may not always result in efficiency improvement as envisaged, illustrated by the lower productivity of reformed SOEs compared to peer SOEs in other sectors. On the other hand, the results of the mining sector restructuring suggest that it may take time for the consolidation to impact SOEs due to coordination challenges. Meanwhile,

[75] See Appendix 4 for more details.

Table 5: Impact of Holding Company Reform in Construction and Mining Firms

Dependent Variable	Assets	Employment	Revenues	Current Ratio	ROA	Productivity
Panel A: Construction Sector						
Reformed SOEs vs. Private firms in the restructured sector	0.541***	0.530***	0.865***	-2.700***	3.038*	0.282*
Observations	293	289	293	293	293	289
Reformed SOEs vs. SOEs in the un-restructured sectors	0.752***	0.675***	0.341***	-1.572	-3.529***	-0.359***
Observations	121	119	121	121	121	119
Private firms in the restructured sector vs. Private firms in the un-restructured sectors	0.100	0.058	-0.441***	2.254***	-0.244	-0.449***
Observations	742	730	742	736	729	730
Panel B: Mining Sector						
Reformed SOEs vs. Private firms in the restructured sector	0.009	-0.145	-0.269	0.551	-1.369	0.132
Observations	413	404	413	411	412	404
Reformed SOEs vs. SOEs in the un-restructured sectors	0.022	0.140	0.270	-1.044*	2.104	0.142
Observations	96	96	96	96	96	96
Private firms in the restructured sector vs. Private firms in the un-restructured sectors	-0.089	0.203**	0.625***	-0.548	9.752***	0.218*
Observations	887	868	887	879	873	868

ROA = return on assets, SOE = state-owned enterprise.

Notes: The table reports the point estimates of the impact of holding company reform with the significant levels and the number of observations. Employment, total assets and revenues are in logarithm. Profit margin refers to the ratio between net profits and revenue. Current ratio refers to the ratio between current liability and current asset. ROA denotes the ratio between net profits and total assets. Productivity refers to the logarithm of the ratio between revenues and employment. The estimations control for firm and year fixed effects.

Data source: AIIB staff estimates.

the reform may motivate private players to pursue more innovation and increase their efficiency.[76]

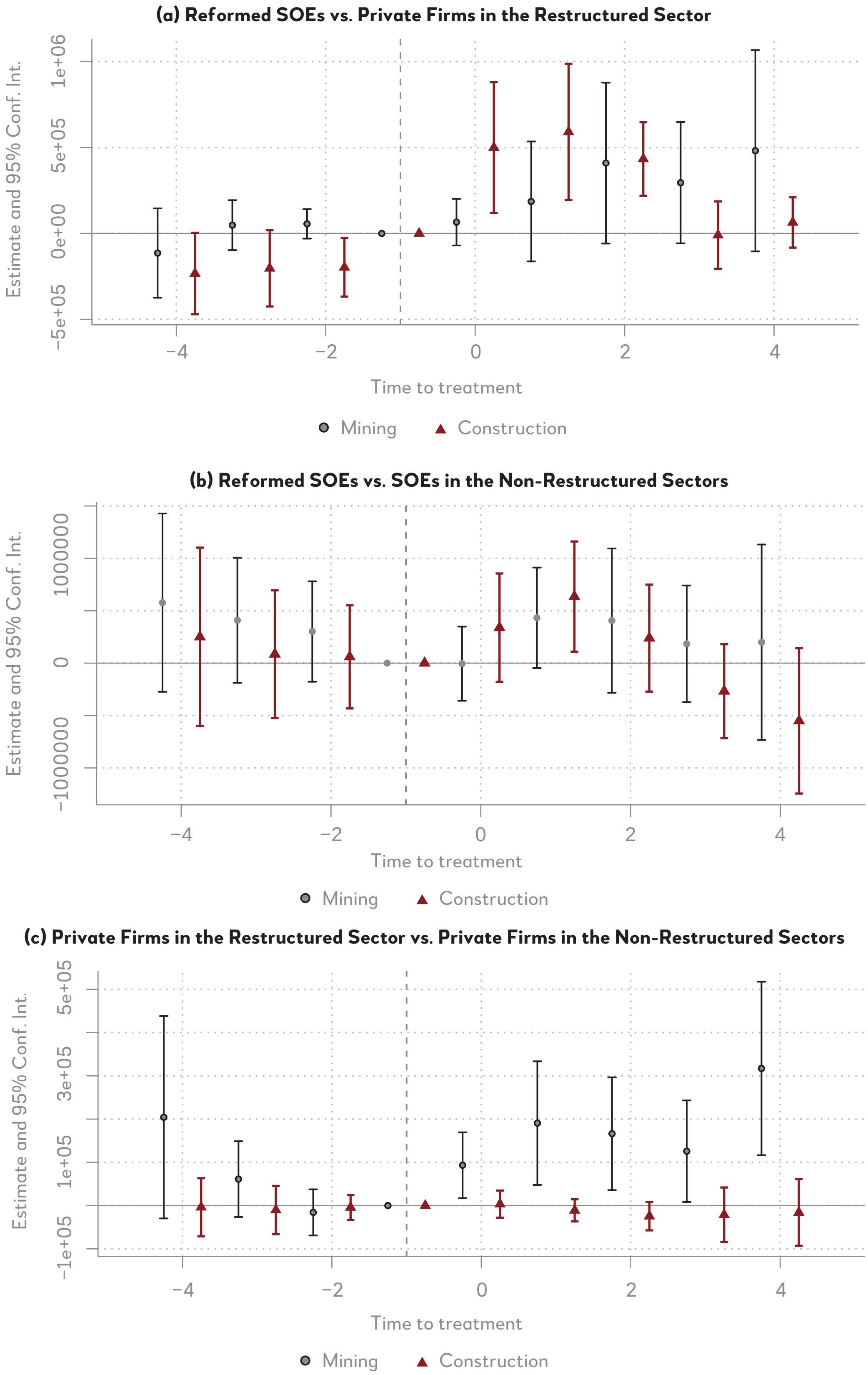
Moving forward, SOEs are poised to remain a dominant force in infrastructure. They are thus critical to the net-zero transition. The current SOE policies driven by the consolidation into SOHCs must be met with supportive regulatory and institutional frameworks to generate broader gains in Indonesia, empowering SOHCs and SOEs to engage with markets in a fair manner. For example, access to finance, access to public procurement and regulatory neutrality could benefit from further attention. Together with holding company consolidation, these reforms will improve competition neutrality, promoting greater private sector participation in infrastructure and stimulating innovation of both public and private sectors toward the transition.

Corporate governance reforms of SOEs should be further encouraged, balancing efficiency, equity and green objectives. These reforms started in 2002 with Ministerial Decrees 117 and 103, which laid out the legal basis. Substantial progress has been made through the promotion of training programs, evaluation frameworks and annual reviews of key performance indicators in SOEs.

Considering the urgency of the net-zero transition, performance indicators related to carbon and climate resilience should be included in the SOE evaluation frameworks. These are likely to be more effective than the legislative, regulatory, and even financial instruments largely used to influence private sector behavior. Of course, market-based mechanisms can be a useful complement in the policy framework toward net zero [Abbott (2020), Clark & Benoit (2020), Shidarta & Huis (2020), IEA (2018), Ministry of SOE (2018-2021), Kim K. (2018)].

[76] Admittedly, these results are subject to some limitations. The data coverage is not universal and is likely biased toward publicly listed firms and those complying more with business registration regulations. The coverage on SOEs and their subsidiaries is more limited than that of private firms based on the background research's comparison. As a result, the number of observations for SOEs is small although it is also a reflection of the actual share of SOEs in terms of the number of firms.

Figure 94: Impact on Revenues of Holding Company Reforms in Construction and Mining



SOE = state-owned enterprise.

Note: The figures report the point estimates of the impact on revenue of holding company reform before and after the implementation with the confidence intervals. Revenues are in logarithm. The estimations control for firm and year fixed effects.

Data source: AIIB staff estimates.

9.2 Dynamic Private Players Lack in Renewable PPPs

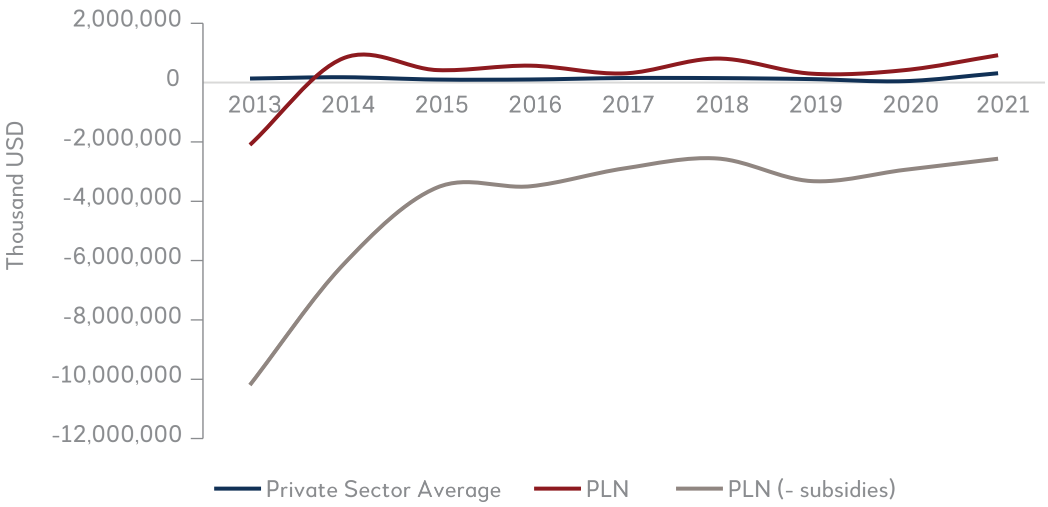
9.2.1 PPP Framework Encouraged Growth, Impact Yet to Be Sustained

Heavy reliance on SOEs is both a cause and a consequence of weak private sector participation in infrastructure. Despite the dominance and improved capacity of SOEs, the private sectors are more efficient and more profitable than SOEs in several sectors. In the electricity sector, private IPPs have been operating with a positive return on average while PLN has been sustaining losses before subsidies (Figure 95). Publicly listed private firms also reported a higher return to assets than SOEs in electricity, gas and oil, mineral and coal, and construction in 2019.[77] The exception is the transportation sector, where SOEs have significantly higher returns. However, the private sector's performance is also less resilient to shocks such as the coronavirus disease (COVID-19) pandemic.

The observed profitability gap suggests that private sector participation, contributing both capital and innovative capacity, can make infrastructure investment more efficient. Yet private companies may also be less willing to take risks associated with these investments. Due to uncertainties associated with many infrastructure projects, including the large sunk costs, limited transferability and low contractability of quality, private players are reluctant to commit without credible and significant counter-commitment from the state. In this regard, PPPs stand out as a promising instrument – that is, with the state providing support in some form to mobilize private sector investments [Engel et al. (2013), Fabre & Straub (2022), Kim K. (2018)].

The concept of PPPs in Indonesia mostly follows the standard definition, as a cooperation between government and business entities with risk allocated between both parties.[78] Although they may be developed on a solicited and unsolicited bases, PPPs are approved and led by government agencies or SOEs. The "private" partner is defined broadly to encompass both private companies and SOEs, but the majority of PPPs only involve private sponsors as the "private" partner.

Figure 95: PLN vs. IPPs



IPP = independent power producer, PLN = Perusahaan Listrik Negara.

Data source: (Perusahaan Listrik Negara, 2013-2021) and AIIB staff estimates.

[77] Appendix 5 provides more details.

[78] PPPs in Indonesia currently defined by Presidential Regulation No. 38 (2015), under the name of Kerjasama Pemerintah dan Badan Usaha (Cooperation between government and business entities) with the specific reference to infrastructure provision. The infrastructure project itself can be proposed from the government or business entity, while the business entity may be either private or an SOE. See Presidential Decree No. 7 of 1988, Presidential Regulation No. 38 of 2015, (ADB, 2020), and (ADB, 2017a) for evolution of PPP definition in Indonesia.

The first wave of PPP regulatory and institutional reforms in Indonesia coincided with major SOE reforms in the aftermath of the Asian Financial Crisis. The period after 1997 can be described as the experimental stage of PPP in Indonesia with a handful of projects on toll roads and power generation. Beginning in 2005, the "inaugural" legal framework of PPPs was laid out with minor amendments in subsequent years. Over this period, multiple public financial institutes were established to support PPPs. The government's support to accelerate considerably from 2015, with incentives and institution reforms by the introduction of further PPP promotion schemes and strengthening legal framework for cross-sector PPPs, involvement of line ministries, SOEs and local governments in PPP procurement.

