Diversified Empowerment of "Blue Insurance" for the Sustainable Development of the Marine Economy in Liaoning Province

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Abstract: As an institutional mechanism of risk transfer related to the marine environment, blue insurance is becoming a more widely acknowledged tool to facilitate sustainable development of the marine economy. Using Liaoning Province as its object of analysis, this paper constructs a conceptual framework whereby blue insurance enables the sustainable development of the marine economy in four ways; risk transfer, price discovery, capital allocation and governance incentive. Based on this, the paper establishes the structural barriers that are currently constraining the effectiveness of blue insurance in Liaoning, such as fragmented regulatory authority, lack of actuarial data, inadequate supply of products and poor demand-side capacity. It also suggests a three-dimensional understanding of diversified empowerment - instrument diversification, functional diversification and governance diversification and deduces policy pathways thereof. The article holds that the empowering impact of blue insurance does not just occur but depends on institutional coordination, data infrastructure and congruency of fiscal tools with insurance processes.

Keywords: Blue Insurance; Marine Economy; Sustainable Development; Liaoning Province; Risk Governance; Policy Pathways

1. Introduction

The success of a marine economy is not just dependent on the level of industrial production, but also, perhaps more importantly, on the institutional ability to absorb and share risks associated with activities that are dependent on the ocean. This offer is based on an understanding that marine economic activity is structurally vulnerable to a unique set of hazards that cannot be effectively addressed by firm-level or household-level strategies. Capture fisheries, aquaculture, offshore wind, marine engineering and coastal tourism are marine industries that face compounded risks: hydro-meteorological extremes, ecological degradation, market volatility and regulatory uncertainty. These risks often combine to generate loss events whose size and timing are hard to predict and whose impacts spread across sectors and jurisdictions. The risk profile thus comprises low-probability, high-impact events and chronic low-level uncertainties, a combination that presents specific challenges for traditional risk-management tools.

Insurance, as a market-based risk-transfer mechanism, holds a unique place in this institutional environment. It can act both as a financial shock absorber for individuals, a credit-risk signal for lenders and a governance tool that encourages risk mitigation through pricing and coverage design. This multifunctional role sets insurance apart from other financial instruments: while credit and equity are primarily about the ex ante allocation of capital, insurance is about risk pooling and contingent loss transfers, which changes the distribution of outcomes among economic agents. The governance aspect is especially important for sustainable development, to the extent that insurance contracts can include conditions, differentials and incentives that influence the behaviour of their insureds. Insurance is thus not only a retrospective compensatory mechanism, but also a prospective tool that can shape risk-taking and risk-reduction behaviours.

Liaoning Province is located on the northeast coast of China, has a large continental coastline and a large marine industrial base, and has formulated ambitious goals of marine economic growth. The marine economy of the province

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includes traditional industries like capture fisheries, aquaculture and port logistics, as well as new industries such as offshore wind, marine engineering equipment and marine biological products. However, these goals are not incompatible with structural weaknesses: a large share of traditional industries, insufficient penetration of risk-management tools, and an institutional framework of marine-specific insurance is just emerging. The fact that traditional industries dominate means that a high percentage of marine economic activity is carried out by small-scale operators who have limited access to formal risk-transfer systems. The low penetration of risk-management instruments indicates that current insurance products do not sufficiently align to the risk profiles of marine activities. The emerging institutional framework shows that coordination between the agencies in charge of marine governance, financial regulation and fiscal support is underdeveloped.

The notion of blue insurance is still under-theorized in the literature and it is sometimes used interchangeably with marine insurance in a more limited sense or as a marketing term to promote carbon-related products [1]. Such laxity in terminology has analytical implications: it blurs the line between traditional marine insurance, which covers a relatively small spectrum of risks, and the larger category of tools needed to cover the risk profiles of sustainable marine development [2]. This paper takes a wider analytic perspective and poses the following question: what does diversified empowerment imply in operational terms, and what are the limitations that need to be overcome to ensure that blue insurance can serve as a substantive enabler of marine economic sustainability in Liaoning? The former question presupposes the specification of the mechanisms according to which insurance influences the results of marine economics and the definition of diversification as something other than product proliferation. The second question will involve identifying institutional, informational and behavioral constraints that are currently constraining the effectiveness of blue insurance in the province [3].

