Market-based instruments for ecosystem services: framework and case study in Lishui City, China

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ABSTRACT

Introduction: Effective provision of ecosystem services (ES) and improvements in well-being of residents can be realized through policy interventions of stakeholder behavior. Of the several policies, market-based instruments (MBIs) have become the focus of global attention.

Outcomes/others: To couple the theory with practice and solve the key problem of unclear definition of property rights, the framework of MBIs is designed. First, property rights of market creation must be clearly defined, verifiable, transferable, enforceable, and have policy continuity. Then, four key characteristics of MBIs need to be considered in the case design, namely those involving ES, stakeholders, trading mechanisms, and guarantee mechanisms. The Pledge Financing of the Right of the Ecological Public Welfare Forest (PFREPWF) in Lishui City is a typical case of China’s current marketization, which is a supplement and improvement to the ecological compensation policy. Based on clearly defined contract rights, Lishui City has realized the integration of ecological compensation and credit creation.

Discussion: The case design still has the problems of lack of quantification and lack of correlations with ES.

Conclusion: The theoretical and practical analysis around the market mechanism has reference value for solving market failures and providing environmental services.

Introduction

The Decades of double-digit economic growth have made China the fastest expanding major economy in history, while saddling the country with likely the worst environmental crisis facing any civilization. China’s ecosystems are very fragile due to severe land degradation, erosion, desertification, water scarcity, and pollution. Ecological threats continue to increase in scales and severity across China, due to rapid urbanization and consumption of natural resources (Mandle et al. 2019). Despite their obvious importance to our well-being, ecosystem services (ES) have largely been ignored in both domestic and international markets, laws, and policies (Whitten and Shelton 2005).

Most existing laws and policies are formulated and enacted to implicitly or explicitly provide ES. While present market has been found to be ineffective in ES supply, for it fails to induce stakeholders to use and manage natural resources in a sustainable way (Randall 1983; Whitten and Shelton 2005). To put it another way, entire costs of supply decisions have yet to be wholly reflected by ES market prices. Supposing that trees in one cubic meter have been chopped down, then the price to be paid actually excludes the cost of natural resource depletion or natural capital degradation (Stuart M. Whitten et al. 2007), in particular true of ecologically sensitive districts.

The degradation of natural capital is the consequence of market dysfunction, which ought to be fixed via the market in ideal consequences (Lockie 2013; Gao et al. 2019). It actually comes from such a proposition claiming that a normal market should take natural capital protection and reproduction that it relies on into consideration. Consequently, cost of conservation, as sort of production cost, needs to be internalized and delivered to consumers or other beneficiaries (Lockie 2013).

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Market-based instruments (MBIs) have been attracting increasing interest as a comprehensive mechanism to translate the external, non-market values of ES into real financial incentives for local actors to provide such services (Engel, Pagiola, and Wunder 2008; Gao et al. 2019). Different classifications have been proposed (Stuart Whitten, Bueren, and Collins 2003; Pirard and Lapeyre 2014; Gao et al. 2019). Concepts, models, classifications, different applications of MBIs, and specific tools for correcting market failures have been the target of extensive discussion (Kemkes, Farley, and Koliba 2010; Pirard 2012; Lockie 2013; Gómez-Baggethun and Muradian 2015; Djanibekov and Villamar 2017).

However, there is a disassociation between the theory and the practices of the existing research, and the pilot cases do not concur with the proposed theoretical model. For example, many broader, empiricist definitions fail to distinguish Payment for Ecosystem Services (PES) from the larger generic family of positive environmental incentives, thus eroding their meaning via excessive vagueness (Wunder 2015). Conversely, we prefer to identify the internal logic of an instrument or mechanism and the preconditions for that instrument or mechanism’s role. Therefore, much attention is paid to the framework of MBIs, including the criteria and key characteristics.

It should be noted that MBIs are not a panacea for solving any environmental problems. There are many reasons for poor ecosystem management. The unclear definition of ecosystem property rights will make it difficult to define the benefits or costs resulting from the impact of land use on ES, leading to free-riding (Engel, Pagiola, and Wunder 2008). The appropriate response in this case is to ensure that ecosystem managers have certain property rights. Other issues such as information asymmetry and high transaction costs that lead to poor ecosystem management. Education, awareness building, and provision of credit channels are the most promising methods. But all measures are based on clearly defined property rights (Lockie 2013). On the basis of a clear definition of property rights, and according to the Coase Theorem, under certain conditions, stakeholders can resolve externality through negotiation (Coase 1960, 1981).

Therefore, we take the definition of property rights as the main direction to solve market failures. In the MBIs framework, we have summarized five criteria for market creation based on property rights and four key characteristics of case design. This framework is based on existing theories and practices, and has reference value for program design. The Pledge Financing of the Right of the Ecological Public Welfare Forest (PFREPWF) carried out in Lishui City, China is chosen to verify the framework. This pilot case is the epitome of China’s current marketization. The integration of ecological compensation and credit creation makes up for the lack of original policies, and provides forest farmers with credit to eliminate market friction. However, the case design still has the problem of lack of quantification and lack of correlations with ES.