According to the World Bank PPI database, PPPs in Indonesia witnessed remarkable growth around 2015 and 2016, indicating a private sector responsive to regulatory reforms and greater incentives. However, like responses to the previous PPP promotion efforts in 1998 and 2005, growth slowed down even before the pandemic. It indicates a lack of sustained impact. To date, over 140 PPP projects have been initiated in Indonesia, totaling over USD67 billion. The fluctuations are apparent when considering the value of capital investment (Figure 96a), and even more so when using the share of gross fixed capital formation, as a proxy for the importance of PPP in total infrastructure investment (Figure 96b).

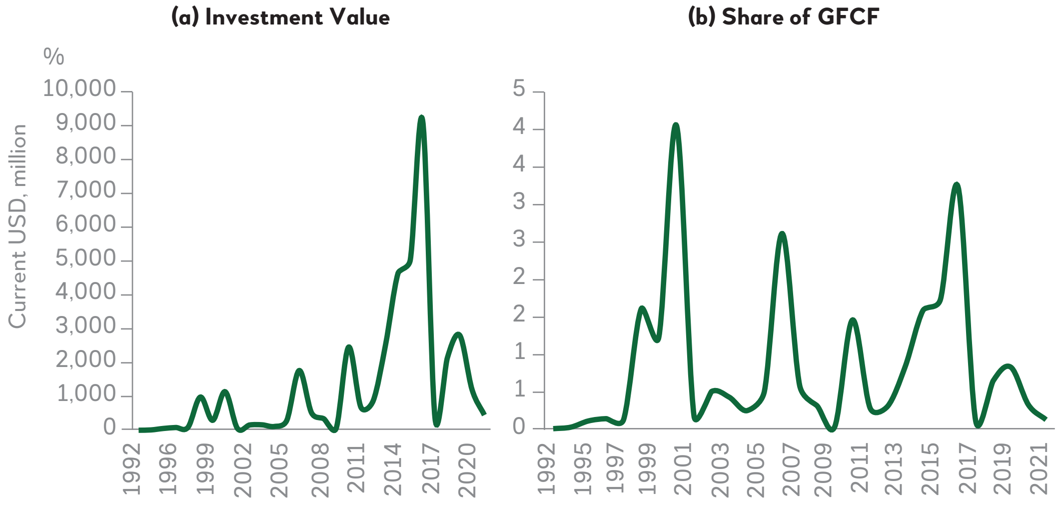
On a more positive take, Indonesia has maintained a low PPP project cancellation rate since the implementation of the 2005 legal framework (Figure 97). Despite the external shocks, the recent growth episode has not resulted in increased cancellation and distress either. The latest substantial period of PPP cancellations followed the Asian Financial Crisis. The situation has improved significantly since 2002 with one cancellation in 2021.

9.2.2 Energy-Sector PPPs Dominate but Renewables Have Not Caught On

Indonesia's PPPs have been traditionally dominated by energy and transportation with projects in energy driving recent growth (Figure 98). Starting in early 2000, PPPs in energy, including electricity and gas, began gaining momentum. They have become the most dominant sector since the 2010s and contributed the most to the significant increase in PPPs around 2015. The trend suggests the importance of sectoral reforms, such as the 2009 Energy Law that formalized guidelines for power purchasing agreements (PPAs) and IPP procurement, in addition to broader PPP regulatory and institutional reforms.

In addition to regulatory and institutional quality, contract design is critical for the success of PPPs because of its role in the allocation of responsibilities and risks. Energy sector contract design indicates a transfer of responsibility to private investors, as

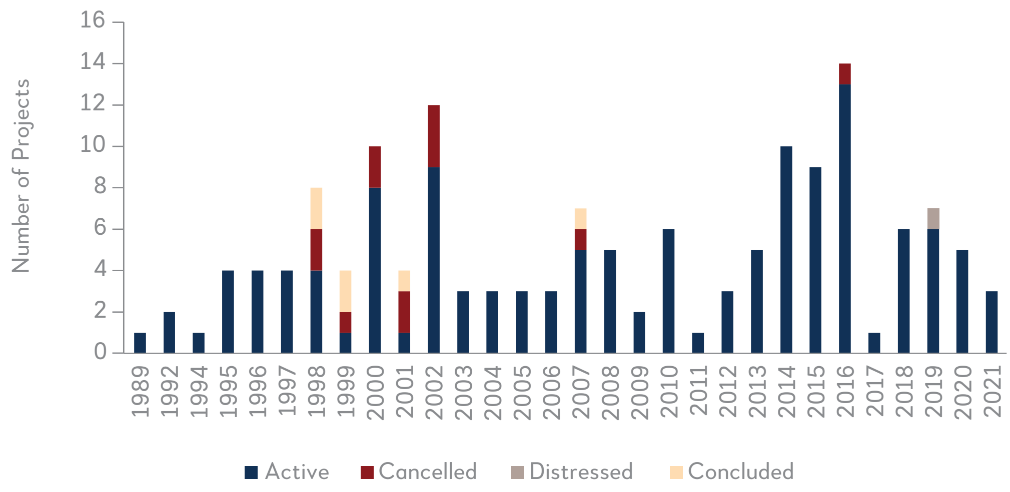
Figure 96: Capital Investments of PPPs, 1989-2021



GFCF = gross fixed capital formation, PPP = public-private partnership.

Data source: World Bank Private Participation in Infrastructure Database and AIIB staff estimates.

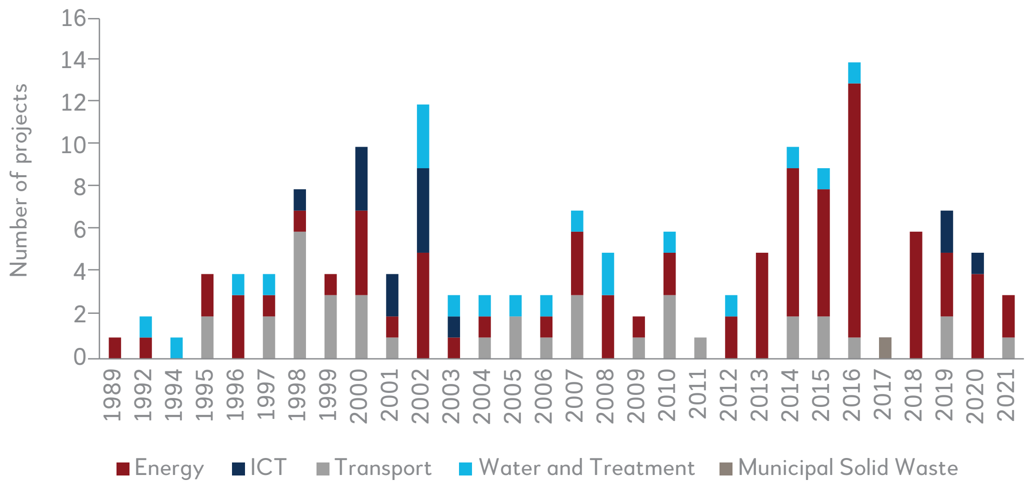
Figure 97: Status of PPPs, 1989-2021



PPP = public-private partnership.

Data source: World Bank Private Participation in Infrastructure Database and AIIB staff estimates.

Figure 98: Sectoral Composition of PPPs, 1989-2021



ICT = information and communication technology, PPP = public-private partnership.

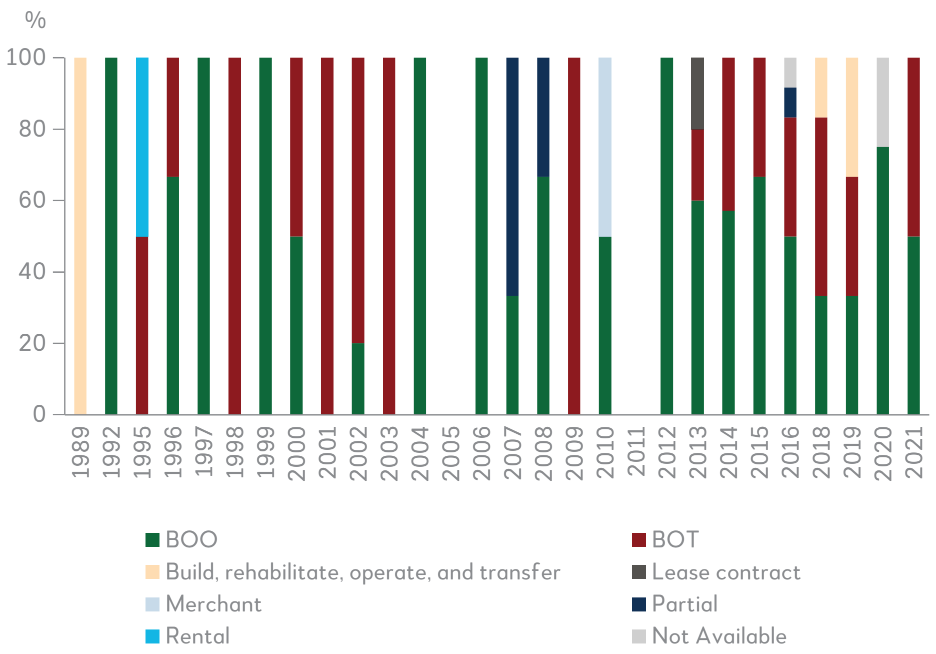
Data source: World Bank Private Participation in Infrastructure Database and AIIB staff estimates.

seen in the rising importance of build-own-operate (BOO) since the 2010s, in comparison with build-own-transfer (BOT) (Figure 99). In transport, BOT has gained importance over rehabilitation since the 2010s. The patterns in both sectors suggest the ability and willingness of both the public and private sectors to set up more complex arrangements.

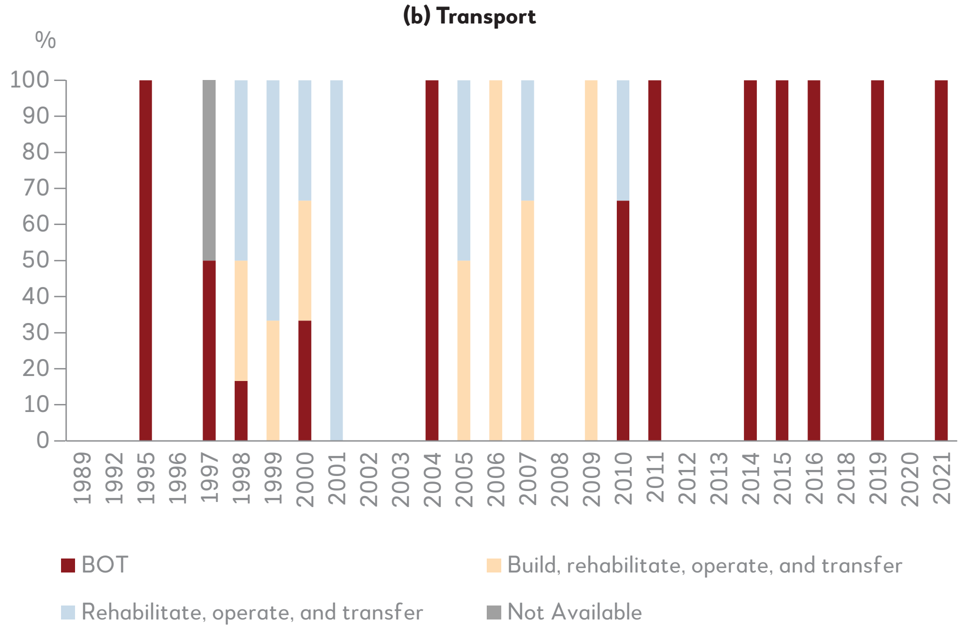
Project funding is another important consideration, as private participation through PPPs does not add new funding sources. At its best, the private sector efficiency and innovative capacity leveraged through PPPs bring gains. Ultimately, project funding comes from user fees and government payments backed up by taxes. In Indonesia, PPP project funding has moved toward a larger share of government payments, while user fees remain the dominant source (Figure 99). In energy, government funding share has become particularly pronounced. The trend toward more diversified funding driven by government sources implies the effectiveness of new government incentive schemes.

