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Co-benefits, contradictions, and multi-level governance of low-carbon experimentation: Leveraging solar energy for sustainable development in China

Abstract

China's photovoltaics poverty alleviation (PVPA) initiative is an ambitious and innovative programme that explores the synergy between renewable energy and sustainable development by using photovoltaics to generate income for impoverished households and communities. However, policy experimentation in China is a decentralised process that is shaped by both central and local actions. This paper examines the experimentation of the PVPA from a multi-level perspective based on Heilman's *experimentation under hierarchy* framework. Drawing from empirical evidence collected over two years from a PVPA pilot, we show that China's multi-level approach to experimentation requires dynamic mechanisms that enable the adaptation of national-level models to specific locations. The resulting experimental governance thus extends from a combination of top-down mechanisms of control, bottom-up responses, and the broader contradictions that emerge from their interactions.

Keywords: low-carbon experimentation; renewable energy; sustainable development; co-benefits; multi-level governance; China

1. Introduction

The last two decades of climate research have provided two key insights into the governance of climate change at the subnational level. The first insight is the realisation that targeted climate change mitigation policies can have co-benefits and has led to an interest in sub-national climate action as providing 'bundles of opportunities' (Heinrichs et al., 2013; Koehn, 2008). In particular, there is a growing emphasis on integrating renewable energy with sustainable development goals in developing countries, such that investment in renewables is not just environmentally friendly but also produces economic and social benefits for the poor (Holden et al., 2014; Kumar et al., 2017; Lu et al., 2015). However, despite the evidence of co-benefits, some commentators have questioned whether low carbon policies can be pro-poor as they depend on infrastructure investments that may exacerbate endemic poverty (Colenbrander et al., 2017). The second insight is the need for more considerable attention to the mechanisms of multi-level governance—that is, to complex systems of networked actors operating at multiple levels, through formal and informal mechanisms—as an effective means to deliver climate policy (Di Gregorio et al., 2019). However, there is a concern about the extent to which the diversification of governance means results in a blame avoidance game, whereby responsibilities are displaced towards increasingly unaccountable levels of government (Bache et al., 2014). Low carbon policies are shaped by inherent contradictions which are not always reflected in the narratives of action but become painfully evident during the process of implementation (Castan Broto, 2015).

These contradictions around both decentralisation and multi-level governance have become visible in China's photovoltaics poverty alleviation (PVPA) initiative, whose objective is to

use renewable energy to deliver sustainable development objectives. While it is common for governments and international agencies to use renewable energy systems such as photovoltaics, biogas and small hydro for addressing energy access and environmental protection issues (Alstone et al., 2015; Chen et al., 2012; Chen and Liu, 2017; Kong et al., 2015; Pang et al., 2015; Sovacool and Drupady, 2012), the PVPA is different as it aims to use renewable energy to generate direct financial benefits for impoverished rural communities and households (Geall et al., 2018; Zhang et al., 2018). As such, the PVPA explores the potential of a new social co-benefit of low-carbon policies.

The PVPA illustrates a distinctly Chinese style of formulating policy—a process that involves conducting a large number of local policy experiments through multi-level governance (Chen et al., 2017; Smart and Smart, 2001; Zeng, 2015). This style has been described as *experiment under hierarchy,* and it is shaping environmental policy not only in China but also in the global arenas where China is increasingly perceived as a leader in delivering low-carbon policies (Andrews-Speed and Zhang, 2018; Lo, 2016; Shin, 2018; Urban, 2015). The notion of policy experimentation that we present in this paper follows Heilmann's characterisation of policy development in contemporary China as a dynamic process comprising bottom-up experimentation and top-down control (Heilmann, 2008b). The consequences of this approach are evident on the ground: local governments are tasked with formulating substantive policy, and their experience plays a significant role in shaping national policy. The Chinese government has put forward a success story based upon this experimentation approach, which links it with wider aspirations to demonstrate leadership in climate policy worldwide (Hansen et al., 2018). However, while ideas of eco-civilisation have shifted local policies and planning paradigms in China, environmental management decisions still rely on a techno-efficiency paradigm where technology implementation is prioritised over other welfare and ecological protection concerns (Pow, 2018; Westman and Castán Broto, 2019). The case of the PVPA provides an opportunity to examine the specific features of the policy experimentation style in China, particularly with reference to the emerging concerns in global environmental governance about the delivery of wider co-benefits for the poor and how to facilitate multi-level governance.