**The role of market mechanism**

Though not all natural capital degradation is inadvisable, it should be noted that the depletion of natural capital far surmounts optimal social standards. This could be fully evidenced by the existence of market dysfunction in various forms (Fletcher et al. 2019). Despite the high attention paid to ES socially or politically, few mechanisms suggest the inadequacy or deterioration of most ES. The potential mechanism for ecosystem to play a role is exactly market mechanism. Efficient market reveals the necessity or scarcity of certain product compared with other products or services by virtue of the price mechanism (Hart 1983; Whitten and Shelton 2005). On the other hand, market signals delivered by price afford incentives to potential producers, for they take this chance to learn the value of ES relative to other outputs.

In a narrow sense, market refers to voluntary exchange between the buyer and the seller (e.g., money for goods or services). In daily life, market is a place which ensures the circulation of life necessities such as food, clothing, and accommodation. Moreover, market also serves as the mechanism rewarding landowners for the contribution of their land to ES such as water regulation, soil retention, and carbon sequestration. It turns out that market is an efficient means that encourages and rewards landowners to protect and produce ES (Whitten et al. 2007).

Such kind of market is universally acknowledged as the “market for ES,” “PES,” “MBIs” or other terms across the international society (Jack, Kousky, and Sims 2008; Paudyal, Baral, and Keenan 2016; Gao et al. 2019; Keenan, Pozza, and Fitzsimons 2019). Among all of these referents, MBIs should be the mainstream, for it encompasses the widespread applications of market policies under natural capital environment such as PES, pollution taxes, tradable permits, eco-certification, and certain capacity building measures (Boisvert, Méral, and Froger 2013; Froger et al. 2015; Zhang 2017). Unlike “true market,” MBIs are created to improve services or ensure protection (Pirard 2012). As a consequence, the paper cites the term MBIs to refer to ES market.

MBIs for ecosystem services are not the silver bullets that can be used to address any environmental problem, but a tool tailored to solve a specific problem (Jack, Kousky, and Sims 2008). There are externalities in ecosystem management, MBIs are needed to achieve internalization of externalities through policy incentives and promote the supply of ES (Engel, Pagiola, and Wunder 2008; Gao et al. 2019). Since it is the
main factor of externalities, public goods, and high transaction costs, unclear definition of property rights is a key problem to be solved in market creation (Whitten et al. 2007). This also meets the requirements of Coase Theorem for the definition of property rights in resource allocation (Coase 1981).

**Framework of market-based instruments**

MBIs have been successful in some areas, such as the Wetland Mitigation Bank, the Conservation Reserve Program, and the Paddy Land-to-Dry Land program (Zheng et al. 2013a; Mandle et al. 2019). The success of the cases lies not in choosing the right method at the right place, but mainly in the scientific design, which reflects the concept of natural capital (Whitten et al. 2007). The framework of MBIs is to deal with the ambiguity of the original theory and the decoupling of theory and practice, and to provide systematic solutions for the realization of ecosystem service value through market tools. Different from previous works, we take the definition of property rights as the basis for the creation of MBIs and emphasize the connection between MBIs and ES. To enhance the practicality of the framework, we absorb the experience of existing cases, and answer the researchers’ concerns (ES, stakeholders, transaction mechanism, additionality, persistence, challenges, etc.) (Bennett 2008; Engel, Pagiola, and Wunder 2008).

**Critical criteria for market creation**

Limited experience accumulated by ES in respect of policy intervention fully indicates the urgent demand to conceive innovative instruments to cope with market dysfunction. In this case, it is rather hard to present instructions for the building of new markets. While some criteria helpful to the building of new markets may be listed yet (Murtough, Aretino, and Matyssek 2002). In nature, market building solves one possible cause threatening the existence of market, i.e., inability of ownership definition and enforcement, by way of policy instruments. According to Table 1, the building of new markets proves to be an effective policy instrument which could be employed to satisfy specific conditions.

Criterion 1 is that property rights must be clearly defined. The main problem to be solved in market creation is to define the nature and extent of property rights in order to ensure the exclusivity of property rights (Kemkes, Farley, and Koliba 2010). The ownership of land in China belongs to the state or the collective, which is different from other countries. Farmers have the right to contract land, and the management right can be traded within the permitted scope. Therefore, a system that clearly defines property rights is needed for regulation. Other rights (such as carbon emission rights, ecological public welfare forest compensation income rights, water rights, pollution emission rights, etc.) related to land use/land cover also need to be defined and regulated by the system (Pan et al. 2017; Mandle et al. 2019). Registration is an important way to clarify property rights. It is necessary to clarify the attributes, quantity, owner’s information, validity period, and use of rights to protect the rights and interests of owners from being infringed.