Figure 99: Modes of Energy and Transport PPPs, 1989-2021

(a) Energy



(b) Transport

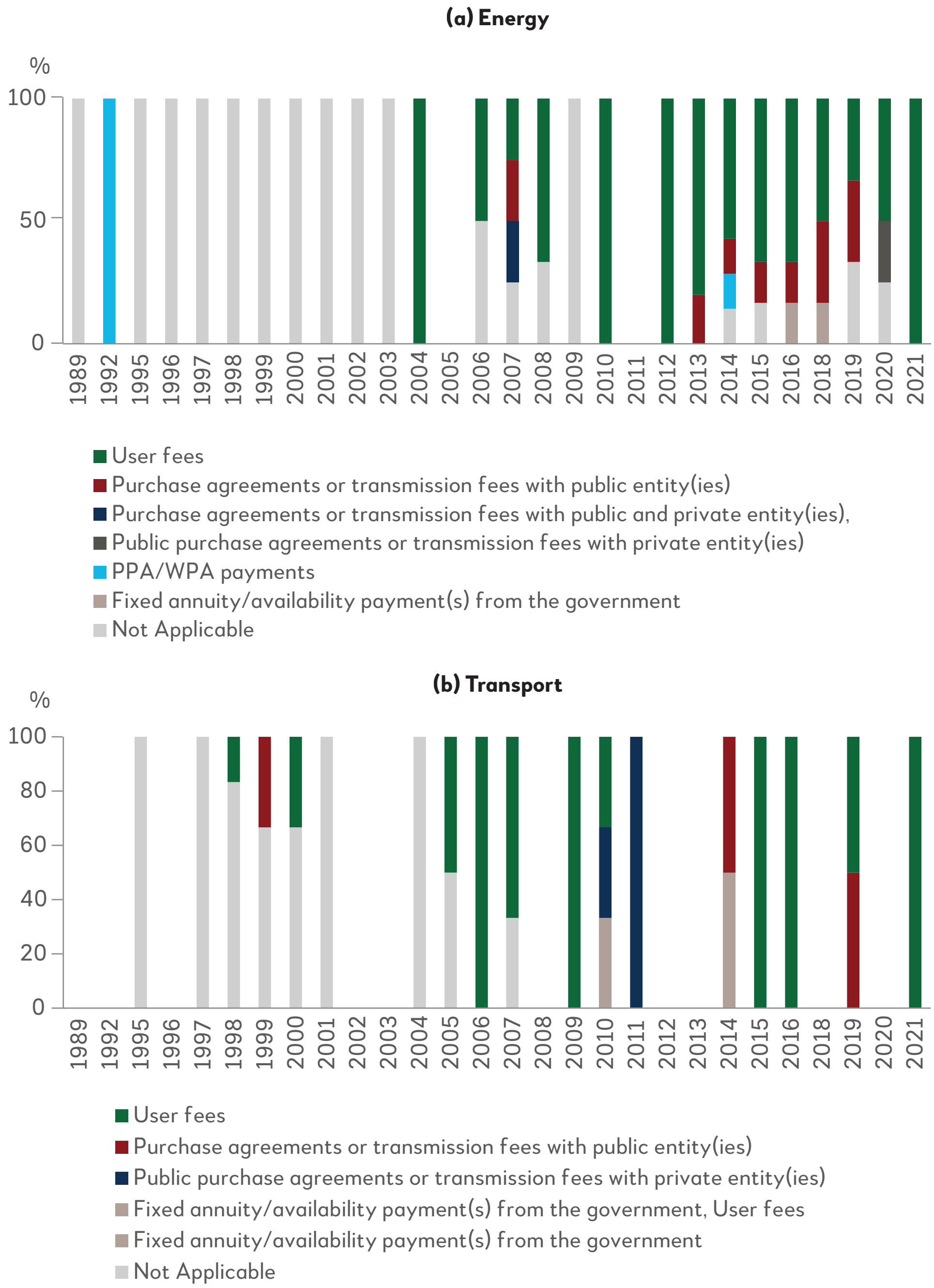


BOO = build-own-operate, BOT = build-own-transfer.

Data source: World Bank Private Participation in Infrastructure Database and AIIB staff estimates.

However, renewable PPPs have not responded to the shift in the division of responsibilities and the growing use of government payments (Figure 101). These renewable PPPs have increased since the 2010s, but not as a share of investment value. Overall, renewables account for 16 percent of PPP investment in the energy sector from 2010 to 2021.

Figure 100: Funding Sources, 1989-2021



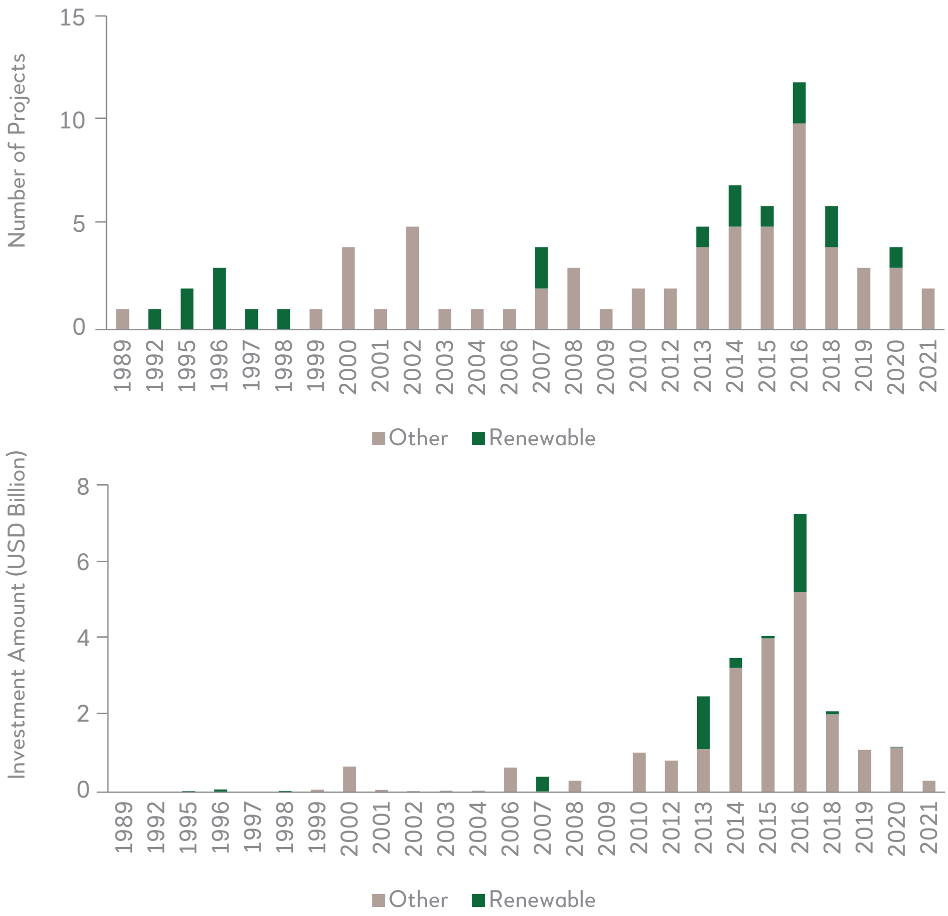
PPA = power purchasing agreement, WPA = water purchase agreement.

Data source: World Bank Private Participation in Infrastructure Database and AIIB staff estimates.

9.2.3 PPPs Correlate with Fiscal Constraints, Less So on Demand for Innovation

From the private sector's point of view, effective property rights protections, fair risk allocation, and the presence of PPP support institutions are some pre-requisites to mitigate hold-ups by government agencies. Limited government capacity has been seen as an impediment to PPP in Indonesia, such as delays in project implementation,

Figure 101: Importance of Renewables in Energy PPPs, 1989-2021



Data source: World Bank Private Participation in Infrastructure Database and AIIB staff estimates.

overlapping regulations, and complex bureaucratic procedures.[79]

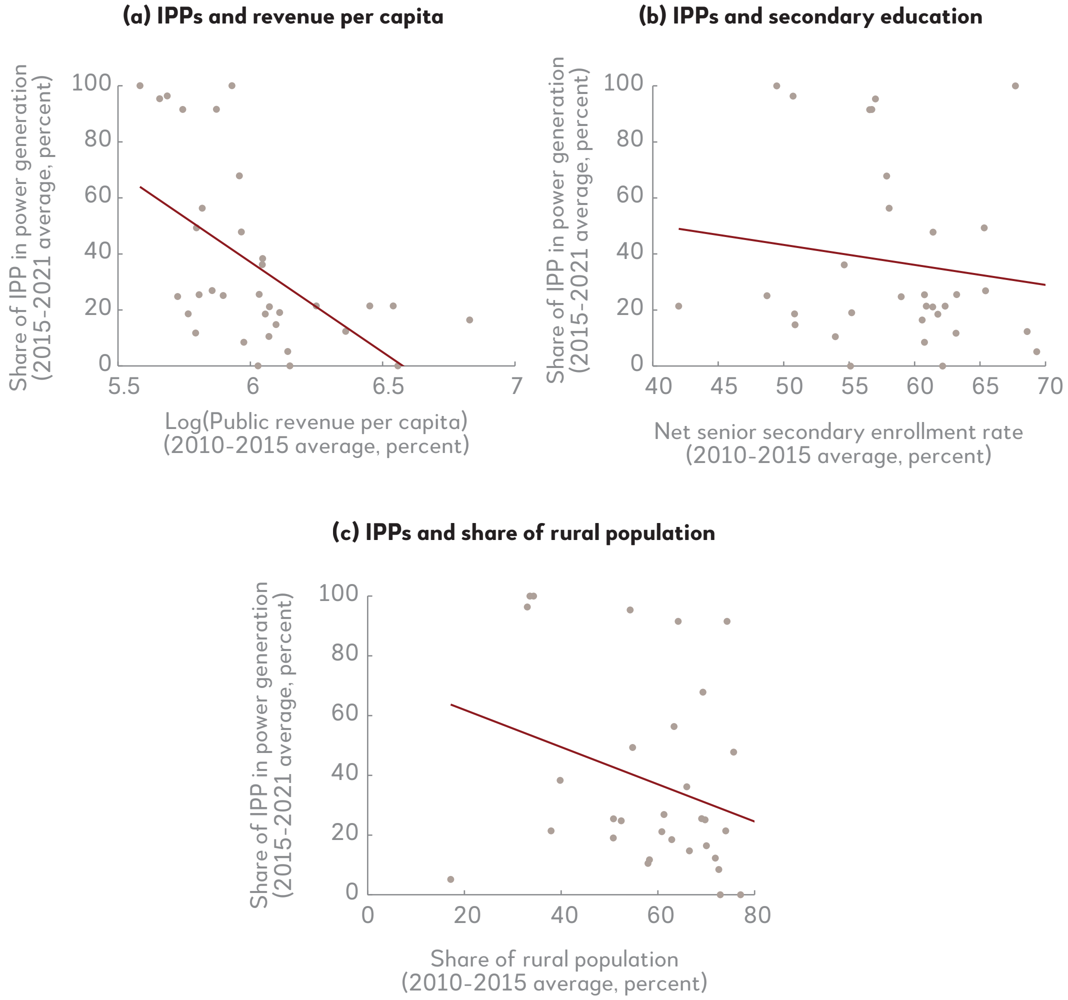
An analysis of local characteristics and IPP generation capacity was conducted as part of the background research to explore the issue of government capacity and PPP in Indonesia. There are three reasons for focusing on IPPs. First, the energy sector is critical to the net zero transition in Indonesia. Second, the energy sector dominates PPPs. Third, the electricity sector, as the main component of the energy sector, is dominated by the PLN, with PPPs mostly taking the form of diversifying power generation through IPPs.

Between 2015 and 2021, the importance of IPPs in the local energy mix was negatively correlated with the local fiscal capacity (Figure 102a). The lower the initial provincial level revenue per capita the higher the share of IPPs in power generation capacity. By contrast, the importance of IPPs is not strongly related to local secondary educational level, a proxy for skill level and local administrative capacity (Figure 102b). These patterns, taken together, suggest that PPPs have been primarily used to address local fiscal constraints. Local institutional capacity has not been an important factor in driving PPPs.

Tapping into private sector innovative capacity is another important consideration in applying PPPs. In Indonesia, electricity coverage has reached 98-99 percent by 2020. Its remote rural areas are much less well-connected, and its rural population accounts for most of the remaining one percent.

[79] See Adiyanti & Fathurrahman (2021), Endo et al. (2021), Casady & Baxter (2020), Kristiawan & Rohman (2020), Panayides et al. (2015), Hammami et al. (2006).

