# *The role of the ocean industry in the Chinese national economy: An input-output analysis*

by
Rui Zhao, Associate Research Fellow
Ocean Economy Department
National Marine Data&Information Service: Tianjin, China.
Visiting Scholar
Center for the Blue Economy
Monterey Institute of International Studies: Monterey, CA
May 2013

# The role of the ocean industry in the Chinese national economy: an input-output analysis

**Abstract:** The Ocean Economy Accounting System (OEAS) was established in China in 2006. However, the economic indirect and induced impact of the ocean economy as part of the Chinese national economy has not been completely understood at the national or regional level. Activities in the marine sector not only affect the industries in this sector but also influence other sectors through inter-sector linkages. This paper employs input-output (I-O) analysis to examine the role of the ocean industry in the economy of Tianjin, China for the year 2007. This paper represents the first effort to quantify the inter-industry linkage effects of China's ocean industry.

**Key Words:** Input –Output table, Input-output analysis, Multipliers, Linkages, Ocean Economy

## 1. Introduction

The realization that the world's oceans play an important role in climate regulation and many terrestrial activities, notably food production, coupled with economic changes and the rapid advancement in ocean technology have seen a shift in the perception of the importance of marine resources [1]. China has abundant marine resources, with its 3 million square kilometers of offshore waters and 32,000 kilometers of coastline [2]. In recent years, the pace of industrialization and urbanization of the Chinese coastal areas has greatly accelerated, and thus marine space for construction is urgently needed.

A new round of Chinese coastal economic development started in 2010. Development strategies of the marine economy in coastal areas were approved by the central government, and accordingly provincial development plans were upgraded as part of the national development strategy [3]. In 2011, "developing the Ocean Economy" was included as one of the national development strategies by *China's 12$^{th}$5-year Plan for National and Social Development*. According to this plan, China's major tasks in ocean development during 2011-2015 are to optimize the structure of the marine industry, and to plan scientifically the development of marine industries, and to sustainably utilize the marine resources . Five national-level ocean economic-development zone plans for coastal provinces, including Guangdong, Shandong , Zhejiang, Fujian and Tianjin, have been approved by China's central government, establishing a new development pattern of China's coastal and ocean area. With a series of national policies and strategies released, a new era of ocean economy has come. It becomes very crucial to provide policy makers with accessible and reliable information regarding the role of the ocean industry, allowing for better decisions for ocean economic policies [4].

The OEAS (Ocean Economy Accounting System) has been established in China for 6 years. However, the economic impact[1] of the ocean economy in China's national economy has not yet been understood clearly at the national or regional levels. The direct impact of ocean industries in China at national and regional levels has been compiled for the period of 2001-2011, but it is still unclear what the overall economic impacts of ocean industries are in the national economy, and how the ocean industries interact with other industries in the national economy. China is similar to other ocean countries in that, - as Colgan [5] suggests that "knowledge of the marine economy is very imprecise because little has been invested in developing the needed data, especially in comparison with the investment in understanding of other natural resources ."

Input-Output (I-O) analysis is applied in this research in order to get the whole picture of the ocean economy in China. Information on an industry's linkages with the rest of the economy helps us to better understand the structure of an economy and how it changes over time, which in turn is important in formulating industrial policies [6-11]. Input-output analysis has been around for decades in various disciplines of economics and is widely used by researchers, policy analysts, and practitioners [12]. Multipliers are used to calculate the overall economic impact of a project or policy change. Two types of multipliers are commonly used, type I multipliers measure the industrial response to the change while type II multipliers measure the consumption-induced response in addition to the industrial response [13].

This paper aims to provide decision-makers, planners, industry and the general public with a measure of the relative economic importance of the ocean. To this end, this paper has two specific objectives: The first is to develop an I-O framework for examining the role of the ocean industry in China. The second goal is to develop a preliminary indication of the size of the ocean industry in China.

The paper continues as follows: Section 2 provides an overview of the ocean economy and major industries in China and the basis for selecting these industries. Section 3 provides a formal overview of the economic impacts evaluation methodologies of four main coastal countries, and tries to find a proper evaluation method for China. Section 4 describes the data requirements, data limitations, and data used in this paper. Section 5 presents the results of the I-O analysis in terms of multipliers and linkages for the ocean sector. Section 6 offers some concluding comments on the analysis.

## 2. The status of the Ocean economy of China

[1]Economic impacts are generated through direct, indirect and induced demand in the economy expressed in terms of industry and consumer purchases of goods and services [14]. If there is an increase in **final demand** for a particular product, it can be assumed that there will be an increase in the output of that product, as producers react to meet the increased demand; this is the **direct effect**. As these producers increase their output, there will also be an increase in demand on their suppliers and so on down the supply chain; this is the **indirect effect**. As a result of the direct and indirect effects the level of household income throughout the economy will increase as a result of increased employment. A proportion of this increased income will be re-spent on final goods and services: this is the **induced effect**. The ability to quantify these multiplier effects is important as it allows economic impact analyses to be carried out for the entire economy.

The 21st century is the century of ocean and blue civilization. Economic globalization is accelerating to push inland economies to move toward the ocean economy.[2] Exploration and protection of ocean resources play an important role in sustainable development, especially in China who has a vast sea territory. Since China adopted the policy of "reform and opening" in 1978, China has witnessed the rapid development of marine resources, especially in the recent decade. China's marine economy has maintained a higher growth rate than that of the national economy during the same period, yet it still has certain disparities with the global marine economy. As mentioned above, a new era of the ocean economy in China has started; the ocean economy will increase greatly in the near future.

According to the *2011 statistical bulletin of China's Ocean Economy*, the Ocean economy in China accounts for nomore than 10 percent of China's gross domestic product (GDP), and it is mainly centered on traditional industries such as fishing, transport and tourism. Emerging industries, including marine-related biomedicine, power, chemicals and seawater utilization, only account for five percent of marine output. Therefore, in this research, I will focus on traditional industries including the ocean transport industry, coastal tourism industry, shipbuilding industry and marine fishery industry [15].

According to the *China marine statistical yearbook 2011*, major marine industries' effects on value added of the national marine economy in 2010 reached 1618.78 billion Yuan, up17.4% from the previous year(unless otherwise specified, the growth rate is calculated in the comparable price). The coastal tourism and marine communications and transportation industry still played a dominant role [16].

In 2010,

- The full-year marine fishery effects on added value were 285.2 billion Yuan, up 6.0% from the previous year;
- The output of seawater aquatic products[3] amounted to 27.975 million tons, registering a decrease of 2.9% compared with that of the previous year,
- The mariculture production[4] amounted to 14.823 million tons, down 3.5% from the previous year;
- The yield from marine fishing[5] 12.036 million tons, down 10.5% from the previous year;
- The yield from the deep-sea fishing[6] 0.888 million tons, up 8.5% from the previous year.