Criterion 2 is that the property rights must be verifiable. Promoting the marketization of property rights is to promote the continuous ES supply, so property rights arrangements need to be linked to ES and be verifiable. Therefore, the market transaction of property rights should be conducted under a unified specification or standard to reduce transaction costs. Ecosystem service evaluation models mostly refer to water balance equation, water purification model, evapotranspiration model, etc., to establish the correlations between land use/land cover and ES, accumulating a lot of data and experience for the marketization of ecosystem services (Ouyang et al. 2020). The core of metric design is the conversion of spatially distributed and differing degrees

| No | Criteria | Description |
|----|----------|-------------|
| 1  | Definable | Unclear definition of property rights is the main influencing factor of externalities. The nature and extent of property rights need to be defined by law and confirmed through registration. The carbon emission rights, water rights, and pollution emission rights associated with land use also need to be defined. |
| 2  | Verifiable | Property rights arrangements need to establish correlations with ecosystem services. Quantification of indicators can achieve comparable results and reduce transaction costs. For example, carbon emission trading, Stormwater Retention Credits. |
| 3  | Transferable | Property rights related to ecosystem services are valuable. Transactions related to property rights require the government to establish a platform for review and supervision to reduce transaction costs. For example, Wetland Mitigation Credits, water rights trading. |
| 4  | Enforceable | Enforcement of property rights is mandatory. Compulsory realization requires supporting measures, such as fines, security deposits, etc. For example, Wetland Mitigation Credits and Stormwater Retention Credits. |
| 5  | Policy continuity | The market creation of ecosystem services is the result of government intervention, and the expected value of its property rights depends heavily on policies. The authority of government is related to policy continuity. |
of outcome change into a single, cardinal, comparable unit (Whitten et al. 2007). If property rights arrangements are recognized on a wider scale, it will undoubtedly be beneficial to market creation, such as carbon emission rights, Stormwater Retention Credits (SRCs) (Alexandrovich 2017) and Wetland Mitigation Credits (Gardner et al. 2009). The Kyoto Protocol has defined greenhouse gases as a tradable commodity, which is expressed as one ton of carbon dioxide equivalent (CO2-eq). Although there may be many gases that affect climate warming, they can be quantified through scientific methods (Murtough, Aretino, and Matysek 2002). In terms of stormwater storage, Washington, DC has identified methods for creating SRC for 13 management measures. One SRC is equivalent to retention of ~4 liters of water for one year (Mandle et al. 2019).

Criterion 3 is that the property rights must be transferable. Property rights should be able to be traded between supply and demand parties at an appropriate price. First, property rights are valuable. The value of ES is embodied in scarcity and utility, so the arrangement of property rights reflects the value attributes of ES. Second, supply and demand affect the feasibility of transactions. Since most ES are public goods, in theory, the transaction demand mainly comes from the governments or non-governmental organizations (NGOs). This will inevitably increase the uncertainty of market creation. Therefore, policy interventions (such as cap, credit offsets) are needed to internalize social externalities and include relevant stakeholders in transactions to achieve a balance between private and social interests. So reasonable entry barriers need to be set up to achieve sufficient competition in order to give play to the regulatory role of the market mechanism. Third, it is necessary to regulate transaction behavior and reduce transaction costs. In order to give play to the government’s management and supervision role, property rights transactions need to be reviewed and confirmed by government departments. The platform established by the government can provide convenience for both parties to the transaction and protect the rights and interests of both parties from infringement. California has established a water rights transfer information management system for water rights trading, and the Water Bank provides a platform for negotiation between the parties to the transaction. In the US wetland protection, the establishment of the Wetland Mitigation Bank, the determination of wetland mitigation bank customers and credit content, the monitoring, and evaluation of wetland compensation, and the developer’s wetland management sequence are all subject to the review and supervision of the US wetland management system (Mandle et al. 2019).

Criterion 4 is that property rights should be enforceable. Executable represents mandatory to ensure the transfer of property rights to the buyer. In addition, according to the Coase Theorem, transaction costs will affect the distribution efficiency of property rights (Farrell 1987). Therefore, the transaction cost of the execution section should be controlled (Brownstein 1980). In order to reduce the risk of implementation, necessary safeguard measures need to be matched. For example, the Wetland Mitigation Bank sells wetland credits to resource developers and needs to pay performance bonds and insurance premiums to the management department. In the stormwater mitigation plan, the supervised project party can choose to generate SRC, purchase SRC, pay related fees, or meet management requirements through some combination of these options (Mandle et al. 2019).

Criterion 5 is related to policy continuity. Successful MBIs usually require policy support to function effectively (Whitten et al. 2007). The market mechanism needs a stable policy mechanism to ensure price stability. The market creation for ES is the result of government intervention, and the expected value of its property rights depends heavily on government decision-making. Promoting the marketization of ES meets the public’s demand for the supply of high-quality ecological products and is an important part of the construction of ecological civilization. Moreover, the authority of the government is closely related to policy continuity, so the government has the motivation to maintain policy continuity and stability (Murtough, Aretino, and Matysek 2002).

