Allocation of Sea Space Resources Based on Factor Endowments: a Numerical Example

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Abstract. A model of sea space resource allocation is constructed based on the idea of factor endowment theory. The effect of the model is explained by a numerical example. According to the theory of factor endowment, each sea area has the advantage of abundant factor intensive sea area utilization type. Each region should put more factors into the advantageous sea area utilization type. Compared with the output of the sea area utilization type with no advantages produced on its own self, the opportunity cost of obtaining the output of the sea area utilization type with no advantages through exchange is lower. The result of the numerical example shows that the total output of the two sea areas increases based on factor endowment allocation of sea resources. Both regions also achieved a win-win situation, with each region increasing its income by exchanging the output of sea use.

Keywords: Marine spatial planning; Marine zoning; Factor Endowments Theory.

1. Introduction
The allocation of sea space resources is an important problem to be solved in marine spatial planning. Recent researches mainly discussed the important role of planning in coordinating the contradiction between using sea and balancing economy and environmental protection. The existing research focuses on the zoning system, zoning method and management measures. There are few researches on how to allocate sea space resources to achieve higher comprehensive benefit. Factor endowment theory is one of the important theories of international economics. It is explained that the two countries with difference in factor endowment can produce relatively abundant factor intensive products through international division of labor, which can bring higher output. The cost of each relative scarce factor intensive product is lower than that of its own production through trade exchange. The theory of factor endowment has realized the optimal allocation of resources, increased the total output, and achieved a win-win situation. Can the idea of factor endowment theory be applied to the allocation of sea space resources? Can it be improved that the utilization output of the sea area? The above questions are discussed in this study. A model of sea space resource allocation is constructed based on the idea of factor endowment theory. The effect of the model is explained by a numerical example.

2. A Model of Sea Space Resource Allocation Based on Factor Endowment

2.1. Model Hypothesis
Suppose the sea area A and B in the two regions, the two types of sea area utilization F and M, and the sea area factors that affect the sea area utilization have two characteristics of H and L.
The two areas have the same sea area. The price of H-type sea area is higher than that of L-type sea area. There are differences in factor endowments in sea areas between the two regions. In sea area A, H factors are relatively abundant, while in sea area B, L factors are relatively abundant. There are differences in the factor use structure of the two types of sea area utilization. F is factor intensive for H and M is factor intensive for L. In the form of allocation of sea space resources without regional division of work, it is assumed that the two regions divide the sea area resources equally between the two types of utilization, and the opportunity cost of utilization output of the two types of sea areas in the two regions is different.

2.2. Principle of Allocation of Sea Space Resources
According to the theory of factor endowment, each sea area has the advantage of abundant factor intensive sea area utilization type. Each region should put more factors into the advantageous sea area utilization type. Compared with the output of the sea area utilization type with no advantages produced on its own self, the opportunity cost of obtaining the output of the sea area utilization type with no advantages through exchange is lower.

In the form of allocation of sea space resources without regional division of work, the relative price of product of F is lower in sea area A, while that of product of M is lower in sea area B. In the form of allocation of sea space resources with regional division of work, the two regions can exchange products of sea area utilization by a compromise of relative prices. Region A uses product of F to exchange product of M from region B, so that the price of M obtained is lower than that of M produced by itself. Without regional division of work, both regions put some of their factors into less efficient types of sea area utilization. Factor H is put into M in region A, and factor L is put into F in region B. With regional division of work, factors are put into the utilization types with relatively higher efficiency, and the total output of the two regions was improved.

3. A Numerical Example
Table 1 shows the difference in factor endowment between the two regions. In sea area A, area of H type is 60 km² and area of L type is 40 km². In sea area B, area of H type is 30 km² and area of L type is 70 km². In terms of factor endowment, sea area A is the abundant H type, while sea area B is the abundant L type.

|       | A (km²) | B (km²) |
|-------|---------|---------|
| H     | 60      | 30      |
| L     | 40      | 70      |

Table 2 shows the output capacity of the two types of sea area utilization using different factors. The output of sea area utilization F using H factor is 100 units, and the output of using L factor is 50 units. The output of sea area utilization M using H factor is 100 units, and the output of using L factor is 100 units. F is H intensive relative to M. At the same price level, more H factor will be put into F than M, and more L factor will be put into M than F.

|       | F (units) | M (units) |
|-------|-----------|-----------|
| H     | 100       | 100       |
| L     | 50        | 100       |