The paper has the following course. Section 2 formulates the analytical framework, defining the concept of blue insurance, the four empowerment mechanisms and the three dimensions of diversification. Section 3 analyzes the current practices in Liaoning and institutional constraints that hinder their effectiveness. Section 4 derives policy tracks based on the three dimensions of diversification. Section 5 concludes with a restatement of the main argument and suggestions of where further research should be done.

2. Analytical Framework

2.1 The Concept of Blue Insurance

By blue insurance in this paper, I mean insurance products and institutional structures that are designed according to the risk profile of sustainable marine economic activities. This definition is more broad than the conventional marine hull and cargo insurance, but less broad than the general notion of blue finance. It incorporates marine disaster insurance, marine ecological and environmental liability insurance, marine fishery insurance and marine new-energy and infrastructure insurance [4]. Such a broad definition is an indication of the variety of marine economic activity: the risk profiles of capture fisheries are extremely different to offshore wind farms and likewise the tools required to address such risks. The definition that would be restricted to traditional marine insurance would not include only those risks that are most pertinent to sustainable development: ecological liability, valuation of carbon sink, failure of infrastructure.

This definition has three points that should be highlighted. To begin with, blue insurance is defined by the object of the insurance, which are marine risks, rather than who is offering the insurance or the legal structure of the insurance contract. This will allow the concept to incorporate products offered by commercial insurers, mutual associations and government schemes. Second, the definition includes institutional arrangements along with products, thereby enabling risk-sharing pools, reinsurance treaties and public-private partnerships to be included in the analysis. Third, the definition is directed at sustainable marine economic activities, i. e., the insurance tools must be considered not only based on their capability to cover losses but also based on their contribution to sustainability of marine economic activities.

This paper understands diversification in three dimensions rather than product variety. The conventional meaning of diversification in insurance talk is the expansion of product

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portfolio- launching new lines of coverage or modifying the current ones. Variety of products is an element of diversification that is necessary but not an analytical category since it does not take into account the time dimension of insurance functions and the institutional set up in which risks are pooled. These other dimensions have been reflected in the three-dimensional conception that has been developed here (instrument diversification, functional diversification and governance diversification) and provides a more appropriate basis on which to analyze policies.

2.2 Four Empowerment Mechanisms

The statement that blue insurance can enable the sustainable development of the marine economy needs to be specified in terms of how this effect works. There are four analytically distinguishable mechanisms, but in practice they work together.

To begin with, risk transfer will decrease the volatility of enterprise cash flows and consequently increase investment willingness in capital-intensive marine activities. The economic activities on the marine front often involve huge fixed investments- vessels, aquaculture farms, offshore installations whose payoffs are susceptible to hazard events. Without risk-transfer mechanisms, businesses have to self-insure by building reserves or ploughing back profits which diminishes the amount of capital that can be used in productive investment. Insurance shifts a specified amount of this risk to a common fund thus decreasing the variance of cash flows and allowing enterprises to make investments that would not have been possible due to exposure to risk. This mechanism is especially applicable to capital intensive marine industries like offshore wind and marine engineering where the investment decision is sensitive to perceived likelihood of catastrophic loss.

Second, price discovery transforms marine risks into visible costs and enhances the allocation of capital and labor in marine sectors. Actuarial evaluations of risk are reflected in insurance premiums and these are conveyed to insureds by means of the pricing mechanism. Pricing risks provides economic actors with information on the relative exposure to hazards of various activities and places and this information is used to make decisions regarding where to invest and what precautions to take. The price discovery function is thus both allocative and informational: it helps in efficient allocation of economic activity in space and in sectors.

Third, capital allocation links insurance to marine ecological restoration through channeling premium reserves and claims payments toward precautionary and restorative activities. Insurance companies have reserves against future claims and the investment of these reserves is a major pool of capital [5]. How this capital is allocated, whether to traditional assets or to marine ecological restoration, sustainable aquaculture and other activities that are consistent with sustainable development has implications on the path of marine economic development [6]. Payments of claims can also be designed in such a way that they facilitate restorative efforts, such as financing the restoration of degraded habitats or compensating lost ecosystem services [7]. This mechanism ties insurance to the larger agenda of blue finance and places insurance in the framework of sustainable ocean governance.