Key characteristics of MBIs

MBIs vary due to different characteristics. Some are because of the differences in the specific ES they are trying to produce or the differences in the social, economic, or political context in which the tools operate, while others are deliberately designed choices (Engel, Pagiola, and Wunder 2008; Jack, Kousky, and Sims 2008). To further answer the researchers’ concerns (Jack, Kousky, and Sims 2008), we summarized the key characteristics of MBIs, including ES, stakeholders, transaction mechanisms, and guarantee mechanisms (Table 2).

Ecosystem services

ES that humans benefit from are based on ecosystem functions, which are external manifestations of the ecosystem structure, and are the inherent attributes of the ecosystem (Mouchet et al. 2014). Therefore, it is necessary to further the research on the differences and dynamics among ES, establish a connection between the land use/land cover and ES provision, and set scientific parameters, indicators, and credits for market creation. In creating mitigation credits for stormwater, carbon, species, and wetland, policymakers have considered selecting effective metrics to measure mitigation outcomes, mitigating the impact of measures on social equity, and ensuring the sufficient demand for credits, especially when markets are new (Mandle et al. 2019; Gao et al. 2020b). In addition, ES are mostly public goods, which hinders the smooth
operation of the market. Thus, ES should be segmented according to certain characteristics (non-rivalry and non-exclusive) and targeted intervention policies. ES are mainly divided into market goods (wood, fiber, medicine, etc.), pure public goods (climate regulation, pest extermination, biodiversity, etc.), toll or club goods (eco-tourism, etc.), and common pool resources (water resources, fishery resources, etc.) (Costanza 2008; Kemkes, Farley, and Koliba 2010).

For their different social attributes, we need to consider targeted policy instruments. For example, market goods can be directly traded through existing markets. Pure public products can be compensated by the governments or NGOs through reverse auctions, such as the Conservation Reserve Program in the United States, environmentally sensitive areas in the United Kingdom, the Bushtender program in Australia, or through tradable permits to reduce the environmental impact, such as the Wetland Mitigation Bank, Biodiversity Conservation Bank in California, and stormwater mitigation in Washington, DC (Gao et al. 2019). Toll or club goods can be paid as pure public products or through certification to eliminate information asymmetry. Common pool resources can adopt community-based natural resource management (Kemkes, Farley, and Koliba 2010), through the establishment of durable cooperative institutions organized and managed by resource users (Ostrom 1993, 2009), or realize the value of resources through tradable permits, such as water rights trading, land development rights trading (Wang et al. 2010).

**Stakeholders, including ecosystem service providers and ecosystem service beneficiaries**

Here, we highlight the importance of stakeholders’ participation. As the main intervention power, the government primarily balances the relationship between the ecosystem service suppliers and the ecosystem service beneficiaries and introduces the beneficiary pays principle (Lockie 2013; Paudyal et al. 2018). Ecosystem service beneficiaries, or buyers, should be first defined according to each ecosystem service.

Beneficiaries. The first concern to be tackled is to figure out the actual buyers of ES. That’s because the case will be totally different when the buyers are ES users or other parties, mostly government authorities, NGOs, or international organizations who act in the capacity of agents of ES users (Engel, Pagiola, and Wunder 2008). In general, projects involved may be classified into user-financed MBIs, government-financed MBIs, NGO-financed MBIs, and multi-element-financed MBIs (Gao et al. 2020b). In particular, under the first category, i.e., user-financed MBIs, actors accessible to most service value information have direct participation, and show intense motivation to ensure service supply. Comparatively speaking, government-financed MBIs may have much more cost effectiveness for its availability of scale economy in transaction costs (Engel, Pagiola, and Wunder 2008). Under some circumstances, capital is gained by charging coercive fees from service users instead of ordinary revenues. As a result, the critical distinction between these MBIs projects is not just limited to the payer of bills, but also the decision-maker responsible for the payment of bills (Engel, Pagiola, and Wunder 2008).

The participation of experienced NGOs can also reduce costs (Kemkes, Farley, and Koliba 2010). As an important force, NGOs can not only play an intermediary role in different administrative regions or fields, but also provide funding and technology for ecosystem protection. For example, the Water Fund promoted by The Nature Conservancy in Africa, South America and other places has brought new models for watershed governance (Goldman-Benner et al. 2012).
Irrespective of higher expectation on the cost effectiveness of user-financed MBIs, government-financed MBIs prove to be the sole choice in many scenarios. Prerequisites for the implementation of Coasian solutions cover clear definition of property rights, coercive enforcement and low transaction costs (Coase 1960). User or ES beneficiary payment mostly takes place at a time when market goods, tolls or club goods is traded or when the scope of beneficiaries is small and corresponding transaction costs are low enough. A typical instance is that a hydropower producer is explicitly benefited by a drainage basin. Thus, user-financed MBIs are usually enforced in condition of local monopoly or oligopoly monopoly (Kemkes, Farley, and Koliba 2010). Accompanied by the mounting number of ES buyers, pertinent transaction costs and free-riding incentives continue to go up. So government-financed MBIs possibly offer the sole solution when ES becomes public goods, like biodiversity.