Table 3 shows the production possibilities of two types of sea area utilization in two regions. If all factors both H and L are put into F in sea area A, the output of product F is 80 units. If all factors both H and L are put into M in sea area A, the output of product M is 100 units. If all factors both H and L are put into F in sea area B, the output of product F is 65 units. If all factors both H and L are put into M in sea area B, the output of product M is 100 units.
Table 3. Production possibilities of the regions.

| A (units) | B (units) |
|-----------|-----------|
| F         | 80        |
| M         | 100       |

Table 4 shows the amount of H and L factor is put into the utilization of F and M and various combinations of outputs in sea area A and Sea area B. All factors are put into M at first, then a marginal change of 10km² is put into F. H factor is put into F first, and then L factor is put into F after H factor is used up. Figure 1 shows the output results of various factor input combinations in the two regions, that is, the production possibility curves of the two regions.

Table 4. Combination of production possibilities of the regions.

| A | B |
|---|---|
| H (km²) | L (km²) | F (units) | M (units) | H (km²) | L (km²) | F (units) | M (units) |
| 0  | 100  | 0         | 100       | 0         | 100     | 0         | 100       |
| 10 | 90   | 10        | 90        | 10        | 90      | 10        | 90        |
| 20 | 80   | 20        | 80        | 20        | 80      | 20        | 80        |
| 30 | 70   | 30        | 70        | 30        | 70      | 30        | 70        |
| 40 | 60   | 40        | 60        | 40        | 60      | 40        | 60        |
| 50 | 50   | 50        | 50        | 50        | 50      | 50        | 50        |
| 60 | 40   | 60        | 40        | 40        | 40      | 40        | 40        |
| 70 | 30   | 65        | 30        | 70        | 30      | 50        | 30        |
| 80 | 20   | 70        | 20        | 80        | 20      | 55        | 20        |
| 90 | 10   | 75        | 10        | 90        | 10      | 60        | 10        |
| 100| 0    | 80        | 0         | 100       | 0       | 65        | 0         |

Figure 1. Production Possibility Curves of the regions and the exchange price.

Without regional division of work, in sea area A, 50km² of H factor is put into F and the output of product F is 50 units, 10km² of H factor and 40 km² of L factor is put into M and the output of product M is 50 units. In sea area B, 30km² of H factor and 20 km² of L factor is put into F and the output of product F is 35 units, 50km² of L factor is put into M and the output of product M is 50 units.

The relative prices of F and M are different in two regions. The relative prices in region A is 1. The cost of producing 1 unit of F is 1 unit of H factor, and the cost of producing 1 unit of M is 1 unit of H.
factor. The relative prices in region B is 2. The cost of producing 1 unit of F is 2 unit of L factor, and the cost of producing 1 unit of M is 1 unit of L factor.

According to the theory of factor endowment, the factors are put into the advantageous utilization types in two regions. In sea area A, 60km² of H factor is put into F and the output of product F is 60 units, 40 km² of L factor is put into M and the output of product M is 40 units. In sea area B, 30km² of H factor is put into F and the output of product F is 30 units, 70km² of L factor is put into M and the output of product M is 70 units.

The total output of both types of utilization increased with regional division of work. The total output of product of F increased from 85 to 90. The total output of product of M increased from 100 to 110. Both can get what they want at a lower price with regional division of work. The product of F from sea area A can exchange the product of M from sea area B. The exchange price can be passed between 1 and 2, so let's say it's 1.5. 10 units of products of F from sea area A exchanged 15 units of products of M from sea area B, vice versa. After exchange, Region A can get 50 units of F and 55 units of M and region B can get 40 units of F and 55 units of M. Region A get 5 more units of M, region B get 5 more units of F and 5 more units of M.

4. Conclusion
A model of sea space resource allocation is constructed based on the idea of factor endowment theory. The effect of the model is explained by a numerical example. The result shows that: the total output of both types of utilization increased with regional division of work. The two regions also achieved a win-win situation by exchanging the output of sea utilization. This study provides a method for the follow-up empirical analysis. In practical application, regional factor endowment analysis, factor structure analysis of each sea utilization type and the production capacity of different regions is needed. Then factor endowment theory can be used to provide decision support for the allocation of regional sea space resources.

Factor endowment is not an absolute concept, but a relative one. A lot of the contradiction of using sea comes from the absolute thinking of factor endowment, which leads to the convergence of the structure of sea utilization between regions, the deterioration of marine environment and other problems. According to the factor endowment theory, the difference of factor endowment between regions is clarified more clearly when to coordinate and deal with conflicts at sea in marine spatial planning. It is better positioning their own development advantages to avoid inefficient development and utilization.

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