[2] In today's world, as the Land resources are increasingly on the verge of exhaustion, the value of the oceans as a coastal economic development strategy space has become increasingly prominent, almost all the coastal countries have launched programs explicitly put forward the strategic initiatives of the development of marine economy.

[3] Seawater aquatic products is the sum of the productions of marine fishing, deep-sea fishing and maricalture.

[4] Maricluture production refers to the output of aquatic products whose young are artificially released or naturally collected, and raised and managed artificially, and which are caught from the waters of mariculture.

[5] Marine fishing refers to the output of the naturally growing aquatic products caught from the sea.

[6] Deep-sea fishing production refers to the output of aquatic products caught in the non-Chinese jurisdictional sea areas (foreign EEE or high sea) by the distant fishing vessel(fleet) organized by various distant fishing businesses and production units

In 2010, the marine shipbuilding industry overcame many difficulties and continued rapid development under the guidance of the Shipbuilding Industry Restructuring and Revitalization Plan. The completed quantity of ships built and the number of received shipbuilding orders has increased by a large margin, and the full-year added value reached 121.56 billion Yuan, increasing by 22.8%.

In 2010, as the international trade situation got better and shipping prices resumed their growth, the marine communication and transportation industry has warmed quickly, and an added value of 378.58 billion Yuan was generated for the whole year, 20.6% up from the previous year. The cargo handling capacity of coastal harbors amounted to 5644.64 million tons, up 15.8% from the previous year and the handling capacity of international standardized containers 131.45 million standard cases, up 19.3% from the previous year.

Coastal tourism effect showed full-year added value of 530.31 billion Yuan in 2010, up 13.3% from the previous year.

## 3. Methodology

This paper uses an I-O analysis. Input-output analysis is the name given to an analytical framework developed by Wassily Leontief in the late 1930s. I-O analysis is the study of quantitative relations between the output levels of the various sectors of an economy, a practical tool for national accounting and planning [17]. I-O analysis is quite useful for analyzing ocean sector issues in the national economy context because it recognizes the interdependence of all sectors of the economy and their ocean consumption embodied in the sectoral output[18].The advantage of I-O analysis is its ease of use and transparency. However, as a methodology for undertaking economic impact analysis the ease of use comes at a cost. In particular, I-O analysis is easy to use because of a number of limiting and unrealistic assumptions [13]. In China, most research about the ocean economy is qualitative analysis, and there is rarely quantitative analysis of the ocean economy. This research represents the first effort to apply I-O analysis in the ocean economy analysis in China.

### 3.1 Literature review

In this section, we review literature focusing on I-O analyses concerning the ocean economy. Until now, five countries, USA, Canada, France, Korea and Ireland, have calculated the multipliers of ocean industries through Input-Output analysis [1,18-21]. These calculations could be further divided into two types: conventional and improved.

#### 3.1.1 Conventional type – America and Canada

Following conventional practice, the research in America and Canada has focused on the direct, indirect and induced effects of ocean industries, measuring with three indicators: GDP, wages and employment.

---

according to the management measures of the China distant fishing projects. The aquatic products caught by the Chinese-foreign joint ventures' and cooperative fishing vessels are counted only for the part owned by the Chinese side accounting to the agreement.

The notion of multipliers rests upon the difference between the initial effect of an exogenous change and the total effects of that change. The total effects can be defined either as the direct and indirect effects (found in an input-output model that is open with respect to households) or as direct, indirect and induced effects (found in a model that is closed with respect to households) [22]. Households, which own most of the factors of production, receive income from the industries in form of wages and salaries, self-employed income, rent, and dividends. In return, households spend a large share of their income on regional goods and services[12]. Although household consumption is clearly a final demand activity, household buying decisions depend largely on their generated income, which is closely related to the level of economic activities in the region. For this reason, households are often included in the endogenous account and treated in the same manner as the industries.

The multipliers that incorporate direct and indirect effects are also known as simple, or type I, multipliers. When direct, indirect and induced effects are captured, they are often called total multipliers or type II multipliers. The research of Canada calculated the type I and type II multipliers for the three indicators. The National Ocean Economics Program (NOEP) research in the United States focused on the type II multipliers. The Director of NOEP, Dr. Judith Kildow, and the chief economist Dr. Charles Colgan, point out that type II multipliers are able to describe the whole picture of the economy, and most people are interested in the indirect plus induced, not the indirect alone.

In type I and type II multiplier analysis, the general form of the model is $X = Lf$ (Here X represents the sum of gross outputs, f represents the part of gross output sold to final demand. L is the Leontief Inverse matrix), the usefulness of the result, will depend on the "accuracy" of both the Leontief inverse and the final-demand vector. Using employment as an example, direct activity is the employment in the industry itself. Indirect employment is the employment in firms within the region who supply goods and services to the industry. Induced employment is the employment affected by the spending of the direct and indirect employment within the region for the purchases of food, cars, services, etc.

The conventional model is

$$x = (I - A)^{-1} f$$

$$x = (I - \bar{A})^{-1} f$$

Here vector $x$ is the sum of gross outputs, vector $f$ represents the part of gross output sold to final demand, $I$represents an identity matrix, and $A$ is a matrix of technical coefficient with households exogenous, matrix $\bar{A}$ is the matrix of technical coefficient with households endogenous. $(I - A)^{-1}$is referred to as the Leontief Inverse.

$A$ is defined as: $$A = a_{ij} = \frac{z_{ij}}{X_j}$$

Where $z_{ij}$ represents the intermediate demand for inputs between sector $i$ and the supply sector $j$ and$X_j$ is the final output for sector $j$.

$\bar{A}$ is defined as $$\bar{A} = \bar{a}_{ij} = \frac{\bar{z}_{ij}}{\bar{X}_j}$$

The difference between $\bar{A}$ and $A$ is that in matrix $\bar{A}$ households are considered as part of the endogenous account. Where $\bar{z}_{ij}$ represents the intermediate demand for inputs between sector $i$ and the supply sector $j$ and$\bar{X}_j$ is the final output for sector $j$.

In what follows, multipliers will be illustrated using employment, but this applies equally well to income and outputs of the sectors in the economy.