2. Multi-level governance and experimentation

Experimentation has emerged as a paradigm in research on climate change governance, particularly linked to ideas of radical change and societal transitions (Turnheim et al., 2018). At the local level, climate change experiments have been embraced as a means to intervene to deliver urgent action in the context of uncertainty (Castan Broto and Bulkeley, 2013; Madsen and Hansen, 2019; Reed et al., 2015). However, in-depth analyses of urban experimentation have suggested that experiments emerge alongside a process of state reconfiguration that requires new means of governing and controlling people and environments (Bulkeley et al., 2014). This critical work points towards how states can adopt experimentation as a strategy to reach locales which were previously outside of control. China's experimental style of governing climate change is a prime example of this.

In his influential paper, Heilmann (2008b) developed an account of China's experiment-based policy cycle to explain the country's capability of introducing socioeconomic reforms. At the heart of the experimentation under hierarchy model is the conduct of centrally coordinated but locally implemented experimentation being extensively used to guide policy

formulation and institutional reforms. By conducting multiple experiments in different localities, novel solutions emerge by trial and error and can be learned and adopted by central policymakers (Xu, 2011). The model explains how China's policy cycle is significantly different from the conventional model commonly adopted in democratic polities, especially regarding the presence of top-down control and the conduct of local experiments through implementation:

> The conventional model of the policy process that is widely taken for granted by jurists, economists, and political scientists holds that policy analysis, formulation, and embodiment in legislation precede implementation. Policy experimentation, as presented in this study, means innovating through implementation first, and drafting universal laws and regulations later. (Heilmann, 2008b, p.4)

China's experiment-based policy cycle can be thought to consist of three stages: small-scale piloting, large-scale piloting, and nationwide implementation. In the first stage, a small number of local governments became "experimental points" in charge of developing the policy from scratch. The central government select pilots based on three principles. The first principle is voluntarism, which holds that local governments should be willing to become pilots. Typically, calls-for-applications are issued, and the central government selects pilots from a pool of applicants. Local governments could be interested in becoming a pilot for several reasons such as perceived personal, institutional, and local benefits of experimentation, individual preferences for innovation and the presence of supportive communities of practice (Shin, 2017; Teets et al., 2017). The second selection principle is capability: local governments need to demonstrate that they can conduct policy experimentation. This is evaluated based on their past record of relevant experimentation, as well as the quality of the prepared application. The third principle is diversity, which means that the central government aims to select pilots from different parts of the country to ensure the results of policy experiments are meaningful at a national level (Khanna et al., 2014).

Financial subsidies are sometimes provided by the central government to support local experimentation, but this does not always happen (Lo, 2015c). Local experimentation at the first stage is sometimes guided by central policy documents, but if they exist, the instructions are often vague at this point, consisting mainly of key principles and policy rationales (Heilmann, 2008a). Local experimenters would formulate strategies based on these principles. The local experimentation process at this stage is also shaped by regular inspection and end-of-term evaluation, where experiences are summarised. Feedback and consultation between national policymakers and local experimenters are facilitated by regular conferences that deal with the lessons learned from local experiments (Heilmann, 2008b).

When the central government deems that sufficient experience has been generated in the first stage of experimentation, the policy process proceeds to the second stage, which also involves piloting but at a much larger scale. This stage is known in China as 'from point to surface' (Heilmann et al., 2013). In this stage, new piloting opportunities are extended to a much larger number of local jurisdictions. Experimentation is again encouraged and guided by top-down policy documents, which usually contain more specific policy details. In this stage, communication is continued between the first wave of pilots and the second wave, as well as between the pilots and the central government. Again, local experiences would be communicated to the central government, which may result in timely policy adjustment in light of the new information provided about problems faced during experimentation. The

second stage is terminated when the central government deems the policy is sufficiently mature to be implemented nationally through central directives, government regulations or law (Heilmann, 2008b).