Providers. Potential ES sellers are actually those actors who are committed to ensuring the normal supply of ES. To be specific, land use conventions affect downstream water services by infiltration, evaporation, erosion, and other physical processes. This naturally suggests that the potential sellers are land owners, including both collectives and government land owners, like natural reserves. Besides that, farmers with contracting rights or management rights can also serve as ES providers (Engel, Pagiola, and Wunder 2008). Except for the directional flow or in situ, it is difficult to identify the providers and beneficiaries of ES (Burkhard et al. 2014; Serna-Chavez et al. 2014; Gao et al. 2020a).

Trading mechanisms
MBIs must solve market failures to promote service supply. In this section, we mainly discuss the transaction typology and effectiveness measures of the tool implementation level.

Transaction typology. ES markets are usually established on the basis of a set of intervention practices, which heavily depends on existing markets, properties of ES markets to be considered during the process of production, as well as potential market participants (Whitten and Shelton 2005). MBIs have been always taken as economic, high-efficient, and pertinent solutions applicable to all sorts of troublesome environmental policy issues. This should be attributable to MBIs’ extra potentials in improving the security of ecosystem service providers (Lockie 2013). There are lots of instruments available to reach the objective, but they share one point in common, that is, all take advantage of the market mechanism, such as trading plans, auctions, and price signals, to affect people’s action in the quest for specific policy targets (Dargusch and Griffiths 2008; Lockie 2013). Some believe that such market mechanism offers a solution with minimum cost, for it enjoys high flexibility in personal resource allocation and affords sustained incentives to innovation (Lockie 2010). As a matter of fact, MBIs provide chances to generate joint social and cultural interests, including better livelihood security for sake of ecosystem service providers (Muradian et al. 2010). As a general rule, MBIs fall into four major categories, namely price-based instruments(I), price-based instruments(II), market friction instruments, and quantity-based instruments. First of all, price-based instruments(II), like market creation, auctions, and tender, encourage the creation of new markets to allocate the payment of ES supply. Thirdly, market friction instruments, like eco-labeling and education, manage to remove or decrease obstacles in existing or potential markets so as to improve mobility signals and incentives. Finally, quantity-based instruments, such as cap & trade and offset schemes, are presented to stress the scarcity of ES markets, and therefore dominate market signals and incentives in favor of scarce ES markets (Lockie 2013; Whitten and Shelton 2005).

Effectiveness measures. The key to define MBIs is additionality. What counts is that a new baseline must be established as much as possible so as to attest if there exists extra ES, transaction cost reduction, or further efficiency improvement. In order to more easily recognize and monitor the development of agency or indexes and offer simplified but accurate and effective ES measures, the prerequisites demand full comprehension about the processes, and recognition about the space scope and distribution laws.

Although all the above tools have been created to promote the supply of ES, they are actually aimed at specific problems, so the methods of effectiveness evaluation are different (Engel, Pagiola, and Wunder 2008). Eco-tax and other tools based on Pigou tax pay attention to the total tax payment and the coverage of supervision to evaluate the effectiveness of supervision. Tools such as auction and tender can choose more cost-effective land and governance plans, such as the Conservation Reserve Program and the Bush tender program, when the protection goals are determined. Certification is a typical way to eliminate market friction. Through certification, companies can achieve brand differentiation, increase consumer loyalty, and obtain product premium income. Cap and trade or tradable offsets can pay attention to transaction volume and quota execution to reflect whether the tool is scientific and reasonable (Lockie 2013).

In addition, effectiveness evaluation can also be based on practices or performances (Banerjee et al. 2013). However, the evaluation has problems such as high evaluation costs, insufficient evaluation methods,
difficulty in monitoring, and data lag, which are faced by many cases (Whitten and Shelton 2005).

**Guarantee mechanisms**

The development of MBIs is inseparable from the interplay of environmental, economic, social, and political factors, as well as the propaganda of multidimensional stakeholders. Facts prove that ES buyers, sellers, or any third party related to MBIs projects possibly produce profound and extensive impacts on the form of project (Engel, Pagiola, and Wunder 2008). This is decided by technical and legal documents. Taking the carbon emission trading, for example, the Kyoto Protocol has requested developed countries listed in Appendix I to cut down gross greenhouse emissions caused by human activities by 5% at least till the first stage in 2008–2012 than 1990 (Ott et al. 2004). Gases with global warming potential are converted by carbon dioxide equivalent indicators, paving the way for carbon emission trading. Therefore, the realization of carbon emission trading is the product of the combination of system and science.

The design of MBIs needs policy support. Quantity-based instruments often require a regulatory basis to create effective property rights. The success of the auction depends on the effective extension of bid development support (Whitten et al. 2007). The MBIs design must include the necessary support mechanisms needed to ensure success, such as regulatory changes or communication and participation plans.