The total economic influence of a given industry's employment in a given region is thus defined as:

$$Total\ Employment\ =\ Direct\ Employment\ +\ Indirect\ Employment\ +\ Induced\ Employment$$

The indirect employment or the sum of indirect and induced employment is referred to as the "multiplier." Total employment may thus also be defined as:

$$Total\ Employment = Direct\ employment \times multiplier$$

Where the multipliers have two types, which are type Ⅰ multiplier and type Ⅱ multiplier.[7]

$$type\ \mathrm{I}\ multiplier = 1 + \frac{indirect\ Employment}{Direct\ Employment}$$

$$type\ \mathrm{II}\ multiplier = 1 + \frac{indirect + induced\ Employment}{Direct\ Employment}$$

As a practical matter, the choice between multipliers depends on the nature of the exogenous change whose impact is being studied. It is generally conceded that type Ⅰ multipliers probably underestimate economic impacts (since households are absent) and type Ⅱ multipliers probably give an overestimate(because of the rigid assumptions about labor incomes and attendant consumer spending).

Oosterhaven (1989) suggest that these two multipliers [type I and type Ⅱ ] may be considered as upper and lower bounds on the true indirect effect of an increase in final demand; a realistic estimate generally lies roughly halfway between type I and type Ⅱ multipliers[23].

### 3.1.2 Improved Type – Korea and Ireland

Morrissey and O'Donoghue (2012) used input-output methodology to examine the linkages and production effects of the Irish marine sector on the national economy[1]. Kwak, Yoo and Chang(2005) employed input-output analysis to examine the role of the maritime industry in the Korea national economy for the period 1975-1998[18].Thesetwo research projects share the opinion that: the conventional Leontief input-output model cannot exactly assess the effects of new production activity in

[7]The designations "type I" and "type II" seem to have originated with Moore(1955) [24]. Calculation of these measures (in a regional setting) was pioneered by Moore and Petersen (1955) for Utah [25] and later by Hirsh (1959) for St. Louis [26].

ocean industries on all other sectors of the economy because changes in the final demand come about as a result of forces outside the model (e.g., changes in consumer tastes and government purchases).[1-2,19] For this purpose, both of them handled the individual ocean sector as exogenous and put into the final demand group. Therefore, they established an ocean industry-based I-O analysis. However, the two types of research also have differences. The main difference is the effects of price change. In Korea's research, they paid particular attention to the production-inducing effects, supply shortage effects, employment-inducing effects of ocean industries and pervasive effects of price change in the ocean industries. The Irish research focused on calculating the backward and forward linkages, but not the effects of price change.

The multipliers in the Irish case contained two types which were Leontief supply driven (LSD) multiplier and Ghoshian supply driven (GSD) multiplier which are principally the same with the variant in the Korea' case(Kwak SJ, Yoo SH, Chang JI2012)[18].

Following Cai and Leung (2004)[7], Morrissey and O'Donoghue (2012)[1] gave the variant of the Leontief input-output model as follows:

$$\begin{pmatrix} x_i \\ x_j \end{pmatrix} = \begin{pmatrix} A_{ii} & A_{ij} \\ A_{ji} & A_{jj} \end{pmatrix} \begin{pmatrix} x_i \\ x_j \end{pmatrix} + \begin{pmatrix} f_i \\ f_j \end{pmatrix}$$

Here i denotes the marine sector and j denotes the rest of the economy. In this model, final demand was divided into ocean based demand$f_i$and non-ocean final demand$f_j$, and outputs$x_i$ and $x_j$ and direct input coefficient matrix, respectively. Thus,

$$x_j = (I - A_{jj})^{-1} A_{ji} x_i + (I - A_{jj})^{-1} f_j$$

The contribution made by the marine sector to other sectors $\Delta x_j$ is

$$\Delta x_j = (I - A_{jj})^{-1} A_{ji} x_i$$

Thus, Leontief supply driven ($LSD_i$) multiplier is given by:

$$LSD_i = 1 + e(I - A_{jj})^{-1} A_{ji}$$

e is the summation vector used to aggregate the elements in Dxj, that is, the impacts of this initial output change on the rest of the economy through the marine sectors i's backward linkages.

And they also used the Leontief row sums which are controversial to calculate measures of forward linkages based on the strength of backward linkages. Morrissey and O'Donoghue (2012) gave the equation of Ghoshian supply driven (GSD) multiplier as follows:

$$GSD_i = 1 + B_{ij}(I - B_{ij})^{-1} e$$

Where $i$ represents the marine sector and j all other sectors. B is the direct output coefficient matrix.

In Korea's case, Kwak et al. (2005) also used the Leontief Price model to investigate the economic impacts of ocean .The Leontief Price model can assess the wholesale price change on the economic system caused by the cost change of the ocean sector, if it is assumed that the cost change of each sector could be completely transferred and annual production of each sector is given [1].

### 3.2 Methodology of China I-O analysis

#### 3.2.1Methodology of China's Ocean Economy Input-Output Analysis

The advantage of conventional methodology is that it can give people a clear and complete picture of the ocean economy, but their economic impact analysis looks backwards rather than forwards through the economy. Both Korea and Ireland have focused on both backward and forward linkage, resulting in variants of conventional I-O models. Their reasons for this are based on the same theoretical point that a conventional model cannot precisely assess the effects of new production activity in each ocean industry on all other sectors of the economy because changes in the final demand come about as a result of forces outside the model (e.g., changes in consumer tastes and government purchases). In this research, the methodologies of the four countries will be integrated to establish the methodology for the China ocean economy input-output analysis.

First, this research will choose type Ⅱ multipliers which describe the whole picture of economic impacts of ocean industries. It allows us to measure the economic impacts by considering households as part of the endogenous account.

The calculations of multipliers are straightforward and based on the corresponding Leontief inverse matrix $(I-\bar{A})^{-1}$. And we have three kinds of Type Ⅱ multipliers, which are output multipliers, income multipliers and employment multipliers.

$$OM_j = \sum_{i=1}^{n} \overline{mult_{ij}}$$

Where,

$OM_j$- type Ⅱ output multipliers;

$\overline{mult_{ij}}$-partial multipliers from the $(I-\bar{A})^{-1}$ matrix;

$\bar{A}$ – technical coefficient matrix with households endogenous;

$n$ – number of industries

type Ⅱ output multipliers increase marginally in magnitude due to the inclusion of households in the endogenous account, referred to as induced effect.