The language of pragmaticism and experimentation is encapsulated in popular maxims, such as Deng's famous 'cross the river by feeling for the stones.' Experimentation is prominent in the rhetoric of policymaking in China, dating back to the foundation years of the Chinese Communist Party (Heilmann, 2008a; Mei and Liu, 2014). This suggests that policy experimentation is a durable and institutionalised governance mechanism in China. Empirical evidence in support of the experiment under hierarchy model can be seen in studies examining very different policy areas—from economic development to housing policy to rural reforms (Heilmann et al., 2013; Millar et al., 2016; Teets, 2015; Zeng, 2015; Zhu and Zhang, 2015; Zhu and Zhao, 2018)—although fewer studies have linked it to policy innovation in the context of environmental and climate governance (Miao and Lang, 2015; Shin, 2018).

Policy experiments are influenced by both top-down and bottom-up politics, although how contradictions between the two processes emerge and shape local experimentation has been subjected to continued debate. From a top-down approach, the central government coordinates local experiments by choosing individuals and institutions as local experimenters, shaping the content of experimental programmes through policy guidance documents, and selectively adopting local lessons to be emulated by others (Heilmann, 2008b; Mei and Liu, 2014). However, in light of weakening ideological control, perceived effectiveness of central control mechanisms depends on the extent to which central policymakers can access information about the performance of local experimenters (Lo, 2014). The lack of financial support, conflicting demands from different central ministries, and the complexity of the evaluation system have further weakened the impact of top-down control (Kostka, 2016; Ran, 2013; Teets et al., 2017). From the bottom-up, given the varied local conditions in China and the fact that the interests of local experimenters and central policymakers often differ, policy experimentation can take on distinct local characteristics or can be co-opted to serve local priorities (Eaton and Kostka, 2014; Lo, 2014; Wu et al., 2017). Theoretical and empirical evidence suggests that when ideals of national experimentation are situated in local contexts the contradictions are inherent to the delivery of China's experiments become visible, as the example of the PVPA demonstrates.

3. Background and methodology

Despite experiencing unprecedented economic growth since the 1980s, China's impoverished rural population stood at 56 million at the end of 2015 (State Council, 2016). Rural poverty is concentrated in interior China, reflecting the entrenched developmental imbalance between the wealthy coastal regions and poor hinterlands (Lemoine et al., 2015; Liu et al., 2014; Lo et al., 2016). President Xi Jinping's highly-publicized, well-resourced and whole-of-government strategy to eliminate rural poverty by 2020 called for a massive increase in funding for poverty alleviation alongside the adoption of a more targeted approach to addressing the longstanding problems of administrative inefficiency and waste (Liu et al., 2017). The concept of 'targeted poverty alleviation' was introduced, referring to the government's improved ability to identify those living in impoverished conditions, as well as developing mechanisms of tailored assistance to alleviate causes of poverty (Zhou et al., 2018).

The PVPA has emerged as a central component of the grand poverty alleviation strategy and is designated as one of the government's top ten poverty reduction initiatives (Zhang et al., 2018). In addition to its primary objective of poverty alleviation, this policy is also intended to contribute to the achievement of China's ambitious renewable energy targets and stimulate domestic demand for PVs in the context of American and European embargos (Andrews-Speed and Zhang, 2018; Geall et al., 2018). The central government positions the PVPA as a means of generating income for those who live in remote and rural areas and are unable to work, such as the elderly and the disabled. To achieve the pro-poor objectives, the PVPA is supported by many policies. The main supportive policy is the solar feed-in tariff policy, which guarantees PV stations, including PVPA stations, a fixed income of 20 years (Li et al., 2018; Lo, 2015a). For the majority of cases, electricity produced by PVPA is sold to the grid rather than consumed at source in order to maximise benefits from the feed-in tariffs, which are currently set at 0.65-0.85 RMB/kWh, depending on location.