Figure 102: IPPs in Power Generation and Local Characteristics



IPP = independent power producer.

Data source: (Perusahaan Listrik Negara, 2013-2021), World Bank Indonesia Database for Policy and Economic Research 1984-2018 and AIIB staff estimates.

Private capital and innovative approach can be instrumental in achieving the last mile of electricity connectivity. However, the importance of IPPs remains negatively correlated with the share of the rural population (Figure 102c). Overall, there is considerable scope to improve government capacity to tap more into the efficiency and innovation capacity of the private sector. The results also point to an opportunity for the private sector to step in and use its comparative advantage to fill the electrification gap in remote rural areas.

To summarize, Indonesia's PPP framework and market are still developing with promising trends. The 2015 reforms have stimulated PPP growth without raising the rate of cancellation. In addition, the share of PPP projects in sectors critical for the net-zero transition has been growing, particularly in energy. However, the growth of PPPs since 2015 is not sustained. Most projects remain in fossil fuel-based energy. The spatial distribution of energy PPPs correlates more with local fiscal constraints than with the demand for private sector innovation to deliver the last mile connectivity.

For PPPs to be fully leveraged in the transition toward net zero, important challenges must be addressed. Substantial coordination efforts are required from the private partner and the government entity spearheading the project. Ameliorating potential financial risks that private investors face through support funds to address risks on cost overruns, collection efficiency, and the inflation rate would be beneficial. Some challenges facing PPPs are particularly pertinent to environmental projects. These include improving coordination across multiple regulators and PPP support agencies with overlapping mandates, and curbing substantial incentives for fossil assets [ADB (2017a), Chou & Leatemia (2016), Siagian (2010)].

9.3 Moving toward Net Zero: Markets and Green Innovation

9.3.1 Power Sector Reforms Fueled Independent Power Producer Capacity and Off-Grid Renewable Growth

In the past, Indonesia focused on expanding the role of SOEs and promoting PPPs to close its infrastructure gap. The approach builds on the need to balance efficiency and equity, the political economic factors, and the fact that its institutions are adapting to its development path. Nevertheless, markets have also played a critical role in Indonesia's economic growth since the Asian Financial Crisis. Power and other infrastructure sectors have made slower progress toward competitive neutrality than commercial sectors. More modest steps had been taken until the early 2010s. The unmatched challenge to achieving carbon neutrality puts power sector reform under the spotlight. Relying on market-based instruments to attract private sector participation and promote investment in renewables has become an important part of Indonesia's policy mix to meet both energy and climate commitments.

The process of power sector market-oriented reforms can be divided into three periods: sector nationalization in 1985, PPP framework revamps in early 2000s, and since 2014 a focus on reducing regulatory burden in tandem with push for renewables. The 2000s saw the introduction of a new PPP legal framework in 2005, the transformation of PLN from a public utility to a state-owned limited liability company, and push for commercializing the energy sector as set out by the 2009 Electricity Law. The new PPP framework permitted IPPs to supply power to the grid and associated regulations. Next, the 2014 National Energy Policy set ambitious renewable energy targets of 23 percent by 2025 and 31 percent by 2050. It also set out goals for increasing power generation capacity, both through IPPs and PLN subsidiaries. Further support to energy sector PPPs came from the establishment of viability gap funding and PPA law introducing power wheeling in 2015. A number of renewable specific reforms were also enacted from 2016-2021. These include the 2016 remote village small-scale electricity supply initiative, IPP hydro power conference in 2017, rooftop solar initiative in 2019 and the 2020 floating solar initiative—to spur on adoption of renewable energy technologies and their access to the national grid.[80]

The market-oriented reforms since 2014 have indeed supported the growth of IPP capacity and its utilization (Figure 103). IPP capacity has been growing steadily since 2014, at 13 percent per year. Electricity purchases by PLN from IPPs have been increasing in tandem since 2016 as well.[81] Although PLN remains dominant over all segments of the supply chain, approximately 50 percent of power generation capacity is linked to entities not operating under PLN.

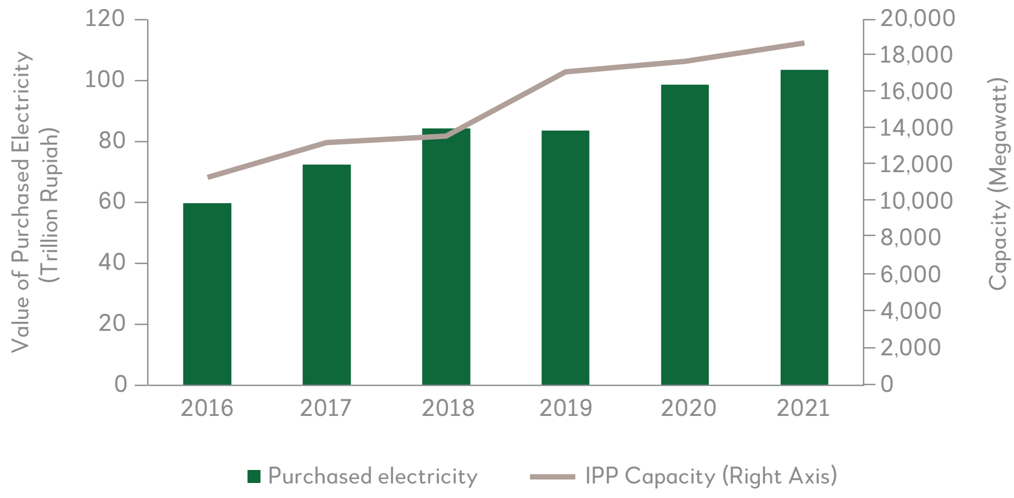
Geographically, capacity improved across provinces (Figure 104). In 2014, over two-thirds of provinces registered a peak load exceeding 100 percent of installed capacity, illustrating a widespread capacity limitation. In 2020, the situation improved dramatically, with no single province reporting that a peak load exceeded full capacity and most reporting 60 percent.

However, the overall impact of power sector reforms on increasing investment in renewables has been limited, despite the announcement of ambitious

80 See 1985 Electricity Law, 2009 Electricity Law, 2014 National Energy Policy, 2020 Omnibus law, (ICLG, 2022), and (ADB, 2020) for detailed discussion of power sector market-oriented reforms in Indonesia.

81 There was an increase in electricity purchases between 2015 and 2016 because of transaction reclassification.

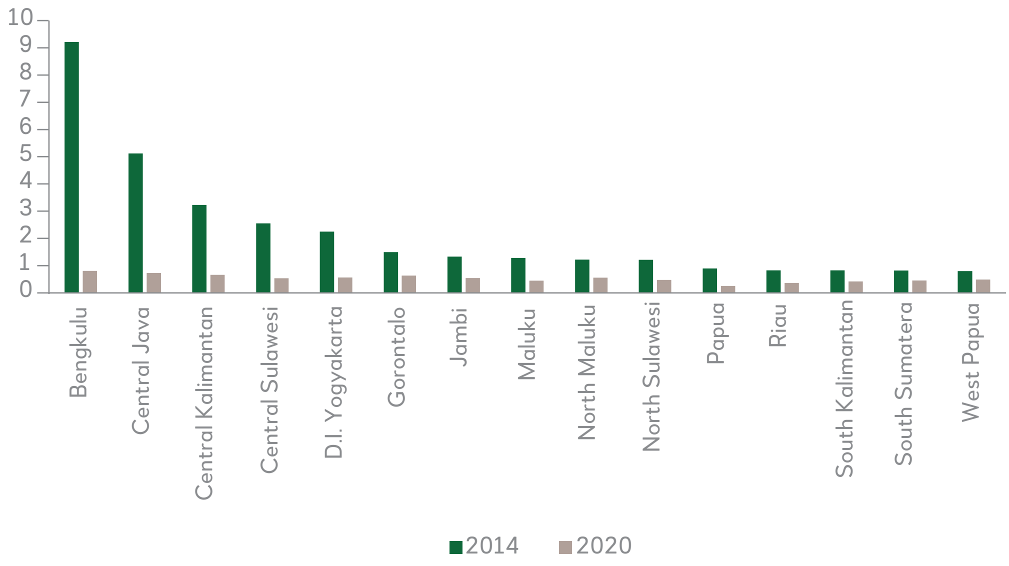
Figure 103: Capacity of and Purchases from IPPs by PLN



IPP = independent power producer, MW = megawatt, PLN = Perusahaan Listrik Negara.

Data source: (Perusahaan Listrik Negara, 2013-2021) and AIIB staff estimates.

Figure 104: Ratio between Peak Load and Installed Capacity, by Provinces, 2014 vs 2020

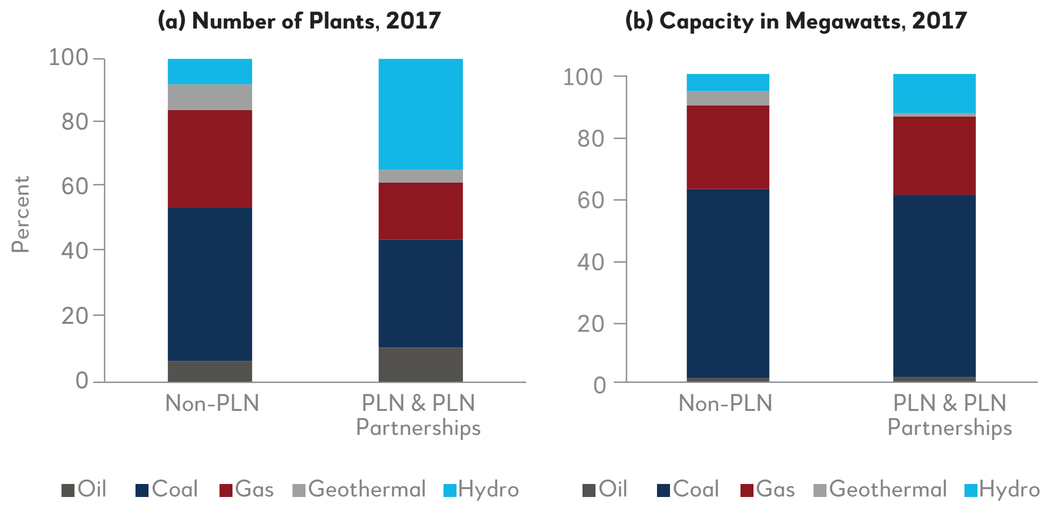


Data source: (Perusahaan Listrik Negara, 2013-2021) and AIIB staff estimates.

renewable targets by the National Energy Policy. Total installed renewable capacity has not been growing consistently since 2014, trailing behind that of fossil fuel. In 2017, the contribution of renewables to total capacity remained low at 10-15 percent across PLN and IPP power plants (Figure 105).

Nevertheless, there are considerable differences between on and off-grid renewables (Figure 106). Fossil fuels dominate on-grid electricity capacity (88 percent in 2021), which accounts for over 95 percent of total installed capacity. By contrast, renewables account for a significant fraction of off-grid power generation (42 percent in 2021) and have contributed the most to off-grid capacity growth since 2018. The bulk of the increase was due to hydro power plants whereas solar also saw sizable growth in share, albeit small in value.

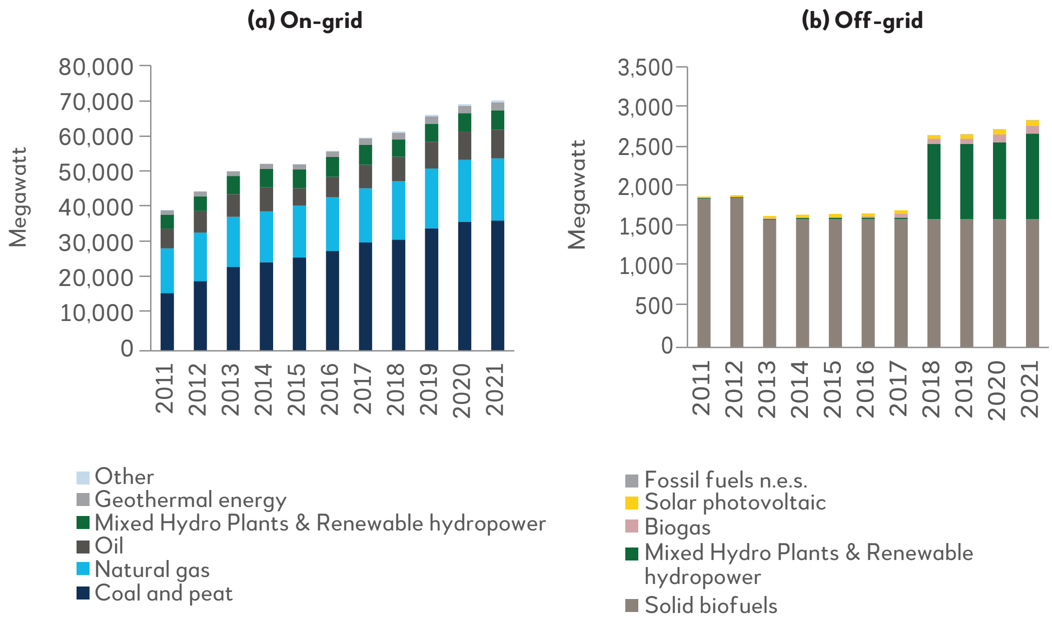
Figure 105: Composition of Electricity Generation, by Sources, PLN vs. IPP



IPP = independent power producer, PLN = Perusahaan Listrik Negara.