Employment is another key variable that is given much attention in economic analysis. In order to calculate the type Ⅱ employment multipliers, one should establish a connection between jobs and output per industry at first. This is usually done by computing employment/output ratios:

$$e_i = \frac{E_i}{X_i}$$

Where,

$e_i$-employment/output ratios;

$E_i$-employment for industry $i$;

$X_i$-output for industry $i$;

The corresponding type Ⅱ employment multipliers($EM2_j$) are defined as:

$$EM_j = \sum_{i=1}^{n+1} \frac{e_i mult_{ij}}{e_j}$$

Where,

$EM_j$- type Ⅱ employment multipliers;

$mult_{ij}$-partial multipliers from the $(I-A)^{-1}$ matrix;

And in the same way, type Ⅱ employment multipliers can be defined as follows:

$$IM_j = \sum_{i=1}^{n+1} \frac{hmult_{ij}}{h_j}$$

Where,

$IM_j$- type Ⅱ income multipliers;

$mult_{ij}$-partial multipliers from the $(I-A)^{-1}$ matrix;

□$_i$-technical coefficients from the A matrix for households, $h_j = \frac{H_i}{X_i}$;

$H_i$ – household payments by industry $i$ from the industry transaction table;

$X_i$ – output for industry $i$.

Following Tong (2005), the $(I-\bar{A})^{-1}$ matrix is calculated as follows：

**F**irstly, take the household as the n+1 sector, and turn the n×n non-household matrix to (n+ 1) × (n+ 1) matrix with household as one sector.

Expansion method: in the rows, the n + 1 row describes the inputs (labor) from household sector to the other sectors. Labor can be represented by the labor remuneration, therefore, as the first step in the extention of technical coefficient matrix, the labor remuneration coefficient vector V=(v1, v2, …, vn) should be added to the n+1 row (household) from the third quadrant of I/O table to the technical coefficient matrix. In the column, the n+1 column from the second quadrant should be added to the origin I/O table to describe the consumption structure of the house hold sector.

$$F = (F_1, F_2, \dots, F_n)^T$$

Here , $F_i$ *r*epresent the goods or service supplied by other sectors to the i sector.

$$f_i = F_i \Big/ \sum_{i=1}^{n} F_i \quad i = 1, 2, \dots, n$$

$f_i$ represents the share of the i sector in the household consumption (ie the household sector technical coefficient). So the vector

$$f = (f_1, f_2, \dots, f_n)^T$$

is the household technical coefficient vector, and:

$$\sum_{i=1}^{n} f_i \ _i = 1$$

The second step is placing the vector $f = (f_1, f_2, \dots, f_n)^T$ in the technical coefficient matrix as the n+1 column, while filling in the cross position of the n+1 row and n+1 column with 0 in the new matrix. So a (n+ 1) × (n+ 1) technical coefficient matrix, including household sector, turns out to be

$\bar{A}$= $\begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1n} & f_1 \\ a_{21} & a_{22} & \cdots & a_{2n} & f_2 \\ & & \vdots & & \\ a_{n1} & a_{n2} & \cdots & a_{nn} & f_n \\ v_1 & v_2 & \cdots & v_n & 0 \end{pmatrix}$ Therefore， we can use $\bar{A}$ to calculate $(I - \bar{A})^{-1}$.

This paper also proposes “linkage analysis” as a complement to multipliers to examine the ocean economy’s economic impacts on the national economy. The linkages analysis, used to examine the interdependency in the production structures, was introduced to the field of input-output analysis in the pioneering work of Chenery & Watanabe (1958)[27], Rasmussen (1956) [28]and Hirschman (1958)[29] on the use of linkages to compare international productive structures, and since that has been improved

and expanded in several ways and many different methods have been proposed for the measurement of linkage coefficient. This paper will use the method created by Rasmussen..
Rasmussen (1956) proposed to use the column (or row) sums of the Leontief inverse, $(I - A)^{-1}$, to measure intersectoral linkages. The backward linkage, based on the Leontief inverse matrix, is simply defined as the column sums of the inverse matrix, i.e.,

$$BL_j = \sum_{i=1}^{n} l_{ij}$$

Where $l_{ij}$is the ij'th element of Leontief inverse matrix that is denoted by L, i.e. $\mathrm{L} = (I - A)^{-1}$. Sector j's backward linkage, BLj , reflects the effects of an increase in final demand of sector j on overall output; in other words, it measures the extent to which a unit change in the demand for the product of sector j causes production increases in all sectors.

Similarly, the corresponding forward linkage can be defined by reference to the rows of the Leontief inverse matrix. Thus a measure of forward linkage of sector is as:

$$FL_j = \sum_{j=1}^{n} l_{ij}$$

It measures the magnitude of output increase in sector i, if the final demand in each sector were to increase by one unit; in other words, it measures the extent to which sector i is affected by an expansion of one unit in all sectors.

The key sectors, which are the most important sectors for the economy, are the sectors, whose values of both backward linkage and forward linkage are above the corresponding average. For simplicity, the linkage indicators are normalized and that their average is equal to one. The normalized values of backward and forward linkages will be calculated on the basis of the following formulas:

$$\mathrm{NBL} = nBL_j \Big/ \sum BL_j$$

$$\mathrm{NFL} = nFL_i \Big/ \sum FL_i$$

The symbols stand for:

$NBL = \{BL_j\}$ - vector of normalized values of backward linkages;

$NFL = \{FL_i\}$- vector of normalized values of forward linkages;

*n* - number of sectors in the input-output table.

According to the size of the various linkage indicators all sectors of an economy may be grouped into four categories. If the values of both backward linkage and forward linkages of sector are all above the

corresponding average (that is the normalized values of both backward and forward linkages is greater than 1), the sector is called key sector. If only the backward linkages of sector are greater than the average (only the normalized value of backward linkages is greater than one), the sector can be termed a strong backward linkages sector. Similarly, if only the forward linkages of sector are greater than the average (i.e. only the normalized value of forward linkages is greater than one), the sector is called a strong forward linkages sector. The fourth group refers to the weak linkages category. This is the case where a sector's backward linkages and forward linkages are both less than one [30].

### 3.2.2 Frame work of Ocean Economy I-O table

I-O table is the foundation and first step of an Input-Output Analysis to serve the needs of I-O analysis. Until now, focus on the establishment of ocean economy I-O tables has been rare in the world. But establishing the framework of an I-O table is definitely important for continuous I-O analysis research in China. This research should be the first effort to establish a framework for the Ocean Economy I-O table.

Based on the conventional structure of I-O tables, this paper rebuilds the framework of the I-O table in order to highlight and analyze the ocean industries. The main focus of input-output tables is the interdependencies of the inter-industry transactions [12]. Input-output tables can be described as a very inclusive set of industry accounts. Reading across the rows identifies sales made by industries-the output, reading down the columns shows purchases made by industries as the inputs. The preliminary framework of the Ocean Economy I-O table should be as follows.