The pace of policy development of the PVPA has been fast, even by China's standard. The experimentation of the PVPA started in October 2014, when the National Energy Administration (NEA) and the State Council Leading Group Office of Poverty Alleviation and Development (OPAD) jointly announced the plan to conduct piloting in 30 selected counties in six provinces (Anhui, Lingxia, Shanxi, Hebei, Gangsu, and Qinghai). In March 2017, the NEA announced the second experimentation phase (2017-2020), which would cover 471 impoverished counties in 16 provinces and would benefit 2 million households from 35,000 villages. By the end of 2017, PV stations with a total capacity of 5.5 GW had been deployed, providing an income stream to 965,000 households (National Energy Administration, 2018).

To explore the dynamics of local PVPA experimentation, empirical fieldwork was conducted in a pilot location in interior China, which will be referred to throughout the paper with a pseudonym (North County). North County was chosen as a case study because it is a site of PVPA experimentation. The county is a remote and largely rural area with a vast, open, flat terrain and a semi-arid, continental, monsoon climate. The county's economy is heavily dependent on agriculture, especially corn. The natural environment is characterised by the profusion of unfarmable saline-alkaline flatland, comprising approximately 50% of the total area of the county (Figure 1). The degraded environment and its remoteness contribute to widespread poverty: in 2017, there were over 90 villages officially designated as impoverished with more than 40,000 registered rural poor, or approximately 10% of the population. Due to ample sunshine and the abundance of saline-alkaline land, North County meets the requirements for PV installation of good sunlight and a large area of flatland. The experimental objective of the county is to support 10,000 impoverished households through the PVPA.

Two rounds of fieldwork were conducted over a two-year period (2017 and 2018). The objective of the two rounds of fieldwork was to trace the impact of policy changes on local experimentation. The sample included 21 interviews with key informants with government officials from three different levels of government (the provincial-level energy and poverty offices, the energy and poverty offices of North County, and the leaders of village governments that have implemented the PVPA) and 15 interviews with members of impoverished households in nine PVPA villages. These villages were chosen because they had PV stations installed in 2017 (Figure 2). For the selection, we used information published

in both the Renewable Energy Feed-in Tariff Subsidy List published by the Ministry of Finance and the North County Photovoltaics Poverty Alleviation Evaluation Report published by the county government. The PVPA projects in all nine villages were built in the first half of 2017 and connected to the grid by the end of June, meaning that they had been operational for one year at the time of our second visit in July 2018.

Figure 1. A typical landscape of North County

Figure 2: A PV station constructed under the PVPA, with the beneficiary village at the background

4. Top-down politics

The document analysis and interviews show the central government shapes local PVPA experimentation primarily through two means: the promulgation guiding policy documents and the approval process, which is required before a locality can become a pilot. Our analysis suggests the central government is conscious of creating space for local governments to experiment with different policy options, but at the same time not afraid to interfere when it deems necessary. This results in an ad-hoc policy refinement process that results in a shift from governance by goals to governance by rules and can be seen as a product of policy learning from local experimentation.

During the early phase of experimentation, the central government attempted to encourage experimentation with different practices in order to identify what might work best. The lack of practical knowledge at this stage meant that the central government had to rely on defining goals to guide local experimentation. The Opinion on the Implementation of PVPA (OIP) released in April 2016 directed attention to the pro-poor objective (providing households without labour ability at least 3000 RMB per year for at least 20 years) sought by the central policymakers rather than to the specific implementation instructions.