Fourth, governance incentive includes risk-reduction conditions in insurance contracts, which leads to safer production practices and thus lowers the systemic exposure at industry level. Deductibles, coverage limits, premium differentials and conditions that reward risky behavior and punish dangerous practices can be included in insurance contracts. These contractual characteristics are used as governance tools in the sense that they influence incentives of insured parties in the long-term. The governance role is not the same as the compensatory role: compensation deals with the aftermath of loss events once they have happened whereas governance incentives are prospective and serve to decrease the likelihood or size of such events. This mechanism is especially applicable to marine activities where personal risk-taking behaviour may produce systemic effects, e. g. aquaculture practices that lead to disease outbreaks or fishing practices that damage habitats.

2.3 Three Dimensions of Diversified Empowerment

Instrument diversification deals with the diversity of risk transfer instruments to marine actors. Conventional hull and cargo insurance covers a small range of insurable risks; the unique risks of sustainable marine development, such as uncertainty in carbon sink valuation,

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aquaculture disease outbreaks, damage to subsea cables, need tools like parametric insurance and carbon sink insurance. Parametric insurance whereby payouts are made based on objective environmental indices instead of evaluated losses can be a solution to loss-adjustment delays and disputes that are typical of marine claims. Carbon sink insurance that safeguards the value of sequestered carbon against loss or degradation is tied to the new market of marine carbon credits. The correspondence between the risk profile of marine activities and the coverage offered by available instruments is used to evaluate the adequacy of instrument diversification.

The change in the temporal orientation of insurance, i. e., the move towards ex-ante risk reduction instead of ex-post indemnification is known as functional diversification. This demands that insurers invest in informational and technical capabilities to engage in loss prevention, and design premium schedules that incentivise proven risk-reduction investments. The traditional role of insurance - pooling premiums and paying out verified losses - is essential but not enough. A risk-reduction approach requires insurers to undertake activities beyond the conventional underwriting relationship: delivering early-warning services based on oceanographic information, assisting clients with strengthening facilities against storm surge, and providing technical support for risk assessment. This is reflected in the notion of "risk reduction management" in Chinese insurance policy discussions. In Liaoning, where aquaculture accounts for a large proportion of marine output value, the functional shift from indemnification to prevention is especially pertinent, as disease outbreaks and water-quality fluctuations are susceptible to prevention measures that can be encouraged by insurance.

Governance diversification deals with the institutional structure by which risk is pooled and managed. The marine risks often surpass the absorptive capacity of single insurers especially in catastrophic perils like storm surge impacting concentrated coastal assets. Governance solutions to this limitation include risk-sharing pools, reinsurance arrangements and public-private partnerships. Risk sharing pools enable insurers to pool their risk and consequently be able to underwrite risks that would otherwise be beyond their individual ability. Reinsurance agreements shift a part of the risk to the world markets thus tapping into extra capacity. In public-private partnerships, governments are exposed to risk either by directly participating in risk pools or by offering contingent support. Another aspect of governance diversification is integration of insurance with other related financial tools, including the connection between carbon sink insurance and carbon quota commitments to be financed by banks. This combination broadens the scope of insurance in credit enhancement hence enhancing its developmental impacts [8].

3. Liaoning's Blue Insurance Landscape

3.1 Existing Practices

The most successful blue insurance innovation in Liaoning so far is the marine carbon sink insurance pilot that was initiated in Panjin, which integrated the protection of the value of carbon sinks with aquaculture costs and experimented with a financing connection between carbon quota commitments and insurance-based credit. The pilot is a break with traditional marine insurance in two ways: it covers an ecological value (sequestered carbon) not normally considered insurable; and it connects insurance to credit markets by means of pledges to carbon quotas. The pilot methodology used included calculation of insurable quantities of carbon sinks by field sampling and laboratory analysis, and a change approach to carbon stock. Although the pilot is important as a feasibility demonstration, its scalability is questionable, at least to the extent that the measurement methodologies used are project-specific and have not been standardized.

Outside this pilot, the provincial blue insurance portfolio is still dominated by traditional products. The portfolio is dominated by hull and cargo insurance, aquaculture insurance and liability coverage, with instruments that target emerging marine industries (offshore wind, marine engineering, marine carbon sinks) being in short supply. The policy measures announced in Dalian list a wider agenda, which includes carbon sink insurance, parametric insurance, marine pasture insurance and offshore wind insurance but there is still a disconnect between policy listing and market practice. This disjunction can be explained by a number of reasons: lack of standardised actuarial approaches to new risks, inability of local insurers to cover new risks, and poor demand-

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side push by marine enterprises that are either uninformed about the existence of such tools or cannot afford them.