**Table1Preliminary design of Ocean Economy I-O Table**

| To / From | | Intermediate Demand | | | Final demand | | Exports | Total Supply |
|---|---|---|---|---|---|---|---|---|
| | | Ocean Industries | Non ocean Industries | Total | Private | Public | | |
| Intermediate Inputs | Ocean Industries | $x_{ii}$ | $x_{ij}$ | | | | | |
| | Non ocean Industries | $x_{ji}$ | $x_{jj}$ | | | | | |
| | Total | | | | | | | |
| Added Value | Fixed Assets Depreciation | | | | | | | |
| | Wages&Salaries | | | | | | | |

| | | | |
|---|---|---|---|
| | Social Return | | |
| Total Input | | | |

In this structure of the ocean economy I-O table, I-O industries are divided into two areas: one being ocean industries, the other non-ocean industries. Therefore, the inter-industry transactions (upper left-hand quadrant) are divided into four parts, and one can explicit the interactions between ocean industries and non-ocean industries, ocean industries and ocean industries, non-ocean industries and non-ocean industries interact. With this table, users can get plenty of information about interactions, final demand consumption, and the added value that are related to ocean industries. And policy analysts and practitioners can use the results of analysis to conduct policies or plans about ocean industries.

### 3.2.3 Aggregation of ocean industries of China

It is difficult to construct an ocean economy I-O table without original survey research. In this research, multipliers calculation follows the methodology used by NOEP. The multiplier effect can be estimated a number of different ways. NOEP uses a regional economic model called IMPLAN, which is commonly used for this type of analysis. Multiplier effects are calculated for all ocean economy sectors and industries at the state and national level [5].What should be noted here is that the methodology of NOEP is to aggregate IMPLAN industries to calculate the multipliers of ocean sectors, as follows.

**Table 2** Ocean sectors aggregation of NOEP

| Aggregated Ocean sector Description | IMPLAN Industry Code | IMPLAN Description |
|---|---|---|
| Living Resources – Marine | 14 | Animal production, except cattle and poultry and eggs |
| | 17 | Commercial Fishing |
| | 61 | Seafood product preparation and packaging |
| | 324 | Retail Stores - Food and beverage |
| Ship & Boat Building | 291 | Boat building |
| | 290 | Ship building and repairing |
| Transportation – Marine | 334 | Transport by water |
| | 338 | Scenic and sightseeing transportation and support activities for transportation |
| | 249 | Search, detection, and navigation instruments manufacturing |
| Construction – Marine | 36 | Construction of other new nonresidential structures |
| | 35 | Construction of new nonresidential manufacturing structures |
| | 34 | Construction of new nonresidential commercial and health care structures |
| Minerals – Offshore | 20 | Extraction of oil and natural gas |

| | | |
|---|---|---|
| | 28 | Drilling oil and gas wells |
| | 26 | Mining and quarrying sand, gravel, clay, and ceramic and refractory minerals |
| | 29 | Support activities for oil and gas operations |
| | 369 | Architectural, engineering, and related services |
| Tourism & Recreation – Coastal | 363 | General and consumer goods rental except video tapes and discs |
| | 311 | Sporting and athletic goods manufacturing |
| | 393 | Other private educational services |
| | 406 | Museums, historical sites, zoos, and parks |
| | 413 | Food services and drinking places |
| | 412 | Other accommodations |
| | 411 | Hotels and motels, including casino hotels |
| | 410 | Other amusement and recreation industries |

Dr. Fernando DePaolis, who oversees multiplier calculation in NOEP, suggests that as generally there is no available data specifically to construct the ocean economy input-output table, it is acceptable to estimate the multipliers of ocean sectors using the aggregation of related sectors available in the I-O table, rather than to estimate the value of ocean sectors. So in the methodology of NOEP, Table 2 is used to aggregate the corresponding IMPLAN sectors. Take Ship & Boat Building for example, the corresponding IMPLAN sectors of Ship & Boat Building, repairing (290) and Boat building (291) are added up in row and column to a new aggregated industry in order to calculate multipliers. Following the same way, the other 5 sectors are also aggregated. As a result, the new I-O table related to ocean industries is created.

Generally, the data needed to set up the ocean economy I-O table like Table 1 can be divided into two types. One is total aggregates, such as added value, total input, total output, the other is sectoral structure data, such as the structure of the intermediate demand or inputs. In China's case, original survey research (which is very expensive and time-consuming) is required to get accurate data for the structure of the intermediate demand or inputs of ocean industries. Therefore, this research focuses on figuring out the key steps of constructing an ocean economy I-O table, as follows:

1. Categorize ocean industries for I-O table. This is the start and foundation of the whole process. In this step, the relationship between ocean industries and I-O table sectors need to be established.
2. Total amount data collecting. In China's case, the total aggregates can be collected through OEAS.
3. Structure data collecting. In this step, the database of sectoral data is mainly from official sources provided by the Chinese government. The best way to do this is using the 144*144 regional (basically the coastal provinces) I-O table. This kind of table is the most specific I-O regional table in China. Therefore, one can get the most accurate results that can be used to calculate multipliers of ocean industries.

4. Original survey research. In order to get the real multipliers of ocean industries, original survey research is necessary. But usually people cannot get enough human and financial resources to conduct this kind of survey. In this research, we did not conduct the original survey, following the NOEP methodology.
5. Construct the ocean economy I-O table. As mentioned above, original survey research is necessary in establishing ocean economy I-O table. In this research, the focus is the relationship between ocean economy and national economy, and the ocean economy multipliers can be computed by using the sectoral data and total aggregates.

The primary problem encountered in the establishment of the marine economy I-O table is the ocean I-O industry classification. That is because in the actual process of setting up an I-O table, industry classification is often far away from the requirement of "pure" sector[8] principle.

In China's case, Ocean industries should be separated from *National Economic industries and codes* (just like NAICS), *Ocean Industries and Their Related Activities (GB/T 20794-2006)*. Two principles should be followed: one is that each sector produces a single output (i.e. all the products of the sector are perfect substitutes for one another or are produced in fixed proportions); and the other is that there is no substitution between the products of different sectors.

Comparing the categories studied in the different national ocean economy studies to date [19], it is generally agreed that the ocean industry should be defined based on a directly related standard, namely, the principle of ocean resources must be directly related to the ocean industries in the ocean economy I-O table. Its range not only contains the industries for development of or use of marine resources, but also industries that directly provide goods or services to the ocean industries, as well as the reprocessing industries that directly use the products of the above mentioned industries. NOEP defined the ocean economy: "The ocean economy is that portion of the economy which relies on the ocean as an input to the production process or which, by virtue of geographic location, takes place on or under the ocean"[20].

According to the above analysis, combined with the present situation of China, the Chinese ocean economy is comprised of the sectors listed in Table 3 .