Data source: World Resource Institute 2021, ORBIS, and AIIB staff estimates.

Figure 106: Composition of Electricity Generation Capacity, by Sources



Data source: Irena database, (Perusahaan Listrik Negara, 2013-2021) and AIIB staff estimates.

These findings, taken together, suggest that market-oriented reforms stimulated renewable growth, but the impact was limited to off-grid capacity generation. In particular, the combination of improved regulatory efficiency and reduced entry barriers coupled with renewable initiatives may help explain the jump in off-grid hydro capacity. For example, in 2016, the remote village small-scale electricity supply program was passed, signaling a push for electrification of last-mile remote areas, particularly through renewables. In 2017, the renewable energy purchase policy was passed, requiring the PLN to purchase power from renewable electricity plants.

Looking ahead, further progress on market-oriented reforms in the power sector is needed to address the low presence of renewables in the energy mix. Currently, the overall market structure remains a monopoly with transmission and distribution remaining in the purview of one SOE. Thus, areas to enhance competition include greater regulatory independence within the sector, horizontal and vertical unbundling, introducing bilateral contracting with third-party access, and reducing private sector entry barriers such as pre-selection of tender candidates, mandatory partnerships with the PLN and limited risk sharing by the PLN.

In addition, power sector distortions limiting renewable investment and their full integration in the system should be addressed. Some salient examples are fossil fuel subsidies, price caps on renewables based on subsidized fossil fuels and restrictions on importing foreign equipment, which can be embedded with renewable technologies or be required to implement these technologies.

The implementation of market-oriented instruments for carbon reduction, such as carbon tax and an emission trading system (ETS), is also critical. Carbon pricing instruments alone are not sufficient to achieve the carbon reduction needed. However, they have been shown to be a cost-effective tool in the broader policy mix for net-zero transition. They also work in tandem with power sector reforms and are less distortive and more sustainable in the longer term.

In October 2021, Indonesia announced its carbon tax scheme, which selects the coal-fired power sector as the first industry for application. A presidential regulation that provides a national legal umbrella for the long-term development of carbon pricing instruments was also signed, including carbon tax, ETS and a carbon crediting mechanism. These important policies signal the state's desire to apply market-oriented instruments as part of its strategy to achieve net zero. Unfortunately, due to high energy prices and other economic impacts of global supply chain interruptions, Indonesia has been postponing the implementation of its carbon tax scheme. Meanwhile, these policies have triggered steps to iron out concrete regulatory and institutional reforms and to understand their implications, which better prepare both the public and private sectors for the major shifts [Sumarno et al. (2022), ICLG (2022), World Bank (2022b), Reuters (2021), Nordhaus (2018), IRENA (2017)].

9.3.2 Green Technology Lagging although Electric Vehicles are a Bright Spot

Achieving green transition relies ultimately on more, better, and cheaper green technologies. Globally, most energy technologies are not on track to provide the urgent green transition. Across countries, the landscape of green technology is uneven and led by advanced economies—China—and a few other emerging economies. Government policies and incentives are central to the success of carbon reduction-related technology innovation and development, to address the double externalities of such innovation. At the same time, the markets' pulling effects are indispensable, together with research institutions, private companies, international collaboration, and knowledge transfers [(Lee et al. (2021), Acemoglu et al. (2018), Aghion et al. (2016)].

Despite the repeated emphasis on technology innovation and development, Indonesia falls behind in green technology. Based on the patents recorded by the ORBIS database, Indonesian companies' filings of the invention in carbon reduction-related technology fields totaled around 1,200 from 2000 to 2021, which accounts for less than one percent of the global company filings of the invention in these fields.

Within Indonesia, foreign companies drive technology innovation and development in green and other fields, while the contribution of domestic SOEs and private firms is limited (Figure 107). 2015 to 2019, one to two percent of patents filed by foreign companies falls into carbon reduction-related technology fields, averaging about 120 patents per year. By contrast, domestic companies' green patents accounted for a slightly higher share compared to foreign firms, but were much smaller in absolute terms, averaging at 20 per year.

SOEs' contribution to green technology is even smaller. These companies filed 12 green patents at the Indonesian patent office over 2007-2021, accounting for seven percent of all files by domestic firms. Indonesia Power PT, an energy SOE, and Pertamina, the Oil and Gas extraction SOE are responsible for the four clean energy related patents. A subsidiary of the Ministry of Agriculture R&D department is associated with the other patents related to recycling.

Figure 107: Green and Non-Green Patent Fillings

Data source: ORBIS Intellectual Property and AIIB staff estimates.

Breaking down by fields, green technology patents by Indonesian companies are more concentrated, while those by foreign companies are evenly distributed (Figure 107). Recycling technology is the most dominant among domestic firms' fillings, followed by solar. The two largest sectors together account for over half of green technology filings. Meanwhile, fillings on wind and solar energy-related patents are rising the fastest. Regarding foreign firms' patent filings, carbon capture and conservation account for the largest shares at 30 percent. The rest of the patents spread across hydro, recycling, and EVs, which total another 41 percent. Over time, the share of carbon capture innovation has been declining while that of conservation, EV, recycling, and hydropower has been increasing.

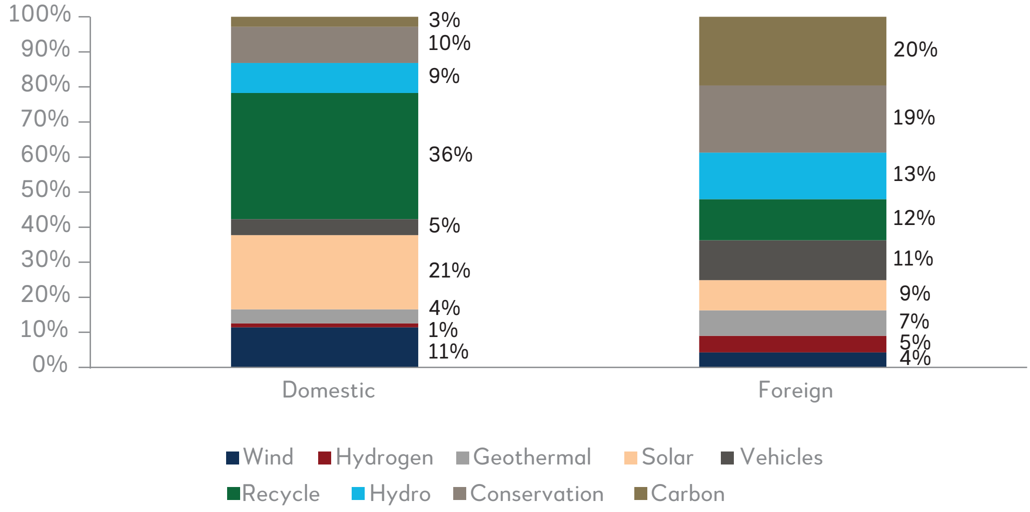
The concentration of innovation in a few green technology fields is likely due to the confluence of market-pulling effects and government instruments. EV patents by foreign firms are a case in point. As Asia's fifth-largest passenger vehicle producer, Indonesia has a considerable automotive sector dominated by foreign brands and joint ventures. In addition, Indonesia is abundant in natural resources that are key materials for EV batteries, including nickel and cobalt. Recent price inflation of these raw materials due to global supply chain interruptions has prompted more foreign investors to diversify their EV battery production and the full EV supply chains to new hubs, such as Indonesia.

Government policies and incentives have been formulated to build synergies across these competitive advantages (Figure 109). First, the Government of Indonesia has laid out an ambitious plan for EV adoption and development of supporting infrastructure.[82] The Presidential Regulation General Planning for National Energy and Presidential Decree on Acceleration on Battery Electric Vehicle Program for Road Transportation have also provided high-level policy supports. Recently, two new EV-related production projects in Indonesia have been initiated by LG Energy Solution and CATL in partnership with the Indonesia Battery Corporation, a conglomerate of Indonesian SOEs in the battery production value chain. These market forces and government incentives fuel foreign firms' innovation in the EV and related fields. In turn, the EV innovation feeds back into the process as a factor itself, speeding up the greening of the automotive supply chain [Reuters (2022), The Purno Yusgiantoro Center (2022)].

[82] The plan envisages 140 GW of batteries by 2030, 5.7 million EVs on the road by 2035, and charging stations in 2,400 locations by 2025.

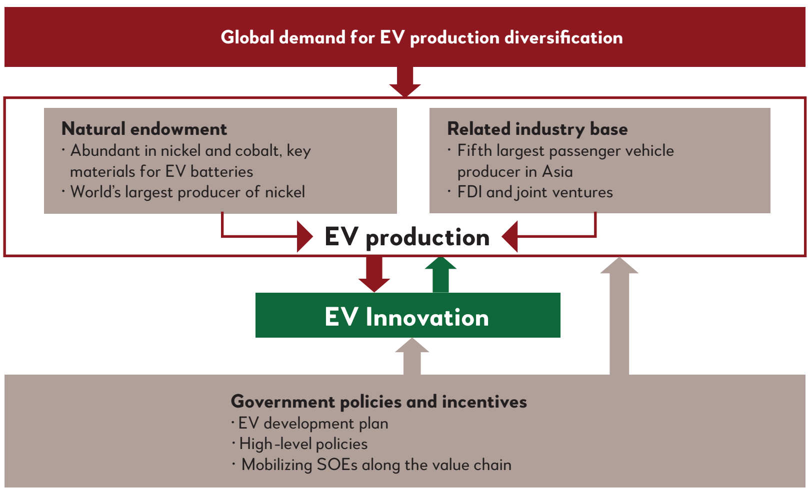
Indonesia holds an untapped potential for green technology innovation and development. Human capital has been growing, from 179 researchers in R&D per million people in 2016 to just under 400 in 2020. The country is also making strides in developing complementary physical and digital infrastructure. On the one hand, government R&D incentives should scale up, especially on carbon reduction-related technology. Over 2016-2020, R&D expenditure made up a quarter of a percent of GDP, far from the official targets of one percent by 2014 and three percent by 2025. On the other hand, incentives and policies should be met by markets to promote green technology adoption and development, as illustrated by the case of EV innovation by foreign companies and the recent development of EV supply chains in Indonesia.

Figure 108: Technological Composition of Patent Filings by Companies in Indonesia, 2000-2021



Data source: ORBIS Intellectual Property and AIIB staff estimates.

Figure 109: Electric Vehicle Innovation and Supply Chain Development in Indonesia



EV = electric vehicle, FDI = foreign direct investment, SOE = state-owned enterprise.

Data source: AIIB staff estimates.

CHAPTER 10

MOONSHOTS FOR THE EMERGING WORLD

The net-zero transition, humanity's biggest mission to date, will pose a great challenge to state capacity in advanced economies, emerging and developing economies alike. For EMDEs where state capacity is weaker, the challenge can seem daunting or even drag on economic development. It does not have to be. Instead, it is a historic opportunity to build sustainable economies with widespread benefits. With a bold vision, policymakers have a chance to organize moonshots for their economies and succeed.

While EMDEs are not responsible for a large part of the historical GHGs emitted, the climate change fight can only be won by EMDEs. Nowhere is this tension more palpable than in Asia. It has the most rapidly growing GHG emissions and the highest carbon intensity. At the same time, 99 of the 100 cities most vulnerable to climate change are in Asia. Many governments are already struggling to cope with severe air pollution in cities and the increasing frequency of storms and floods.