The trend that emerges is selective innovation and stubborn conventionality. The Panjin pilot shows that innovation in instruments can be achieved with policy attention and technical support. But the spread of such innovations beyond pilots needs conditions (data infrastructure, actuarial skills, demand-side readiness) that are not yet available. The disconnect between policy listing and market practice is thus not just an implementation gap but a symptom of structural limitations.

3.2 Institutional Constraints

There are three limitations that should be considered. To begin with, the regulatory authority is divided between agriculture and fisheries, energy, transportation and financial regulators and the test of durability of coordination mechanisms has not been tested. Various agencies have jurisdiction over marine economic activities, each agency having its mandate, data systems and policy priorities. Agricultural and fisheries authorities regulate aquaculture, offshore wind, transportation authorities regulate shipping, and financial regulators regulate insurance products. The coordination needed to create and oversee blue insurance products thus cuts across a number of administrative fields. The Dalian initiative, which engaged various municipal departments, is one such effort to surmount this fragmentation, yet institutionalization of this coordination, in the form of standing mechanisms, allocation of authority and budget, has not been realised. Even well-meaning episodic cooperation cannot sustain the long-term endeavor needed in product development, sharing of data and market regulation.

Second, actuarial information on marine-specific risks is not sufficiently systematic, and parametric products specifically demand historical loss data and hazard models that are not easily accessible to the coastal areas of Liaoning. Insurance pricing involves an estimate of frequency and severity of losses which in turn involves historical data on losses and exposures. In most marine risks, these data are limited: aquaculture disease outbreak losses are not reported systematically, subsea cable damage is rarely reported, and carbon sink valuation is methodologically unstable. The parametric products are especially data-intensive since the index needs to be proven to be correlated with real losses to prevent basis risk- the lack of correspondence between trigger events and actual damages. Lack of systematic data infrastructure thus limits the pricing of traditional products as well as creation of new products. The Panjin pilot overcame this limitation by using project-specific measurement, yet it is an expensive and hard-to-scale approach.

Third, the demand-side capacity is low: small-scale aquaculture farmers and fishing households have limited knowledge of insurance and price sensitivity, and subsidies for premiums are inconsistent across programs and governments [9]. Insurance demand is not a given; it requires risk awareness, knowledge of insurance systems and payment capacity. Small-scale marine operators often lack financial literacy to assess insurance products and/or the means to pay premiums. Subsidies for premiums (where permitted) are delivered through various programs with varying eligibility and processes, leading to confusion and lower uptake. There is a perception that insurance is an expense rather than a risk management tool, exacerbated by past experiences with claims problems and slow payouts. So, demand-side capacity is not just about affordability but also trust and knowledge.

These three constraints are mutually dependent. Fragmented authority hinders the creation of common data infrastructure; lack of data hinders the pricing of products that would be appealing to demand-side actors; low demand diminishes the motivation of insurers to invest in product development. The interdependence of constraints means that policy interventions which seek to deal with only one constraint at a time are not likely to work. There is a need to have a coordinated approach, which covers regulatory, informational and behavioral dimensions concurrently.

4. Policy Pathways

4.1 Institutionalizing Inter-Departmental Coordination

The Dalian initiative offers a blueprint, yet more than issuing documents jointly is needed to institutionalize it. An established coordination mechanism with assigned authority, budget and performance measures would turn the episodic cooperation into long-term governance.

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Particular functions that deserve coordination are the incorporation of oceanographic monitoring information into underwriting platforms, alignment of fisheries subsidy programs with insurance premium support, and collective catastrophe risk assessment of coastal zones. Such a mechanism should define the lead agency, decision making processes, resource commitments of agencies involved and indicators used to evaluate performance. In the absence of such specification, coordination mechanisms will be at risk of being ceremonial as opposed to operational.

The incentive structures that are presented to the agencies involved also need to be considered in the institutionalization of coordination. The agencies might not want to share information or relinquish power when it is costly and does not have a matching payoff. Coordination mechanisms must thus include incentives to participate, such as tying resource allocation to proven cooperation or developing joint performance measures that reward group performance. Other coastal provinces experience in setting up marine economic development coordination mechanisms can provide some lessons, but it should not be supposed that the institutional designs can be transferred to other provincial settings.