**Table3** Classification of major ocean industries and definitions

| Ocean industry | Definition |
|---|---|
| Marine Fishery | Includes mariculture, marine fishing, marine fishery service industry and marine aquatic processing, etc. |
| Offshore Oil and Gas Industry | Refers to production activities of exploring, exploiting, transporting and processing raw oil and natural gas in the ocean. |
| Ocean Mining Industry | Includes the activities of extracting and dressing beach placers, beach soil chloride |

[8] A sector in the input-output table is called "a pure sector", which has the same product characteristics, i.e. the same input structure, the production process and the usage. The pure sector clearly demarcates sectors, making it possible for quantitatively measuring industry convergence.

| | |
|---|---|
| | and sand, submarine geothermal energy, and coal mining and deep-sea mining, etc. |
| Marine Salt Industry | Refers to the activity of producing salt products with the sodium chloride as the main component by utilizing seawater, including salt extracting and processing. |
| Shipbuilding Industry | Refers to the activity of building ocean vessels, offshore fixed and floating equipment with metals or non-metals as main materials as well as repairing and dismantling ocean vessels. |
| Marine Chemical Industry | Includes the production activities of chemical products of sea salt, seawater, sea algal and marine petroleum chemical industries. |
| Marine Biomedicine Industry | Refers to the production, processing and manufacturing activities of marine medicines and marine health care products by using organisms as raw materials or extracting useful components therefrom. |
| Marine Engineering Building Industry | Refers to the architectural projects construction and its preparations in the sea, at the sea bottom and seacoast for such uses as marine production, transportation, recreation, protection, etc., including constructions of seaports, coastal power stations, coastal dykes, marine tunnels and bridges, land terminals of offshore oil and gas fields as well as building of processing facilities, and installation of submarine pipelines and equipment, but not the projects of house building and renovation. |
| Marine Electric Power Industry | Refers to the activities of generating electric power in the coastal region by making use of ocean energies and ocean wind energy. It does not include the thermal and nuclear power generation in the coastal area. |
| Seawater Utilization Industry | Refers to the activities of the direct use of sea water and the seawater desalination, including those of carrying out the production of desalination and applying the seawater as water for industrial cooling, urban domestic water, water for firefighting etc., but not the activity of the multipurpose use of seawater chemical resources. |
| Marine Communications and Transportation Industry | Refers to the activities of carrying out and serving the sea transportations with vessels as main vehicles, including ocean-going passenger transportation, auxiliary activities of water transportation, pipeline transportation, loading, unloading and transport as well as other transportation and service activities. |
| Coastal Tourism | Refers to the tourist business and service activities with the backing of coastal zone, sea islands as well as a variety of natural and human landscape of the ocean, mainly including marine sightseeing, living a life of leisure and recreation, going on vacation and getting accommodation, sports, etc. |

Because of the statistical classification in China, government Input-Output Data does not identify for ocean, therefore, the corresponding input-output sectors in the China Input-Output table should be selected according to the definitions of the Input-Output sectors and ocean economy I-O sectors. Generally, I-O tables of China are built with 144 I-O industries, 22 of which are corresponding industries of major ocean industries.

Table 4 provides the corresponding relationship between ocean industries and I-O sectors. What is interesting is that in the 12 major ocean industries, 7 of them are related to only one I-O sector. Therefore these 7 ocean industries can use the multipliers of their corresponding I-O sectors. On the other hand, the other 5 industries need to be aggregated as calculating the multipliers of ocean industries. Following the methodology created by NOEP, the main aggregation method used in this research is to add up all the corresponding industries in rows and columns to develop a new I-O matrix.

**Table4** Corresponding relationship between ocean industries and input-output sectors

| Ocean sectors | Ocean industries | Input-output sectors |
|---|---|---|
| Marine Fishery | Mariculture | 03003 Fishing |
| | Marine Fishing | 03003 Fishing |
| | Fishery Service industry | 05005Agriculture, Hunting, Forestry and |

| | | |
|---|---|---|
| | | Fishing services |
| | Seafood Processing | 13016Aquatic products processing |
| Offshore Oil and Gas Industry | Offshore oil and gas exploration and production | 07007 Petroleum and Natural Gas Mining |
| | Support activities for oil and gas | |
| Ocean Mining Industry | Sea beach placer mining and quarrying | 08008Ferrous Metals Mining and Dressing<br>09009Nonferrous Metals Mining and Dressing |
| | Sand & stone Mining and quarrying | 10010Nonmetal Minerals Mining and Dressing |
| | Submarine geothermal power and coal mining | 10010Nonmetal Minerals Mining and Dressing |
| | Deep sea mining | 08008Ferrous Metals Mining and Dressing<br>09009Nonferrous Metals Mining and Dressing<br>10010Nonmetal Minerals Mining and Dressing |
| | Other ocean mineral resources mining | 08008Ferrous Metals Mining and Dressing<br>09009Nonferrous Metals Mining and Dressing<br>10010Nonmetal Minerals Mining and Dressing |
| Marine Salt Industry | Salt industry of seawater | 10010Nonmetal Minerals Mining and Dressing |
| | Salt processing | |
| Shipbuilding Industry | Ship & boat building and repairing | 37075Ship and Floating Equipment Manufacturing |
| | Offshore fixed and floating devices manufacturing | |
| Marine Chemical Industry | Sea salt chemical industry | 26039 Basic Chemistry Industry |
| | Seaweed chemical industry | |
| | Sea water chemical industry | |
| | Offshore oil & gas chemical industry | 25037 Oil and Nuclear Fuel Processing |
| Marine Biomedicine Industry | Marine medicine producing | 27046 Manufacture of Medicines |
| | Ocean health products | |
| Marine Engineering Building Industry | Ocean engineering building | 47095 Construction of Buildings and Civil Engineering |
| | Offshore engineering building | |
| | Submarine engineering building | |
| Marine Electric Power Industry | Oceanic energy | 44092 Production and supply of Electric Power and Heat Power |
| | Offshore wind | |
| Seawater Utilization Industry | Seawater desalination | 46094 Production and Supply of Water |
| | Direct seawater utilization | |
| | Other seawater utilization | |
| Marine Communications and Transportation Industry | Marine cargo transportation | 54102 Water Transport |
| | Marine passenger transportation | |
| | Submarine pipeline transportation | 56104Pipeline transport |
| | Sea ports | 57105Loading, Unloading and Other Transport Services |
| | Marine transportation service | |
| Coastal Tourism | Hotels and lodging places | 66113 Hotels |
| | Amusement and recreation, | 67114Catering Services |
| | Coastal tourism services | 74125 Tourism |
| | Coastal tourism and cultural services | |
| | Other coastal tourism services | |

Based on the relationship between ocean sectors and input-output sectors as presented in table 3, the ocean industries I-O table can be carried out by aggregating corresponding I-O sectors both in rows and columns. It should be noted that in this step, multipliers are focused, regardless of the valuation of ocean economic activities. Therefore the aggregation mentioned above can be conducted, given the hypothesis of ocean industries have the same technological coefficient as the corresponding I/O sectors.