Nevertheless, the central government highlighted certain key issues that require the attention of local policymakers and provided some policy options as the foundation of experimentation. For example, while the OIP stated that the PVPA was not applicable everywhere, it did not identify eligible villages. Instead, the OIP tasked county governments with identifying suitable villages with establishing clear rules and transparent processes to ensure the selection outcome is fair. Similarly, the OIP stated that impoverished households and villages should not be required to contribute funds to the implementation of the PVPA, but did not specify what other funding mechanisms the PVPA should use. Instead, the OIP suggested that the local government could use the poverty funding and low-interest loan from the Agricultural Bank and the National Development Bank to support the PVPA. The OIP also recommended three types of PV projects: rooftop solar power (RSP), village-level solar power (VSP) and centralised solar power (CSP). RSP refers to small scale solar units installed in individual houses and owned by individual households. VSP are medium-scale power stations installed within a village jurisdiction, owned by the village committees who are responsible for managing the collective economy. CSP are large-scale power stations owned by companies and requiring a significant investment in CSP.

In 2018, we noticed how the central government has considerably strengthened the top-down control by establishing additional rules, which introduced more limits on local discretion (Table 1). The Management Methods of the PVPA (MMP), released in March 2018, introduced a series of restrictions over programme eligibility, such as stating that the construction site cannot belong to agricultural land or non-agricultural construction land. This came in addition to other land-use regulations that ruled out the development of ecologically significant land. It emphasised that the village collective should be the main beneficiary of the income generated from the PVPA, although the use of the funds must be for poverty alleviation purposes. The MMP strongly promoted VSPs, likely from experiences showing that the cost of rooftop systems is too high whereas the CSP has often been exploited to circumvent the solar power quota imposed by the central government. The MMP also introduced clear regulations over the size: 300 kW for a typical VSP, which can be relaxed to

500 kW if technical conditions such as grid capacity are met. In one of the most striking policy changes, the MMP strictly forbade local governments to finance PVPA through borrowing over the concern that borrowing would mean that less money was going to poor households.

The approval processes were also modified in 2018 to strengthen central control of PVPA experimentation. At the early phase of experimentation, the central government did not control the approval process, in the sense that applicants could rely on getting permission quickly, according to our interviewee. In 2018, the central government introduced an online approval system of PVPA that imposed strict design parameters, such as the size of the proposed power stations. As an interviewee from the energy office explained:

> The State Council developed a new system to manage the approval of PVPA projects. To apply for the PVPA, we need to login to the system and choose a province, and then a county, and then a village, and then the system automatically generates the number and names of the impoverished households from the national database. The system set the size of PV stations at five kW-7 kW per household, so, for example, if the village has 20 poor households, you can only choose to build a PV station of 100 kW-140 kW. (an energy office official)

Access to the new approval system was given to the poverty office only. As the energy official noted, 'the whole approval process has to be initiated by the poverty office; we (the energy office) provide support after it is approved. This is because we were not given access to the system'. Thus, by refusing the energy office access to the approval system, the central government sought to make the poverty office more involved in the planning process.

Table 1. Comparison of top-down control in 2017 and 2018

	2016	2018
Responsible agency	No clear guideline.	The poverty office should be in charge.
Site selection	Tasked local governments to establish clear rules and transparent processes to ensure the selection is fair.	Forbade the use of agricultural land or non-agricultural construction land for building PVPA.
Technical design	Provided three options: No clear guideline. Roof-top solar power (RSP), village-level solar plants (VSP), and concentrated solar plants (CSP).	VSP as the preferred mode and there are guidelines on size of VSP (300-500 kW).
Funding mechanisms	Local government should use poverty funding and/or low-interest loan.	Ban to prevent local governments to finance PVPA through borrowing.

5. Bottom-up politics

The energy office, the poverty office, and the forestry office were the main players in bottom-up politics over the experimentation of the PVPA. The PVPA requires expertise in both

renewable energy and poverty alleviation. However, the experimental approach was made difficult by unsupportive local authorities.