Especially for new pilot projects, transactions rely on legal and policy support to achieve continuity and stability. Multiple regulations in the United States, including the US Clean Water Act, California’s Environmental Quality Act, and Endangered Species Act, and the California Global Warming Solutions Act promote the implementation of mitigation programs (Mandle et al. 2019; Gao et al. 2020b). In order to promote the process of ecological civilization, China has promoted the beneficiary pays principle through institutional innovation. Ecological compensation mechanism in form of projects is being developed in the direction of normalization and standardization. Carbon emission trading, water rights trading, eco-certification, and other pilot work are carried out in region scales.

**Pilot case study in Lishui City, China**

China integrates the value of ES into decisions for the promotion of natural capital via policy formulation, financial compensation, information, and education (Mandle et al. 2019; Gao et al. 2020b). In recent years, China has founded the ecological compensation mechanism (equivalent to PES) in forests, grasslands, wetlands, deserts, oceans, water flows, cultivated land, and other important areas, such as prohibited development zones, key ecological function zones, and more (Mandle et al. 2019). However, the existing ecological compensation that provides low, undifferentiated, and goalless payments may lead to social inefficiency (Engel, Pagiola, and Wunder 2008; Gao et al. 2019). First, the funds mainly come from the central government, lacking a diversified and market-oriented trading mechanism. Second, the existing payment standard is primarily based on the cost of ecological protection inputs or the opportunity cost of crop yield changes (Paudyal et al. 2018; Gao et al. 2020b). It is so low that participants are calling for a higher payment standard. Third, the development of the participants and regions involved is limited. The livelihoods and sustainable growth capacities of farmers are affected to varying degrees.

If the imperfection of the capital market prevents owners from adopting privately profitable technologies or practices that increase the provision of ES, then providing credit channels is the most promising approach (Engel, Pagiola, and Wunder 2008). Based on the national ecological compensation policy, Lishui City has designed tools with local characteristics to improve service supply and the welfare of forest farmers.

By introducing a third party, PFREPWFW enacted in Lishui City, China realizes the integration of ecological compensation and credit creation, and provides loans to eliminate the problem of insufficient participation of forest farmers due to affected livelihoods. In addition, we hope to verify the applicability of the theoretical framework through the analysis of the pilot case in Lishui City and discover the problems that still exist in China’s market tool design.

Lishui City is located southwest of Zhejiang Province in East China (Figure 1). The mountain area of Lishui City accounts for 88.42% of the administrative area, and it slopes from the southwest to the northeast. The city has an area of 17,298 square kilometers and a constant population of 2.19 million. The forest land area is 21.93 million mu (~1.46 million ha; 15 mu = 1 ha), with a forest coverage rate of 80.79% in 2016 (LSB, L.S.B. 2019). It belongs to a typical southern collective forest area in China.

As a national demonstration area of ecological civilization in Zhejiang Province, Lishui City’s economic and social development ranks in the middle level of China, with a per capita Gross Domestic Product (GDP) of 56,238 RMB (~US$ 8,034; 7 RMB = US$1), slightly higher than the national average of 53,680 RMB (~US$ 7,669) in 2016. As an ecological barrier in East China, Lishui City has a population density of 1.22 people/ha, close to the national average of 1.43 people/ha (NBS, N.B.o.S. 2018; LSB, L.S.B. 2019). Lishui City’s economic and social development level and natural conditions are the epitome and typical sample of the whole country.
Ecological public welfare forests and ecosystem services

As an important natural capital, forests not only have the role of protecting ecosystems but are also a key livelihood resource for the majority of forest farmers. However, forestry has always been targeted at meeting the economic demand, resulting in environmental problems such as excessive logging and forest land reclamation. In the face of this dilemma, central government has proposed a wide range of national and regional ecological restoration projects, including the ecological compensation for ecological public welfare forests (Mandle et al. 2019). Ecological public welfare forests mainly refer to forests located in areas that are extremely ecologically important or areas wherein ecological conditions are extremely vulnerable. They are protected mainly to provide the regulating services, e.g., water retention, biodiversity, soil retention, sandstorm prevention, and flood mitigation (Ouyang et al. 2016).

Given the special nature of ES generated by ecological public welfare forests, payment has been the primary tool option. As the Central Forest Ecological Benefit Compensation Fund was officially set up throughout the country in 2004, the ecological public welfare forest compensation mechanism was found. Compensation standards differ as does ownership, including maintenance subsidies and public management expenditures (Liu 2015). The current compensation standard is still calculated based on the opportunity cost of forest land, and has not yet referenced the value of ES. Theoretically, the value of ecosystem services provided by forest land can already be accounted for to a certain extent, but there is still a certain gap in the research and application of accounting methods and value. The bundling of ES is still only theoretically feasible (Kemkes, Farley, and Koliba 2010).

Forest land contract right holders, government, and policy financial institutions

Forest land contract right holders

Ecological public welfare forest land contract right holders are suppliers of ES (Kemkes, Farley, and Koliba 2010). Due to the restricted development of ecological public welfare forests, forestry income has dropped sharply, and the livelihoods and sustainable improvements of forest farmers have been affected. External benefits need to be quantified, and the rights and interests of forest farmers should be compensated. Stakeholders could compensate through a variety of means (financial payment, loans, technical training, etc.) to increase their motivation to participate.