A moonshot means three things. First, it is about providing the big vision while unpacking the challenge into smaller, mission-oriented, and actionable parts. Second, it requires aligning, organizing and crowding in all actors—state and private—toward the vision. Third, it is imperative to acquire and deploy new technologies. Moonshots are often associated with advanced economies, but EMDEs also need such frameworks for driving the transition. Arguably, a strong mission is important in these countries with more limited state capacity and where markets and regulations are still imperfect.

After Prime Minister Modi announced India's vision to be net zero by 2070, the state-owned coal miner Coal India Ltd (CIL) has been focusing on renewables, particularly solar. India rail is stepping up solar power for trains and train stations. The state of Kerala is even introducing solar-powered mini trains—a small practical step but it counts! The Chinese government has set up its twin targets and directed the big five SOEs in electricity generation to lead the greening of the electricity system. State-owned financial institutions are also changing—the Chinese EXIM Bank has announced the adoption of a green framework for its operations in China.

The most challenging aspect of the transition is coordination. A credible vision itself acts as a powerful mobilization tool. Just as how a credible monetary policy anchors inflation expectations, a credible net-zero policy spurs citizens and businesses to act, as seen by the examples above. A carbon price too plays a critical role in this coordination, allowing consumption and investments to accurately price in environmental costs, solving intertwined externalities. The moonshot will require new technologies. As described in the report, EMDEs can adopt a mix of local innovation incentives or inward FDI promotions to make the necessary jump, much like how earlier generations of emerging economies achieved industrialization through these measures.

To succeed, the net-zero transition must ultimately be perceived as just—not only globally between rich and poor countries, but also within countries. Reskilling, repurposing land and transferring valuable skills from fossil fuel operations to renewables will take investment and careful execution. Countries like Afghanistan, Bangladesh and Maldives are among the most vulnerable and those with the weakest state capacity. These countries deserve special support to build state capacity to deal with a problem they didn't cause.

As highlighted throughout this report, EMDEs have overall lagged in the net-zero transition. EMDEs can develop their own inspirational moonshot missions toward net zero—and in the process create new sectors and job opportunities for many. The net-zero transition presents this opportunity for EMDEs to perfect a form of development that is truly sustainable for all.

APPENDICES

Appendix 1: Identification of SOEs and Merging with Transactions

For the analyses in the various chapters of the report, the Asian Infrastructure Investment Bank (AIIB) research team undertook the identification of state-owned enterprises (SOEs) through ORBIS ownership data and matched this to various datasets for infrastructure investments, syndicated loans, bond issuances, patent filing etc. This resulted in several large (combined) datasets that then supported the analyses and provided new insights for this report. The data process is explained in this Appendix.

As of July 2022, the ORBIS company database had information on 318 million entities and companies that were active, with information on ownership structure, operating sector and various firm-level financial metrics. The identification of SOEs is based on one of the following three separate methods:

- The first method leverages ORBIS' reporting of the Global Ultimate Owner (GUO). ORBIS combines the ownership share in each layer of the ownership structure tree and provides the corporate share of the ultimate owner users (Kalemli-Ozcan et al., 2015). The GUO is the largest cumulative shareholder at the top of the ownership structure. The GUO can be a private company, fund, individual or public entity. The definition of a public entity includes but is not limited to government, local government bodies, agencies and international organizations. In this report, a firm is considered an SOE if the GUO is a public entity, with the total cumulative share of being more than 25 percent. For this type of company, the public entity is the largest shareholder. In addition, based on the location of the ultimate owner, it can be further determined if the SOE is a domestic one (same location) or is a foreign SOE (different locations). The research records 506,790 active companies that fit this criterion globally.
- The second approach relies on the share and status of direct ownership. A firm is considered an SOE if there is a public entity that has 25 percent direct ownership. In this instance, the public entity does not have to be the single largest owner—that is, there is a GUO that is a non-public entity. But with 25 percent of public entity ownership, the government could participate in the decision-making process of this firm. This type of SOE is more common in Europe and East Asia and business service and public administration industries. The research recorded 296,607 companies using this method.
- The third method identifies SOEs through a classification of "national legal forms." This method works when the SOE is defined by national statutes rather than corporate shareholding by the state (hence, national legal form). This is common for many ex-central planning economies. The national legal form is defined by the government of each country. There are 118 unique national legal forms in 124 economies. The most common ones are "branch," "corporation," "public limited company," "fund" and "sole proprietorship." The research team selects labels explicitly connected to the state as SOEs. Examples are "state-owned company," "government-sponsored company," "unitary enterprise," "state-budget company" and "state collective company." The research team also adopts an economy-by-economy approach, selecting the legal forms that are, to the best knowledge, most relevant for the specific economy context. From here, almost 1 million entities, including branches, are found. However, many entities are direct subsidiaries of government agencies and do not have any financial information.

From these three methods, the research team obtained 1,179,511 records of unique SOEs worldwide. Because of the last method, Eastern Europe is the most prominent host of SOEs, followed by East Asia and North America (Figure 110).

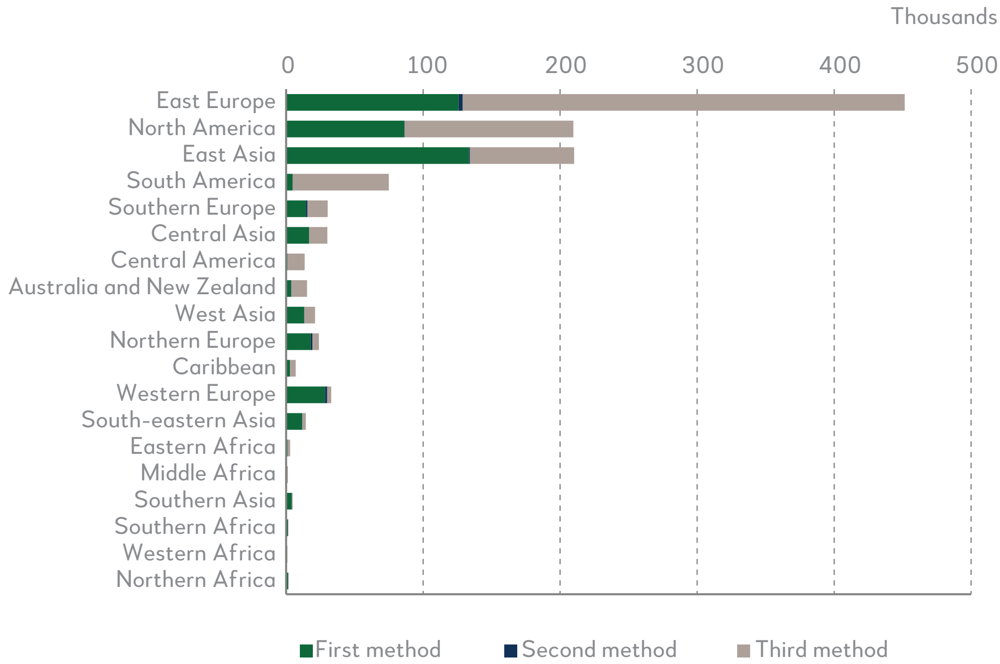
Furthermore, only 17 percent of the companies disclose financial data regularly, among which only 3,545 are publicly listed.

Every SOE identified has a unique ID (labelled as Bureau van Djik identification or BvD ID), which is made up of the two-digit country ISO code and the firm code. The research team relied on this ID as the key to match company information in transactional databases. In this report, this is done for three databases: "IJGlobal", "Refinitiv" and ORBIS Patent.

IJGlobal records private-financing transactions in the infrastructure industry, while Refinitiv is a comprehensive financial database with deal data on bonds, loans, equities, etc. The research team extracted the company name from these two databases and used the fuzzy search function of the ORBIS database to match the company name with ORBIS. This fuzzy search function would return matched results with the corresponding BvD ID to allow for matching. However, not all companies in the transactional databases can be matched with the ORBIS database. Other than translation issues in the company names, the main reason for not matching is that the transactional databases would record the names of the temporary vehicles/entities disclosed in the document rather than the parent/owning company. The research team manually matched the rest of the data to the best efforts possible and treated the unmatched ones as non-SOEs in the analysis.

The research team identified around 11,000 companies in the IJGlobal database and around 58,000 companies in the bond and loan database. Some 84 percent of IJGlobal companies are matched with ORBIS and 69 percent with Refinitiv. In terms of transaction value, 90 percent of IJGlobal companies are matched with the ORBIS, and 85 percent are matched with Refinitiv. Finally, the research team also performed a match with ORBIS Intellectual Property database for the analysis of patents and technology. This step is relatively straightforward as the dataset has the same BvD ID firm identifier.

Figure 110: Number of State-Owned Enterprises by Region



Note: The above follows UN Subregion classification.

Data source: ORBIS Company database, and AIIB staff estimates.

Appendix 2: ORBIS Intellectual Property Database Methodology

For the patent analysis in Chapter 6, the main data source is ORBIS Intellectual Property (OIP). OIP is a global patent database provided by Bureau van Dijk, covering about 148 million patents from 157 countries linked to over 2 million companies around the world. In addition to basic patent information, OIP also collects market valuations of patents, which is a distinct feature compared to other patent databases.

Data collection and cleaning

There are many different layers of complexity around how to use patent data, including patent offices, patent families, and patent values. For Chapter 6, built on other similar reports and literature, data filters listed in Table 6 have been widely used and were applied to get globally comparable datasets for the focused countries/regions in the analysis.

Since IPC Green Inventory does not include hydrogen production technologies, the team identified IPC codes for this purpose, including the IPC codes C01B/00, C01B3/02, C01B3/38.

After obtaining filtered patent datasets based on the criteria above, the team further merged the data with Orbis firm database to label if the applicants are SOE or not[1], by the applicant's BvD ID (if available). The merging rule: if the applicant's BvD ID can be found in the SOE database in Appendix 1, the applicant is labelled as SOE; all other applicants are labelled as "Not SOE".

Calculation of patent application counts and patent values

Fractional counting

Cleaned patent data were aggregated by applicant nationality and other categories listed below. Note that there are many patent applications that involve more than 1 applicant, so that data aggregation needs to be done by fractional counting. For example, if a patent valued at USD100 has two applicants with one from China and the other from Germany, then China and Germany each would record 0.5 as in patent application count, and 100/2 = USD50 as in patent value. Fractional counting avoids duplicated counting in any country aggregations and widely used by other literature for similar purposes.

Patent values

OIP collects patent values based on their proprietary sources and methods. In short, the patent values are drawn from three different sources: fair market value, income value, and cost approach. Fair market value refers to the monetary value for patents traded in the market, for example by transactions like acquisitions, licensing and liquidation. Income value reflects the net present value of the potential revenues that can be generated by a patent. Patent value from cost approach typically reflects the cost of developing the technologies involved in the patent. OIP collects values for as many patent records as possible.

As a result of multiple sources of value information for the same patent, a patent usually has many different values across years and across patent offices filed. For the analysis in Chapter 6, the team decided to use the maximum value of the latest available year during which a patent was evaluated. This is to reflect the biggest possible value potential for a patent in the global market.

Other categories for aggregation

International co-patenting: In Chapter 6, Figure 49 presents patent by types of co-patenting. International co-patenting is defined as patents where there are applicants from at least two different economies, while domestic co-patenting refers to patents with at least two applicants but they all come from the same economy. Single patenting means there is only one applicant for the patent.

Fossil-fuel companies

Figure 47 presents patenting activities by major oil and gas companies listed in Table 8.

[1] See Appendix 1 for details how AIIB team identified SOE firms. To the team's best efforts, a global SOE firm database with BvD ID was built.