One of the key bottom-up factors in North County was that the poverty office refused to get involved with the PVPA. This is quite puzzling given that the PVPA should help the poverty office achieve its political target of eliminating poverty by 2020. The poverty office's refusal to get involved was often made on technical grounds; that the poverty officials do not have relevant technical expertise, so it is best to hand responsibility over to the energy office. However, when probing deeper, the poverty officials expressed surprisingly critical views about the PVPA, especially regarding the ways it helps the poor:

> The PVPA is going to turn people into lazy people, sitting at home waiting for income. It is quite an idealistic thought to give impoverished households 3000 RMB for 20 years, but that is just going to make people lazy. When we talk about poverty alleviation, we focus on self-help. We provide people with means of production, like a few sheep and cows to help them get milk, or some seed and equipment to help them grow fruit, but you have to work hard and succeed through your own effort. It is about giving people the means to generate income, not giving people money directly. (a poverty office official)

This comment indicates that the PVPA faced ideological challenges from the local poverty office. In particular, the idea of giving money to the poor—which is the key goal of the PVPA—contradicts the belief held by the poverty officials at North County, which in Chinese is expressed as it is best to be 'teaching to fish' (i.e., creating new economic opportunities) rather than 'giving fish' (i.e., giving money to the poor) because the former is believed to be more sustainable while the latter creates dependency on the state. However, the central government now recognises that both 'teaching to fish' and 'giving fish' strategies can be effective and complement each other (State Council, 2018). The local attitude towards the PVPA is a symptom the discursive gap between the central policymakers and local officials. Lieberthal and Oksenberg (1988) argue from an institutionalist perspective that the success and failure of specific policies in contemporary China depend on consensus-building and cooperation among a significant number of policy actors. Such consensus building was clearly lacking in the poverty office of North County.

The poverty office's refusal to cooperate created two problems. First, the energy office had to conduct the experiment almost all by itself and, consequently, the design of PVPA did not have adequate input from the poverty office. Lack of input prevented the integration of the PVPA into a more comprehensive poverty alleviation strategy. Instead, technical factors dominated the PVPA design. Villages were chosen to install PVPA primarily on technical feasibility, particularly the capability of the grid to support the additional load created by the PV stations, rather than poverty alleviation needs. While the chosen villages were genuinely poor, many poor villages were ruled out of the implementation plan simply because they did not have enough grid capacity. The conservative size of the solar power stations stemmed from concerns over grid capacity.

Inadequate funding for experimentation was the second problem. Despite the consistent decline in costs, constructing PV stations remains capital-intensive and requires significant upfront costs (Andrews-Speed and Zhang, 2018). Since the central government required that villages or households not be asked to pay, it was left to the local governments to figure out ways to finance the projects. Like many other policies, the central government did not create

specific funding tied to the PVPA. Instead, the central government wanted local governments to use funds earmarked for poverty alleviation to support the PVPA. North County was a national level poverty county and therefore received significant funding from the central government in support of its poverty alleviation activities. However, the funds earmarked for poverty alleviation were tightly controlled by the poverty office, who refused to release the funds to support the PVPA. With no other source of funding, the energy office had to limit the scale of the project, as well as request the contracted PV developers to help secure a loan from the bank, and to pay back the loan from the income generated by the solar power stations. This approach further reduced the ability of PVPA to support the poor.

Another contradiction made obvious during the experimentation in North County was the conflicts between the energy office and the forestry office over land use. PV is land-intensive and the central government had explicitly forbidden the conversion of productive farmland into PV stations. In North County, during site selection, the energy office made sure that the PV stations were built on non-farmed land, such as saline-alkaline land. However, a large tract of the land had been classified as wetland of national significance and, therefore, was under the jurisdiction of the forestry office. Nevertheless, the local forestry office was not consulted during the site selection process, and after it found out that some PV stations were built on wetland designated as nationally significant, it ordered the PV stations to be removed. As a result of the removal, the villagers stopped receiving PVPA income, and they received no information or guarantee on whether they would ever get a new PV station. Land conflicts affected future projects as well. The village officials informed us that it became very difficult to build new PV stations because of the objection from the forestry office. Lack of enrolment of the Forestry Office at the earlier stages of the programme had further consequences for the future development of the PVPA.