## 4. Data

Every five years, in a year ending with 2 or 7, China's national and provincial statistical bureaus conduct the input-output survey and compile the benchmark input-output tables of the corresponding year. The most recent national and provincial input-output tables are those compiled for 2007. The I-O survey for 2012 will be carried out in 2013.

As analyzed above, without original survey data, the national input-output data cannot be used directly to calculate ocean economy multipliers, because 2/3 of Chinese provinces are not coastal. There are 11 coastal provinces (including 2 municipalities and 1 autonomous region). In order to take advantage of the government data, this paper chooses one coastal province, Tianjin, to conduct the empirical research using the methodology of ocean economy I-O analysis. Tianjin is located on the western edge of the Bohai Sea, east of Beijing,  inan area that was formed by sedimentary deposits of nine rivers. Since its early days, it has served as a gateway to Beijing and a pivotal city for the area. Due to its geographical advantages, Tianjin has become the center of the Bohai-rim economic development and the biggest city on the North China coast, with the implementation of opening up and reform policy in China.

Tianjin's marine economy has deep roots and is an important part of the city's strategic development plan. At present, Tianjin has a coastline of 153.2 kilometers, the oil reserve of Bohai Bay adjacent to Tianjin has 9.8 billion tons of oil and gas reserves of 190 billion cubic meters.  Since the beginning of the 21st century, Tianjin has become the major seaport for northern China, with a world-class deep-water port. Its freight volume in 2011 broke the 450-million tons mark, while the number of standard containers handled was 11.5 million. Tianjin Port is also slated to be a large home-port for Asian cruise ships, and open a new chapter as the center of international cruise lines for this part of China.

Tianjin has 27 ocean research institutes and marine-related institutions of higher learning. It also has a great number of State- and city-owned ocean enterprises employing more than 10,000 talented people. The annual production of crude salt in Tianjin is about 220 million tons, accounting for 1/10 of the national total output.

In order to conduct the I-O analysis of Tianjin province, the regional 144*144 I-O table of Tianjin for 2007 was used to calculate the multipliers of ocean industries. As mentioned above, in order to conduct the Input-Output Analysis of ocean industries, the regional I-O table should be aggregated based on Table 3. The Leontief inverse matrix of Tianjin's I-O table turned out to be 137*137. Then, the aggregated I-O table can be used to conduct Input-Output analysis for ocean sectors in Tianjin.

## 5. Results

### 5.1 Output Type II multipliers analysis

Table 5 presents the output type II multipliers for each sector within the Tianjin economy. It should be noted that Insurance, Animal Husbandry and Forestry are the top three sectors with highest output type II multipliers in Tianjin, followed by marine fishery. However, what is interesting is that within the wider

Tianjin economy, only one marine sector is ranked within the top 10 sectors (those with the strongest output indirect and induced effect). Within 11 ocean industries of Tianjin, 6 industries have the output type II multipliers above 5.00. These are marine fishery, Marine Engineering Building Industry, Seawater Utilization Industry, Shipbuilding Industry, Marine Communications and Transportation Industry, Marine Chemical Industry.

Examining the magnitude of the multipliers for ocean industries in more detail, marine fishery is 5.59 which is the highest output total effect of 11 ocean industries in Tianjin. This implies that $ 5.59 of the total value of production in all sectors of the Tianjin economy that is necessary in order to satisfy a dollar's worth of final demand for the output of marine fishery.

**Table 5** Type II output multipliers of ocean sectors in Tianjin

| Rank | Sector | TypeII multiplier |
|---|---|---|
| 1 | Insurance | 6.52 |
| 2 | Animal Husbandry | 5.75 |
| 3 | Nonferrous medaling roll processing | 5.60 |
| 4 | Marine fishery | 5.59 |
| 5 | Animal slaughtering & meat processing | 5.57 |
| 6 | Corn milling | 5.55 |
| 7 | Wire, cable, optical cable and electrical appliance manufacturing | 5.53 |
| 8 | Feed processing | 5.53 |
| 9 | Forestry | 5.46 |
| 10 | Farming | 5.43 |
| 11 | Sports activities | 5.38 |
| 12 | Storage | 5.29 |
| 13 | Building installation | 5.25 |
| 14 | leather, furs, down and relate products | 5.21 |
| 15 | Other food processing | 5.20 |
| 16 | Social security | 5.20 |
| 17 | Public management and social organization | 5.18 |
| 18 | Environmental management | 5.17 |
| 19 | Health | 5.16 |
| 20 | Communications equipment manufacturing | 5.15 |
| 21 | Social welfare | 5.14 |
| 22 | Post | 5.13 |
| 23 | Sugar manufacturing | 5.12 |
| 24 | Computer manufacturing | 5.12 |
| 25 | Geologic prospecting | 5.11 |
| 26 | Automobile manufacturing | 5.11 |
| 27 | Building decoration | 5.11 |
| 28 | Metallurgy, mining, construction industrial equipment manufacturing | 5.10 |
| 29 | Marine Engineering Building Industry | 5.10 |
| 30 | Nonferrous metal rolling processing | 5.06 |
| 31 | Vegetable oil refining | 5.06 |
| 32 | Metal products | 5.03 |
| 33 | Other construction | 5.03 |
| 34 | Furniture manufacturing | 5.02 |