Government

ES are benefits produced by ecosystems, but since most ES are public goods, governments as agents need to purchase ES (Gao et al. 2019). The payment standard can be determined according to the ecological protection input, opportunity cost, or value of ES (Zhou et al. 2019; Gao et al. 2020a). Since the government is the primary supplier of ecological compensation policies for ecological public welfare forests, the compensation funds mainly come from government finances. Although investment is increasing every year, considering the stage of national economic and social development, the government’s budget for compensation funds is limited, resulting in lower compensation standards. The average compensation rate
for state-owned national public welfare forests is 5 RMB per mu (~US$ 10.7 per ha) per year; the compensation rate for collective and individually owned national public welfare forests is 15 RMB per mu (~US$ 32.1 per ha) per year. The existing compensation standard is much lower than the market land-use values, not to mention the value of ES generated by ecological public welfare forests.

In general, the government is the main body of public economic activity or perhaps the only one. Cai, Wen, and Lu (2005) believed that the main force of ecological public welfare forest compensation should be diversified rather than singular to include the state, the users, and the society. It can be compensated by various means, including financial allocation at all levels, collection of ecological compensation funds, main beneficiary input, preferential credit, etc. (Cai, Wen, and Lu 2005).

In order to realize the marketization and diversified participation of ecological compensation, in December 2018, the National Development and Reform Commission and eight other departments jointly issued the Action Plan for Establishing a Market-oriented and Diversified Ecological Compensation Mechanism.

**Policy financial institutions**

Policy financial institutions are an important force in addressing the lack of marketization of the value of ES. Under the premise of clear contract rights, the compensation income certificate can be used as the basis for credit creation of policy financial institutions (Gao et al. 2019). The loan funds reflect the increase in the value of ES and also meet the forest farmers’ demand for funds to support their industrial transformation. Moreover, the granting of loans by policy financial institutions has further improved the market financing mechanism, which is conducive to the transformation of government functions.

**Property rights and financing**

The design of ecosystem service markets largely depends on the characteristics of the environmental problem being addressed. Political recognition of China’s crisis began in 1998 when deforestation and erosion led to massive flooding along the Yangtze River. Thousands of people were killed by the floods, more than 13.2 million people were left homeless, and property losses amounted to 36 USD billion (Mandle et al. 2019). In order to repair and protect ecosystems, China carried out the Natural Forest Protection Project in the upper Yangtze River, the upper and middle Yellow River, the Northeast and Inner Mongolia, and other key forest areas in 2000, with a cumulative investment of over 47 USD billion (Mandle et al. 2019). In China, the ownership of forest land belongs to the state or collective, and farmers hold the right to contract and management. Once the forest lands are classified as national ecological public welfare forests, the county forestry department signs a management agreement with the forest land contract right holders, clarifies the rights and obligations of the parties, and stipulates the responsibilities of management and protection (Figure 2). The national public welfare forest compensation fund is paid by the central government, and the local government can provide supporting facilities according to actual conditions. Although developed provinces such as Zhejiang and Beijing have generally raised the compensation standards, the value of natural capital and ES has not yet been recognized.

In order to solve externalities and improve the livelihood of forest farmers, Lishui City actively piloted the reform of the forest right system. The original ecological compensation policy has clarified the property rights and beneficiaries of forest land. PFREPWF further facilitates financing on the basis of clear property rights. Forestry departments issue compensation income certificates for foresters according to compensation funds and forest area. Forest farmers can directly apply for loans from designated policy financial institutions with certificates, and the maximum amount of compensation income can be 10 times (Figure 2).

The average value of each household loan amount is estimated to be 14,377 RMB (~US$ 2054). The compensation income right of the ecological public welfare forests is used as the pledge financing, which solves the problem of the regulation not allowing the forest assets to be mortgaged, and bad loans cannot be disposed of by logging trees. Under the premise of not cutting trees, the new MBI has achieved a win-win for forest land contract right holders, policy financial institutions, and the government. In order to reduce the risk to financial institutions, Lishui City is also promoting the construction of a rural credit system, introducing third-party guarantee institutions, and operating policy insurance to eliminate the risk of loss of the compensation income right.

As of 2017, Lishui City had issued a total of 182 loans and 23.08 million RMB (~US$ 3.3 million), with a balance of 107 and 15.59 million RMB (~US$ 2.2 million). The bad loan ratio has remained at zero.

As mentioned above, many communities depend on forests for their livelihoods. The restriction of forest resources imposed by the state will limit the development of local residents and may lead to social conflicts (Engel, Pagiola, and Wunder 2008). The introduction of credit loans on the basis of ecological compensation policy can further improve the value of forest protection to local residents, and also increase the incentive of local residents to self-protect forests, thus helping to overcome the difficulties of lack of supervision.
Low sovereign risk

The enforceability of PFREPWF based on ecological compensation should consider policy continuity. A low sovereign risk means that it does not prevent a market from forming (Murtough, Aretino, and Matysek 2002). Future government decisions are unlikely to significantly reduce the property rights' value.