6. Contradictions and consequences

The contradictions of top-down and bottom-up politics discussed above eventually shaped the possibilities of local experimentation in North County. The local energy office, as the lead PVPA experimenter, was placed in a difficult situation. On the one hand, it needed to fulfill the central government's goal of quickly installing PV to ensure that impoverished households would receive 3000 RMB per year, and on the other hand, it needed to design and implement the experimentation plan without the support of the other local bureaucracies, especially the poverty office.

Despite the difficulties, the energy office was able to move quickly. A company was promptly set up by the energy office to manage the projects and handle the tendering procedure, although the village collectives would be the official owners of the PV stations. Contract tendering was released in February 2017, and contracts were awarded based on the price and historical record of the companies. While it is reported that rent-seeking and local protectionism are common in photovoltaic project development (Kayser, 2016), there was no local preference as there were no PV manufacturers in North County. The contract was ultimately awarded to several top-tier companies from Jiangsu, China's leading PV production base. What followed was a frenzy of construction activity, which had only just begun in April because the long winter made it impossible to begin earlier. The energy office pushed to complete the installation—that is, to connect to the grid and produce electricity—before the end of June, less than a year after the start of the experimentation. The State Grid

made the feed-in tariff payments generated by the PV stations to the poverty office, who then distributed the funds to the village committee. We verified with the impoverished households that they received the payment of 3000 RMB—the minimum amount required by the central government—in a timely manner, with the money deposited directly into their bank accounts. Most of those who received the funds had disability issues or were elderly people who had little ability to earn wages. The income they received was mostly spent on daily necessities such as medicine and food.

Notwithstanding these positive results, there are some notable limitations and concerns that negatively affected the pro-poor impact of the PVPA in North County. The first problem was that the energy office had to limit the scale of experimentation. While there were close to a hundred officially impoverished villages in the county that were eligible to participate in the PVPA under the guidelines defined by the central government, only nine PV stations were built by mid-2018, with no plans for more projects. Consequently, many impoverished households were unable to benefit from the PVPA. Most of the built PV stations were small (100 kW capacity). Capacity limited the amount of income that the PVPA could generate and reduced efficiency (Wu et al., 2018). All households and village officials to whom we spoke stated that they preferred the PV to be larger and generate more income, which was both an endorsement of the PVPA and a critique of the size of the PV stations.

The second concern is over the distribution of the benefits. While we could confirm that impoverished households received 3000 RMB a year payment, there was no guarantee of how long such payment would continue. Interviews with village officials revealed that there were plans to cease payments after 2020. Instead, PVPA-generated income would be given directly to the village-level government with the discretion to spend it as it sees fit. In this case, the village heads intended to use this income to fund a health insurance scheme benefiting everybody- not just the poor- in the village. Such approach goes against the central government's pledge to support impoverished households for at least 20 years. As one official put it, 'there will be no more poor people by 2020 according to the central government'. This represents a vision of poverty as a one-off, simple problem. Poverty is, however, a complex problem that depends on structural drivers of vulnerability. For example, PVPA benefited mostly the elderly and other groups of the population who are generally unable to work or access any other income. These poor households often cited illnesses and disabilities and made it clear that they were not able to escape the poverty trap without consistent support. However, local officials seemed unable to focus on action to address the structural drivers of poverty, deploying instead clichés about the distinction between lazy and deserving populations. The PVPA payment was conceived as a one-off experiment rather than as a long-term consistent strategy to alleviate poverty.

The new approval system and guidelines introduced by the central government intended to address some of these experimentation problems. These changes, however, came too late for the projects already built in North County. Furthermore, the transfer of responsibility to the poverty office may not have made a difference because the poverty office remained steadfastly uninterested in the PVPA. While there was significant potential for future expansion, the local government currently has no plans to build new PVPA stations now, or in the foreseeable future.