Table 6: OIP Data Filters

	Filters	Search conditions	Justifications
1	Applicant locations	European Union members, United Kingdom, ASEAN members, China (including Hong Kong, China; Macau, China; Taiwan, China), India, Japan, Republic of Korea, United States. This filter also limits the data search by patent applicant nationality, not inventors. Patent inventors tend to by individuals, which cannot be matched with firm level database.	EU+UK, China, Japan, Republic of Korea, US are typically selected in many reports regarding patent applications because collectively they account majority of world's total patent applications. In addition to these economies, Chapter 7 added India and ASEAN members to reflect AIIB's regional focus.
2	Application date	From January 1, 2000 to May 31, 2022.	To reflect the patent trend in the past two decades that cover the 2008 Financial Crisis.
3	International Patent Classification Code	See Table 7 for more details. There are 9 green technology sectors selected for the analysis by filtering the patents by IPC codes from WIPO's Green Inventory list.	WIPO identified a list of green technologies using IPC code. See IPC GREEN INVENTORY (wipo.int). It is widely used in patent trend analysis and validated by WIPO's patent experts.
4	Family members	The earliest patent filing in the same patent family is selected in the analysis.	This is to reflect the earliest timing point when a new patent idea is formalized in patent filing. A patent family refers a group of applications for the same technology but filed across different patent offices.
5	Patent office	All patent offices around the world.	This is a distinct feature of this report to reflect as broad data coverage as possible. Many reports, especially by IEA, rely on patent data filed in European Patent Office, or some major patent offices like US and Japan. But after some data check, it excludes a significant amount of patent applications by Chinese applicants who file in China patent office. AIIB team decided to include all patent offices to avoid data omission.
6	Excluding utility models	Patents for utility models are excluded.	It is advised by ORBIS team and other literature to exclude utility model patents for global comparison. This is because utility model patents tend to be dominating in applicants from some economies (e.g., China) while not applicable in other economies. Also, in general, utility model patents usually go trough less thorough review processes, leading to concerns about paten quality issues.
7	Excluding patents with no companies associated	Only include the patents filed by company applicants.	In theory, the filter 2 by applicants automatically filters the data to patents filed by company applicants, but there are still a few individual applicants in the results. These results are irrelevant to the analysis because the filtered datasets need to be merged with Orbis firm level database by company BvD ID, which individual applicants do not have.

Table 7: Patent Classifications Selected in Filter 3

IPC Green Inventory	Selected IPC Codes	AIIB Labelling
Hydro energy	All IPC codes under hydro energy category	Hydro
Wind energy	All IPC codes under wind energy category	Wind
Solar energy	All IPC codes under solar energy category, except B60K16/00 and B60L8/00 (propulsion of vehicles using wind/solar power)	Solar
Geothermal energy	All IPC codes under geothermal energy category, except B60K16/00 and B60L8/00 (propulsion of vehicles using wind/solar power)	Geothermal
Transportation	All IPC codes under the vehicles in general sub-category of transportation category	Clean power vehicles
Energy conservation	All IPC codes under the 1. storage of electrical energy, and 2. power supply circuitry subcategories of energy conservation category	Grid technologies
Waste management	All IPC codes under the carbon storage and storage subcategory of waste management category.	Carbon capture and storage
Waste management	All IPC codes under the reuse of wate materials subcategory of waste management category.	Recycle

Table 8: Top Oil and Gas Companies

	China	EU+UK	India	Japan	Russia	US
1	China Shenhua Energy Co Ltd	OMV Aktiengesellschaft	Reliance Industries Ltd	ENEOS Holdings, Inc	Surgutneftegas Public JSC	Enterprise Products Partners LP
2	CNOOC Ltd	Polskie Gornictwo Naftowe i Gazownictwo SA	Indian Oil Corp Ltd	Cosmo Energy Holdings Co, Ltd	Public JSC Rosneft Oil Co	ONEOK Inc
3	China Petroleum & Chemical Corp	Polski Koncern Naftowy ORLEN Spolka Akcyjna	Bharat Petroleum Corp Ltd	Osaka Gas Co, Ltd	Public JSC Gazprom	UGI Corp
4	PetroChina Co Ltd	Neste Oyj	Oil & Natural Gas Corp Ltd	Idemitsu Kosan Co, Ltd	Public JSC Transneft	Atmos Energy Corp
5	Shaanxi Coal Industry Co Ltd	Snam S.p.A.	Hindustan Petroleum Corp Ltd	Tokyo Gas Co, Ltd	PJSC Tatneft	Kinder Morgan, Inc
6	Yanzhou Coal Mining Co Ltd	TotalEnergies SE	Coal India Ltd	Inpex Corp	PAO NOVATEK	Magellan Midstream Partners LP
7	China Coal Energy Co Ltd	Italgas S.p.A.	GAIL (India) Ltd		PJSC LUKOIL	Energy Transfer LP
8	ENN Energy Holdings Ltd	Royal Dutch Shell plc	The Tata Power Co Ltd			Chevron Corp
9	China Gas Holdings Ltd	BP p.l.c.				The Williams Companies, Inc
10	Kunlun Energy Co Ltd	Lundin Energy AB (publ)				Exxon Mobil Corp

Source(s): S&P Global Commodity Insights Top 250 Global Energy Company Rankings 2021. Note: S&P Global Commodity Insights measures companies' financial performance using four key metrics: asset worth, revenues, profits, and return on invested capital. The company rankings are derived using a special S&P Global Commodity Insights formula. They added each company's numerical ranking for asset worth, revenues, profits, and ROIC and assigned a rank of 1 to the company with the lowest total, 2 to the company with the second-lowest total, and so on.

Appendix 3: Data and Methodology of Quantitative Analyses in Chapter 7

Impact Assessment of SOE Reforms in China's Power Sector

The data on power generation firms was extracted from the Annual Survey of Industrial Firms (ASIF) that covers all SOEs and non-SOEs above the designated scale over 1998-2013. The scale threshold was an annual revenue of RMB5 million before 2011 and was raised to RMB20 million in 2011. The data reports detailed financial statements and other basic firm-level information, including but not limited to unique firm identifier, ownership type, capital structure, age, assets, sales, liability and employment.

The data on power generation firms' environmental performance was extracted from the Annual Environmental Survey of Polluting Firms (AESPF) over 1998-2013. It was compiled by the Ministry of Ecology and Environment of China and covers heavily polluting industrial firms, which account for 85 percent of county-level emissions of major pollutants (e.g., sulfur dioxide [SO_2], nitrogen oxide [NOx], dust, wastewater, Chemical Oxygen Demand [COD] and solid waste). The data reports detailed information on firm-level environmental activities, including generation and emission of each major pollutant, pollution abatement devices and energy consumption (e.g., coal), among others. For analysis of environmental performance, the AESPF data and ASIF data were matched by firm identifiers and firm names.

Impact Assessment of Privatization

A staggered difference-in-differences (DiD) analysis is conducted, following the methodology by (Callaway & Sant'Anna, 2021). The sample is restricted to firms that were wholly state-owned in the initial period and the partial privatization of an SOE is marked by the time when it introduces any private capital. Estimation is carried out in four steps.

First, treated groups (i.e., privatized SOEs) and their respective treatment time (i.e., the year of being first treated) as well as control groups, are identified. Control groups include both the "not-yet-treated" group and the "never-treated" group, i.e., SOEs that were not yet privatized or never privatized in the sample period. There is variation in treatment timing as different SOEs were privatized in different years.

Second, the generalized propensity score is estimated, that is, the probability of being first treated in the treatment year conditional on pre-treatment covariates and on either being a member of this first treated group or a member of the "not-yet-treated" group by the next treatment year (a special case is "never-treated" group). The covariates include firm-level characteristics such as age, fixed assets, sales, and leverage, as well as city-level characteristics such as city population, per capita GDP and industry structure.

Third, for each treated group and their respective control group, and for each outcome of interest, the group-time average treatment effect on the treated (ATT) is estimated with the generalized propensity score in weights. Outcome variables include economic efficiency (i.e., profitability, labor productivity, leverage, administrative expenses and employment) as well as environmental activities (i.e., SO_2 emission, NOx emission, dust emission, coal intensity and abatement devices).[2]

Finally, the multiple group-time ATTs are aggregated across years and across groups to obtain the overall treatment effect of privatization (Callaway & Sant'Anna, 2021). The estimation results are presented in Table 9.

Impact Assessment of SOE Green Personnel and Evaluation Policies

A canonical DiD setup with two periods (i.e., pre-treatment and post-treatment) and two groups (i.e., the treated group and control group) is employed. Specifically, the sample includes all polluting firms with environmental performance indicators in the power generation sector, the treated firms are SOEs, and the treatment time is 2010 when the policy was implemented.

[2] Profitability refers to the ratio between net profits and sales. Labor productivity refers to the logarithm of the ratio between sales and employment. Leverage refers to the ratio between liability and assets. Administrative expenses are rescaled by dividing by sales. Employment is in logarithm. All environmental indicators are in logarithm. Coal intensity refers to the ratio between coal consumption and output. Abatement devices refer to the number of air pollution abatement equipment.

The outcome variables of interest are firms' environmental performance, including log values of generation and emission of SO_2, NOx and dust. The estimation controls for a set of firm characteristics in the previous period including age, fixed assets, sales and leverage as well as city characteristics such as city population, per capita GDP and industry structure. Firm and year fixed effects are also included in the estimation. The estimation results are presented in Table 10.

Impact Assessment of Unbundling Reform

A canonical DiD is applied, with central SOE power plants as the treated group and 2002 as the treatment year (i.e., the year of unbundling reform). The outcome variables are selected economic and environmental indicators, including profitability, labor productivity, leverage, SO_2 emission, dust emission, coal intensity and abatement devices. The estimation also controls for the same set of previous firm characteristics, city characteristics and firm and year fixed effects, as the above DiD analysis. The estimation results are presented in Table 11.

Table 9: Impact Assessment of Privatization in China's Power Sector

	(1)	(2)	(3)	(4)	(5)
Dependent Variables	**Profitability**	**Labor Productivity**	**Leverage**	**Administrative Expenses**	**Employment**
ATT	0.0710***	0.208***	-0.0672**	-0.0840**	-0.156*
	(0.0153)	(0.0615)	(0.0292)	(0.0363)	(0.0863)
Observations	8,296	9,189	9,198	8,335	10,536
	(6)	**(7)**	**(8)**	**(9)**	**(10)**
Dependent Variables	**SO_2 Emission**	**NOx Emission**	**Dust Emission**	**Coal Intensity**	**Abatement Devices**
ATT	-0.0626	-0.0600	-0.376	-0.0714	0.0846
	(0.309)	(0.409)	(0.294)	(0.155)	(0.362)
Observations	1,686	371	1,679	518	1,223

ATT = average treatment effect on the treated, NOx = nitrogen oxide, SO_2 = sulfur dioxide.

Note: Standard errors are in parentheses and clustered at firm level. *** p<0.01, ** p<0.05, * p<0.1.

Data source: AIIB staff estimates.

Table 10: Impact Assessment of SOE Green Personnel and Evaluation

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variables	**SO_2 Generation**	**NOx Generation**	**Dust Generation**	**SO_2 Emission**	**NOx Emission**	**Dust Emission**
ATT	-0.130**	-0.0974	-0.237**	-0.773***	-0.114***	-0.385***
	(0.0265)	(0.0414)	(0.0502)	(0.0496)	(0.00937)	(0.0256)
Observations	2,900	3,078	2,903	3,436	2,962	3,440

ATT = average treatment effect on the treated, NOx = nitrogen oxide, SO2 = sulfur dioxide.

Note: Standard errors are in parentheses and clustered at firm level. *** p<0.01, ** p<0.05, * p<0.1.

Data source: AIIB staff estimates.

Table 11: Impact Assessment of Unbundling Reform

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent Variables	**Profitability**	**Labor Productivity**	**Leverage**	**SO2 Emission**	**Dust Emission**	**Coal Intensity**	**Abatement Devices**
ATT	0.0445**	0.205**	-0.0321*	-0.0154	-0.137	0.0518	-0.0333
	(0.0189)	(0.0831)	(0.0185)	(0.0714)	(0.113)	(0.0468)	(0.0409)
Observations	20,218	20,341	18,034	3,850	3,762	1,868	3,897

ATT = average treatment effect on the treated, SO2 = sulfur dioxide.

Note: Standard errors are in parentheses and clustered at firm level. *** p<0.01, ** p<0.05, * p<0.1.

Data source: AIIB staff estimates.

Private Participation in China's Environmental PPPs

The chapter relies on the National PPP Platform maintained by China's MOF for PPP analysis instead of the World Bank's PPI database. This is because the PPP definition in China is different from the one proposed by the World Bank, and the National PPP Platform covers all PPPs that conform to China's PPP definition. Specifically, by design, the World Bank's PPI database includes projects in which private firms have at least 20 percent participation, measured by equity share. Projects with a lower private participation rate and those with SOEs as the only sponsors are not considered. As such, it misses information on a considerable share of PPPs that follow China's PPP definition. During 2014-2020, the World Bank PPI database contains 701 Chinese PPP projects, totaling USD112 billion, while the National PPP Platform reports 9,882 projects, totaling approximately USD2,309 billion (RMB15,283 billion).

Two steps are taken to identify the ownership of project sponsors (i.e., social capital) in China's environmental PPPs. In the first step, the names of the sponsors are manually collected from the PPP contracts released on the National PPP Platform. In the second step, based on firm names, the ownership is manually searched and identified from a Chinese business registration database, i.e., Tianyancha.com, which provides information on ownership networks for more than 100 million firms.