4.2 Building Marine Risk Data Infrastructure

A provincial marine risk data platform that taps into satellite remote sensing, buoy networks, fisheries records and historical claims would have several uses: it would allow the actuarially sound design of products, it would support parametric trigger calibration, and it would provide an evidence base to support premium differentials that reward risk-reducing behavior. The platform ought to be constructed as a common resource with proper data governance procedures. Data governance is an important yet often overlooked aspect: the platform should indicate what agencies and insurers can access what data, under which terms, and how confidentiality and commercial sensitivity are protected. In the absence of proper governance measures, data sharing can be opposed by agencies that fear liability or insurers who fear being at a disadvantage.

The platform should be developed in stages, starting with the data domains where existing systems are most advanced and growing as governance processes evolve. Key areas include oceanographic and meteorological monitoring data, which are gathered by government agencies and can be easily shared; fisheries production and loss data, which need to be coordinated with industry groups; and insurers' claims data, which need to be handled with commercial confidentiality in mind. The platform should also include standards for carbon sink measurement based on the methods used in the Panjin pilot, and extended to other aquaculture species and areas.

4.3 Linking Insurance with Fiscal and Financial Instruments

Fiscal assistance must be structured in a way that it is an addition to insurance and not a replacement. The functional shift towards ex-ante prevention would be supported by premium subsidies based on demonstrable risk-reduction investments. Subsidy design must define the risk-reduction behaviors that are eligible, how they are verified and the size of the subsidy difference. Unconditional subsidies run the risk of being appropriated by insureds without causing any change in behavior; conditioned subsidies can take advantage of the governance role of insurance to encourage risk reduction.

The connection of carbon sink insurance and carbon quota pledge financing, as tested in Panjin, may be applied to other ecological resources, thus incorporating insurance into the larger blue finance framework [10]. To extend this extension, methodologies of valuing ecological assets would have to be developed, markets or market-like structures established to trade ecological credits and credit assessment practices modified to accept insurance-backed ecological assets as collateral. The combination of insurance and credit markets enhances the developmental impacts of insurance through lowering the cost of capital on sustainable marine operations.

4.4 Enhancing Demand-Side Capacity

Demand-side barriers would be addressed by insurance literacy programs among aquaculture operators and fishing households, standardized and simplified policy terms, and integrated subsidy channels. The design of insurance literacy programs must take into account the particular information requirements and decision-making situations of small-scale marine operators, as opposed to using generic financial education resources. Simplified and standardised

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policy conditions lessen the mental load of assessing insurance products and enhance the chances of insureds knowing what they have bought. Streamlined subsidy outlets minimise administrative burden on applicants and boost uptake.

The creation of marine economy insurance alliances, based on risk-sharing and cooperation principles, would both enhance supply capacity and decrease the transaction costs of small-scale actors. Alliances are able to consolidate demand, bargain with insurers and offer technical support to members. They may also be used as risk sharing vehicles where small scale operators can share their risks and thus have access to insurance that they would not have accessed individually. The design of alliances ought to consider governance structures, financial sustainability and incentives alignment of the members otherwise alliances will be reliant on outside help or susceptible to bad selection.

5. Conclusion

The paper formulates a conceptual framework of analyzing the role of diversified blue insurance in empowering sustainable development of the marine economy in Liaoning Province. It gives an analytical foundation to policy design by defining four empowerment mechanisms and three diversification dimensions, as well as by defining the structural constraints that are currently constraining effectiveness. The main thesis is that the empowering impact of blue insurance is not automatic but conditional: it requires coordination of institutions, data infrastructure, and the fit of fiscal tools and insurance mechanisms.

There are three implications of this argument. To begin with, the creation of blue insurance must be imagined as an institutional project and not just a product development exercise. The limitations found in this paper fragmented authority, lack of data, weak demand are institutional in character and can only be addressed by institutional solutions. Second, the three diversification dimensions are interdependent: instrument diversification without functional diversification can lead to products that compensate losses without decreasing their incidence; functional diversification without governance diversification can go beyond the capacity of individual insurers. Policy interventions must thus deal with the three dimensions in conjunction. Third, the applicability of the framework to other coastal provinces is to be evaluated taking into account the variations in industrial structure, institutional capacity and policy priorities.

Future studies may take a number of directions. The framework created in this paper can be operationalized by using case studies of certain blue insurance products, following their development, adoption and impacts. A comparative study of the coastal provinces could determine the institutional circumstances in which blue insurance innovations spread. And the interaction between insurance and other blue finance tools, credit, bonds, investment funds might be analyzed to evaluate the complementarities and substitution effects. These research directions would build on the analytical framework proposed here and would help to further develop the overall knowledge of how financial instruments can contribute to sustainable development of marine economies.

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