7. Concluding remarks

Environmental governance in China is typically conceptualised as a top-down process (Lo, 2015b), but examining the PVPA from a multi-level governance perspective shows that both top-down and bottom-up politics are essential in the context of policy experimentation. Local governments, as the primary implementers of the experimental approach, are empowered to make decisions according to their local settings, capacities, and constraints. Local discretion, subject to restrictions imposed by top-down control, is important in encouraging pragmatic innovation. The central government systematically orchestrates local experiments. These experiments are the means whereby the central government gathers information about what works and what does not through local experiences and then refine the policy in a step-by-step fashion. Tasking local governments to experiment through implementation also has the advantage of expediting the policymaking process. PVPA is a highly innovative policy, which means that it could be time-consuming for the central government to understand—let alone to weight—the intended and unintended consequences of the many different options in the technical, financial, and management components of the program. By not having to work out a detailed plan, China's approach allows for the quick introduction and implementation of PVPA.

Initially, the case study suggests that China's attempt to explore new, pro-poor, co-benefits of low-carbon policies through policy experimentation has been frustrated by the contradictions between top-down and bottom-up politics, manifested by uncooperative local officials. Environmental governance can be mobilised to suggest a menu of options about how to improve the implementation of the PVPA, for example, through an engagement with conventional ideas of coordination and alignment. For example, collaboration among the energy office, the poverty office, and the forestry office since the beginning of the project could have delivered radically different results. Cultural change in the poverty office about the co-benefits of energy policies could have helped them to embrace the programme differently. A better understanding of the qualitative characteristics of poverty could have helped define targeted programmes for poverty reduction. These are all reasonable proposals. However, while we would not be opposed to any of those proposals, we think such analysis misses the point.

The Central government uses the experimental approach not only to deliver policy but also, to design and test that policy. Developing a new policy is costly, disruptive and prone to failure. This approach enables the central government to fit policies on the go, without initial investment on the assumption that failure is allowed. In the PVPA case, for example, there is not only experimentation with technology and financial models, but also with the context of governance in which this policy is implemented. Bulkeley et al (2014) have argued that rather than looking at low carbon experimentation as a collection of separate, indeterminate projects we should be thinking of experimentation as the primary way in which energy and the climate are governed (cf. Turnheim et al., 2018). From this perspective, China provides an example of a system of governance which not only allows the experimentation approach but also, explicitly pursues it. The case of China also demonstrates that experimentation is not inherently benign. Bottom-up imaginations of community-based, low carbon experimentation contrast with the evidence that experimentation is a common approach among authoritarian states and obscure multinationals.

Decentralising policy experimentation pushes the burden of policy development and the risk of failure to local governments, and thus may become sources of central-local conflicts.

Given that local governments, especially at the county level, have limited resources and capacity, and that they often do not receive sufficient financial support from the central government for conducting policy experiments, it is not at all surprising that experimentation results are often not ideal. On the other hand, these results have shaped a new generation of poverty alleviation policies. As Castán Broto (2015) has argued, the contradictions embedded in low carbon policies are the engines that continue moving action forward. However, moving forward comes at a cost. Low carbon policies should not be assumed to be inherently benign, as it became evident with the conflicts around the wetlands in North County.

In sum, our analysis shows that the model of experimentation under hierarchy requires dynamic mechanisms that enable adapting national-level models to specific locations. The results emerged from a combination of top-down mechanisms of control, bottom-up responses and the broader contradictions that emerge from their interactions. In the case of the PVPA, the visionary approach of the national government—linking explicitly environmental and sustainable development goals—encountered resistance on the part of local authorities. Conversely, national visions were hindered by top-down mechanisms of control, which stiffened the possibilities for local appropriation and innovation in context. The experimentation under hierarchy approach is a strategy to deliver policy incompletely while sticking to ambitious goals. In practice, however, the question that matters is what transformations these policies enable? There is scant evidence of a democratisation of environmental governance or an actual material transformation of people's lives. The appropriation of experimental approaches within what is, in essence, a technocratic state apparatus removes both ambiguity and potentiality and delinks experimentation from sustainability transformations.

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