A total of 1,129 environmental PPPs were recorded over 2014-2020, with 2,346 project sponsors. Of these sponsors, 31 percent are private partners and 66 percent are SOEs. Among the private sponsors, the vast majority are domestic and very few are foreign firms (one percent of total sponsors). This is in contrast with the situation in the 1980s and 1990s when foreign firms actively participated in China's build-operate-transfer (BOT) projects. The ownership type of the remaining three percent of project sponsors cannot be identified.

Impact Assessment of China's Regional Emission Trading System Pilots

In the analysis of China's emission trading system (ETS) pilots, the outcome variables of interest include carbon dioxide (CO_2) emissions, economic activities, green innovation, imports of environmental goods, as well as climate awareness. Specifically, the CO_2 emission data is from the Center for Global Environmental Research and at a spatial resolution of one kilometer. Economic activities are measured by nighttime lights intensity at a spatial resolution of 500 meters. The nighttime lights data is from Chen et al. (2021) and their data release on Harvard Dataverse. The green innovation is proxied by green patent applications from almost all patent offices in the world, rather than patents filed at China's patent office. The patent data is from the ORBIS Intellectual Property Database. Imports of environmental equipment are extracted from China's Customs trade dataset at the HS6-digit product level, based on the Asia-Pacific Economic Cooperation (APEC) List of Environmental Goods. Public awareness is measured by keyword search frequencies from the Baidu Index.

All these measures on outcomes are aggregated to city level and in log scale. For CO_2 emissions, nighttime lights and innovation, all the cities in China are covered over 2007-2019. For imports, the period is 2010-2017. For keyword search frequencies, only large cities are considered, as they have better access to internet and similar internet user preferences, and the period is 2011-2019.[3]

A staggered DiD approach is applied, following the methodology by Callaway and Sant'Anna (2021). Estimation is conducted in the following steps. First, treated groups (i.e., ETS pilot cities) and their respective treatment time (i.e., operation years of ETSs) as well as control groups are identified. Control groups include both the "not-yet-treated" group and the "never-treated" group, i.e., cities that implemented ETS schemes in the later years and cities that never had ETS pilots. There is variation in treatment timing as pilot cities implemented ETSs in different years (i.e., 2013, 2014 and 2016).

[3] Large cities refer to municipalities directly under the central government, provincial capitals, and sub-provincial-level cities.

Second, the generalized propensity score is estimated for each pair of treated and control groups, i.e., the probability of being treated based on pre-treatment city characteristics, including city population, per capita GDP, city industry structure, and regions (east, middle and west).

Third, for each pair of treated and control groups, and for each outcome variable, the group-time ATT is estimated with the generalized propensity score in weights. Then, the multiple group-time ATTs are aggregated to generate event-study-type ATTs. The estimation results are presented in Table 12.

Table 12: Impact Assessment of China's Regional Emission Trading System Pilots

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variables	**CO_2 Emission**	**Nighttime Lights**	**Green Patents**	**Imports of Environmental Goods**	**Carbon Word Frequency**	**Other Environmental Word Frequency**
T-5	0.00837	0.0161	0.0109			
	(0.0633)	(0.163)	(0.244)			
T-4	-0.0613	-0.104	-0.0949		0.108	0.0836
	(0.0459)	(0.132)	(0.203)		(0.122)	(0.133)
T-3	0.00505	0.194	-0.0793	-0.0399	0.200	0.0776
	(0.0414)	(0.147)	(0.209)	(0.191)	(0.229)	(0.329)
T-2	-0.0344	-0.0942	-0.239	0.259	0.320	0.218
	(0.0280)	(0.0951)	(0.168)	(0.296)	(0.346)	(0.266)
T-1	-0.00701	0.271	0.0565	0.183	0.0615	0.133
	(0.0303)	(0.183)	(0.131)	(0.186)	(0.162)	(0.0916)
T0	-0.0817	0.0111	0.162	0.0785	0.0248	0.0156
	(0.0570)	(0.0604)	(0.349)	(0.186)	(0.0998)	(0.129)
T+1	-0.101	-0.0510	0.0274	0.165	0.186	0.143
	(0.0677)	(0.238)	(0.243)	(0.349)	(0.194)	(0.134)
T+2	-0.160**	-0.0821	0.272	0.428**	0.235**	0.214*
	(0.0683)	(0.240)	(0.329)	(0.177)	(0.0972)	(0.114)
T+3	-0.194***	-0.0563	0.316	0.486**	0.264***	0.120
	(0.0713)	(0.268)	(0.436)	(0.224)	(0.0793)	(0.190)
T+4	-0.181***	-0.0219	0.0553		0.362*	0.0675
	(0.0489)	(0.116)	(0.250)		(0.207)	(0.280)
T+5	-0.247***	-0.0200	0.558**		0.448***	0.185
	(0.0579)	(0.161)	(0.283)		(0.128)	(0.183)
Observations	3,364	3,663	2,050	2,051	276	276

ATT = average treatment effect on the treated, CO_2 = carbon dioxide, ETS = emission trading system.

Notes: Standard errors are in parentheses and clustered at city level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Rows are event-study-type ATT relative to ETS operations. For example, T0 refers to the operation year of ETS pilots, T-1 refers to one year prior to the operation, and T+1 refers to one year after the operation.

Data source: AIIB staff estimates.

Appendix 4: Definition of SOEs in Chapter 8 and Summary Statistics

This analysis is based on the Annual Survey of Industries, 2018-19. The survey covers factories comprising industrial units registered under Sections 2(m)(i) and 2(m)(ii) of the Factories Act, 1948. Factories (this report calls them firms to be consistent with other parts of the report) are not readily identified as state-owned enterprises (SOEs) and Non-SOEs in the survey. Instead, the ownership criterion identifies firms into government and non-government.

With some margin of error, this ownership criterion is roughly classified into SOEs and non-SOEs for the analysis. Table 13 details the definitions and the sample sizes used in the analysis. The sample comprises around 53,000 firms, of which 681 firms can be identified as government-owned or state-owned enterprises (SOEs), while the rest are non-SOEs or private. As such, the SOEs are on average larger than non-SOEs in terms of net assets, but the sizes of many non-SOEs, however overlap with the SOEs.

In this analysis, fossil fuel intensity is measured as the total value of the fuel consumed in the form of electricity (own+ generated), petrol/ diesel/oil/ lubricants, coal, gas, and other fuel, as a share of total input cost. Following Ghosh et al. (2022), since approximately 60 percent of electricity is generated by coal, this share is used to adjust the contribution of electricity toward fossil fuels. Normalizing is done using total input cost.

Table 13: Identification Criteria of SOEs and Non-SOEs and Summary Statistics

Type	Identification Criteria
SOE	Government Company-Private (289)+ Government Company-Public (681). Total share = 1.30 percent (681 observation) A government company is a company where the paid-up share capital of the appropriate government (central, state or local) is not less than 51 percent. The classification of public and private is based on the number of shareholders.
Non-SOE	Non-Government Company-Private (21,273), Non-Government Company-Public (5,477), Proprietary (11,699), Partnership (12,152), Limited Liability Partnership (429), Cooperative Society (839), Others (333). Total share = 98.7 percent (52,202 observations) A non-government company is a company with paid-up share capital of the appropriate government (central, state or local) of less than 51 percent.

Data source: Annual Survey of Industries 2018-2019, and AIIB staff estimates.

Appendix 5: Data and Methodology of Quantitative Analyses in Chapter 9

Impact Assessment of Cross-Sectoral State-Owned Holding Company Reforms in Indonesia

Data

The data on company financials and employment were extracted from ORBIS database that covers commercially available information on SOEs and non-SOEs between 2013 and 2020. The ORBIS data reported detailed financial statements and other basic firm-level information, including unique firm identifier, four-digit sector activity classification, ownership type, capital structure, age, assets, sales, liability and employment. Given the relatively limited coverage of firms reporting financial information, only consolidated financial statements were considered. Branches and inactive firms were removed from the sample. The coverage varies across sectors, firms and over time. Therefore, to maintain a sufficient sample size, only an unbalanced panel was constructed.

Methodology

A difference-in-differences (DiD) analysis was conducted with two periods (pre-treatment and post-treatment) and two groups (the treated group and control group). The sample is restricted to firms in two sectors undergoing SOE restructuring into state-owned holding companies (SOHCs) prior to 2021 and firms in two sectors without such an intervention; mining and construction sectors and information and communication technology (ICT) and accommodation sectors, respectively. The data consist of 30 (7) firms in construction, 50 (4) in mining, and 72 (5) in ICT and accommodation sectors for listed private (SOE) firms.

SOEs are distinguished from private firms based on the classification methodology outlined in Appendix 1, and further supplemented by desk research and reconstruction of SOHC subsidiaries above the 25 percent ownership threshold and across multiple ownership "levels," using the ORBIS ownership data module.

For each sector, three sets of analysis were conducted with different treatment and control groups. In the first analysis, the restructured SOEs as the treatment group were compared with the private firms in the same sector. In the second analysis, the restructured SOEs were compared with the SOEs in other sectors (ICT and accommodation) that had not experienced holding company reform. In the third analysis, the private firms in a sector experiencing holding company reform were compared with their private peers in other sectors.

Intervention periods are defined as follows. The mining SOHC was established in 2017, and although announced in 2017, the infrastructure (predominantly construction sector) SOHC was formally established in 2018. Due to the short timing gap and expected market signaling from the announcement, year 2017 was selected as the intervention date for both sectors. As a form of sensitivity analysis, the results were repeated using staggered treatment event study analysis using the Sun and Abraham (2020) methodology, with similar results.

Detailed results of DiD regression are presented in Table 14. The table reports the point estimates of the impact of holding company reform with the significant levels and the number of observations. Employment, total assets and revenues are in logarithm. Profit margin refers to the ratio between net profits and revenue. Current ratio refers to the ratio between current liability and current asset. ROA denotes the ratio between net profits and total assets. Productivity refers to the logarithm of the ratio between revenues and employment. The estimations control for firm and year fixed effects.

Table 14: Regression Results

Dependent Variable	Assets	Employment	Revenues	Current Ratio	ROA	Productivity
Panel A: Construction Sector						
Reformed SOEs vs. Private firms in the restructured sector	0.541***	0.530***	0.865***	-2.700***	3.038*	0.282*
Observations	293	289	293	293	293	289
Reformed SOEs vs. SOEs in the un-restructured sectors	0.752***	0.675***	0.341***	-1.572	-3.529***	-0.359***
Observations	121	119	121	121	121	119
Private firms in the restructured sector vs. Private firms in the un-restructured sectors	0.100	0.058	-0.441***	2.254***	-0.244	-0.449***
Observations	742	730	742	736	729	730
Panel B: Mining Sector						
Reformed SOEs vs. Private firms in the restructured sector	0.009	-0.145	-0.269	0.551	-1.369	0.132
Observations	413	404	413	411	412	404
Reformed SOEs vs. SOEs in the un-restructured sectors	0.022	0.140	0.270	-1.044*	2.104	0.142
Observations	96	96	96	96	96	96
Private firms in the restructured sector vs. Private firms in the un-restructured sectors	-0.089	0.203**	0.625***	-0.548	9.752***	0.218*
Observations	887	868	887	879	873	868

ROA = return on assets, SOE = state-owned enterprise.

Note: *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Data source: AIIB staff estimates.

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ASIAN INFRASTRUCTURE FINANCE 2022

MOONSHOTS FOR THE EMERGING WORLD

Building State Capacity and Mobilizing the Private Sector Toward Net Zero

The net-zero transition is increasingly characterized as a "moonshot," a once-in-a-lifetime inspirational project requiring a mission-driven industrial policy with coordination across all parts of the economy, and in the end globally. In emerging and developing economies these "moonshots" are very much about speeding up innovation and adoption of green innovation elsewhere but doing so in a mission-driven purposeful manner. Reaching net zero in time will be the greatest challenge for state capacity to date for these economies. The impact of climate change will be the most severe where state capacity is in the shortest supply. The state will need to work with all the instruments it has at its disposal, harnessing the private sector and working with development partners, but it must go beyond individual instruments and collaborations and step in to solve coordination failures. The 2022 Asian Infrastructure Finance report by the Asian Infrastructure Investment Bank examines the main "tools" of the state—the state-owned enterprises, the state-owned financial institutions and private-public partnerships together with national innovation and technology adoption frameworks—and how these can work together to accelerate the net-zero transition.

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