China guarantees the legitimacy and stability of the instrument at two scales. At the national scale, China has actively promoted the process of ecological civilization and issued a series of major decision-making arrangements. The Opinions on Improving the Ecological Compensation Mechanism and Measures for the Management of Public Welfare Forests at the National Level have increased the institutional guarantee of the mechanism. An ecological compensation regulation has entered the legislative process as well.

At the local scale, Zhejiang Province has issued the Administrative Measures on the PFREPWF. In 2016, based on the pilot experience, Lishui City issued the Guiding Opinions on Promoting the PFREPWF. In addition, the Forestry Bureau and the People's Bank of Lishui City issued the Measures for the Compensation Income Certificate of Ecological Public Welfare Forests and Interim Measures for PFREPWF. The pilot case in Lishui City has been recognized by the national forestry and financial sectors. The realization of ecosystem service value based on MBIs is increasingly accepted by policy makers.

Discussion

Faced with a fragile ecosystem, the potential goal of any such action is timely action. Therefore, the most ideal tool in the short to medium term is the MBI that can provide faster results under the current legal system, and provides lessons learned in regional operation for the future development and implementation of MBIs.

MBIs are an important option for policy instruments

Large-scale market reforms are impossible in the short to medium term. Moreover, there may still be sufficient justification for government payment to purchase public goods or stimulate structural adjustment. However, ecological compensation mechanisms that provide lower, undifferentiated, and goalless payments may lead to low social efficiency (Engel, Pagiola, and Wunder 2008; Gao et al. 2019). In the face of market failures, although academic research always tends to choose among tools, the more operational problem is how to combine different tools to achieve the goal of protection. Compared with the direct, and inefficiency tools such as regulations (Kemkes, Farley, and Koliba 2010), market mechanism has innate advantages in cost savings, stimulating innovation, and flexibility (Whitten et al. 2007; Lockie 2013). MBIs have received more attention as a comprehensive mechanism to translate the non-market, external value of ES into actual economic incentives for local participants to provide such services (Engel, Pagiola, and Wunder 2008).

PFREPWF has a positive impact

The theoretical framework not only answers the relevant questions, but also provides reference for the scheme design. PFREPWF has validated the theoretical framework and is positive in terms of impact. In the short
term, it can reduce the cost of financing and increase the value of natural assets. The government attaches importance to the signal of ecosystem, which can stimulate the protection of forest farmers. In the long run, the increased awareness of property rights will encourage foresters to pay more attention to market mechanism. The improvement of forest farmers’ livelihoods will also promote community development and harmony between man and nature.

Choose right MBIs according to resource endowments

The optimal market tools are those that are suitable for regional conditions, can really solve market failures, and have prospects. The mountainous area of Lishui City accounts for 88.42% of the administrative area, the forest coverage rate is 81.70%, and the ecological public welfare forest (852,000 ha) accounts for 58.12% of the forest area (1.5 million ha) in 2018. Lishui City has the typical advantage of piloting PFREPWF. In addition, Zhejiang Province has been raising the compensation standard for ecological public welfare forests (up to US$ 85.7 per ha in 2017) for many years, which makes the implementation of PFREPWF more promising (LSB, L.S.B. 2019). In the future, other regions can carry out corresponding work on natural capital (arable land, water flow, forests, etc.) and social capital (homestead, land management rights, property rights of small water conservancy projects, etc.), and promote marketization and diversified participation.

Existing problems

The specific needs of each MBI will vary depending on current market failures, biophysical, and market context. However, many aspects of the design, implementation, adoption, and effectiveness of MBIs are still not well understood, and there are still opportunities for improvement.

When designing the MBI mechanism, it is necessary to quantify the correlation between land use and ES, and also to quantify the benefits of actions to suppliers and beneficiaries (Zheng et al. 2013b; Ouyang et al. 2016). By eliminating information asymmetry, the market mechanism is then promoted to be highly efficient. Constrained by the development stage and the lack of research methods, the pilot case in Lishui City still lacks relevant research.

The pilot case is an effective attempt to develop a market mechanism in China at this stage. Due to the lag effect of data, the effectiveness of ecological protection and the improvement of livelihoods cannot be effectively quantified (Salzman 2005). Therefore, relevant evaluation indicators need to continue to be tracked and monitored, combined with surveys, interviews, and other forms.

In the future, further research is needed around ecosystem service accounting and ecosystem service flow (Gao et al. 2020a). The good news is that in recent years, China has actively promoted the pilot work of the value realization mechanism of ES, which will actively promote the construction of China’s ecological civilization.

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Author Contributions

Resources, Z.O., W.X.; writing—original draft, X.G., Y.H.; writing—review and editing, X.G., Y.H, Z.O., W.X.; visualization, X. G., Z.O.; supervision, Z.O.; funding acquisition, Z.O., W.X.

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