| | | |
|---|---|---|
| 35 | Handicraft article | 5.00 |
| 36 | Journalism and publishing activities | 5.00 |
| 37 | Urban public transport | 4.99 |
| 38 | Production and supply of Gas | 4.98 |
| 39 | Household video and audio equipment manufacturing | 4.95 |
| 40 | Other electrical machinery manufacturing | 4.94 |
| 41 | Shipbuilding Industry | 4.94 |
| 42 | Boiler and motor manufacturing | 4.93 |
| 43 | Timber processing, bamboo, cane, palm fiber and straw products | 4.91 |
| 44 | Chemical, timber, non-metal processing equipment manufacturing | 4.89 |
| 45 | Pump, valve, compressor and similar machinery manufacturing | 4.89 |
| 46 | Stationery and office machinery manufacturing | 4.88 |
| 47 | Plastic product manufacturing | 4.88 |
| 48 | Synthetic material manufacturing | 4.88 |
| 49 | Hemp, silk and thin silk weaving processing | 4.88 |
| 50 | Relay and industrial control manufacturing | 4.87 |
| 51 | Services of science and technology exchanges and promotion | 4.86 |
| 52 | Education | 4.84 |
| 53 | Knit fabric, knitting and product manufacturing | 4.83 |
| 54 | Cultural, educational and sports goods | 4.80 |
| 55 | Special chemical product manufacturing | 4.80 |
| 56 | Road transport | 4.80 |
| 57 | Pesticide manufacturing | 4.77 |
| 58 | Textile product manufacturing | 4.76 |
| 59 | Instrument and meter manufacturing | 4.76 |
| 60 | Liquid dairy and dairy products manufacturing | 4.75 |
| 61 | Spice, seasoning & fermented products manufacturing | 4.75 |
| 62 | Other food manufacturing | 4.74 |
| 63 | balata product manufacturing | 4.73 |
| 64 | Seawater Utilization Industry | 4.73 |
| 65 | other environmental protection, social security special equipment manufacturing | 4.72 |
| 66 | Instant food manufacturing | 4.71 |
| 67 | Steel rolling processing | 4.71 |
| 68 | Electronic components and devices producing | 4.70 |
| 69 | other general equipment manufacturing | 4.69 |
| 70 | Printing and medium reproduction | 4.68 |
| 71 | Ceramic product industry | 4.67 |
| 72 | Household electrical and non-electrical appliance manufacturing | 4.66 |
| 73 | Cotton and chemical fiber spinning and weaving & dyeing refined processing | 4.66 |
| 74 | Cultural and art activities | 4.65 |
| 75 | Alcohol and wine industry | 4.65 |
| 76 | Cement and gypsum product manufacturing | 4.64 |
| 77 | Textile garments, shoes and caps products | 4.63 |
| 78 | Motor and generator manufacturing | 4.62 |
| 79 | Radar detectors, radio broadcasting equipment manufacturing | 4.59 |
| 80 | Fireproof materials products | 4.57 |
| 81 | Metal processing machine manufacturing | 4.54 |
| 82 | All other transportation equipment manufacturing | 4.54 |
| 83 | Marine Communications and Transportation Industry | 4.53 |

| | | |
|---|---|---|
| 84 | Black lead and other nonmetal mineral products | 4.52 |
| 85 | Crane transportation equipment manufacturing | 4.51 |
| 86 | Chemical fertilizer manufacturing | 4.51 |
| 87 | Entertainment | 4.51 |
| 88 | Marine Chemical Industry(25037,26039) | 4.49 |
| 89 | Coat, printing ink and dyeing materials manufacturing | 4.49 |
| 90 | Wool spinning, weaving and dyeing refined processing | 4.48 |
| 91 | Metal smelting | 4.45 |
| 92 | Research and experimental development | 4.43 |
| 93 | Marine salt industry | 4.42 |
| 94 | Other electronic devices manufacturing | 4.41 |
| 95 | Rail transport equipment manufacturing | 4.38 |
| 96 | Broadcasting, television, movies and audiovisual activities | 4.38 |
| 97 | Computer services | 4.38 |
| 98 | Coking processing | 4.37 |
| 99 | Papermaking and paper products | 4.33 |
| 100 | Soft drinks and refined tea processing industry | 4.33 |
| 101 | Tile, lime and light construction material manufacturing | 4.33 |
| 102 | Other real estate activities | 4.33 |
| 103 | Daily chemical product manufacturing | 4.33 |
| 104 | Marine Biomedicine Industry | 4.33 |
| 105 | Steel smelting | 4.30 |
| 106 | Leasing | 4.30 |
| 107 | Iron alloy smelting | 4.28 |
| 108 | Air transport | 4.28 |
| 109 | Cement, lime and gypsum manufacturing | 4.24 |
| 110 | Agriculture industry machinery manufacturing | 4.23 |
| 111 | Real estate broker business | 4.18 |
| 112 | Marine Electric Power Industry | 4.18 |
| 113 | Professional technical services | 4.13 |
| 114 | Glass and glass product | 4.11 |
| 115 | Coastal Tourism | 4.09 |
| 116 | Chemical fiber manufacturing | 4.09 |
| 117 | other services | 4.09 |
| 118 | Business services | 4.07 |
| 119 | Software | 3.99 |
| 120 | Coal mining and dressing | 3.85 |
| 121 | Services to households | 3.64 |
| 122 | Management of Public facilities | 3.50 |
| 123 | Retail trade | 3.48 |
| 124 | Management of water conservancy | 3.06 |
| 125 | Wholesale trade | 2.91 |
| 126 | Tobacco products | 2.87 |
| 127 | Offshore oil and gas industry | 2.64 |
| 128 | Other financial activities | 2.48 |
| 129 | Telecommunication and other information transmission services | 2.47 |
| 130 | Property management | 2.28 |
| 131 | Bank | 2.25 |
| 132 | Waste product and material | 2.22 |
| 133 | Railway transport | 2.05 |
| 134 | Real estate development and operation | 1.83 |

| | | |
|---|---|---|
| 135 | Security activities | 1.79 |
| 136 | Ferrous metals mining and dressing | 1.00 |
| 137 | Nonferrous metals mining and dressing | 1.00 |

According to OEAS in China, ocean industries which are comparable with the data of NOEP include marine fishery, coastal tourism, marine communications and transportation, offshore oil and gas industry. Based on the results of table 5, one can get the total effect of each industry.

**Table 6 Type II Output multiplier comparison**

| China ocean sectors description | 2007 Value added of Tianjin (billion dollars) | 2007 type II multipliers of Tianjin | 2007 type II multipliers of the USA | NOEP ocean sectors description |
|---|---|---|---|---|
| Marine fishery | 0.07 | 5.59 | 2.04 | Living Resources |
| Offshore oil and gas industry | 4.15 | 2.64 | 2.16 | Oil & Gas Exploration and Production |
| Shipbuilding Industry | 0.11 | 4.94 | 2.90 | Ship & Boat Building |
| Marine communications and transportation industry | 2.53 | 4.53 | 2.45 | coastal tourism |
| Coastal tourism | 3.32 | 4.09 | 2.61 | Transportation |

Table 6 provides the output type II multipliers comparison between Tianjin and the USA. This shows that 4 multipliers of the 5 ocean industries in Tianjin are higher than USA. This means the ocean industries in Tianjin are more strongly linked to the rest of the economy, especially the marine fishery.

### 5.2 Analysis of income type II multipliers

Generally, an analyst is more likely to be concerned with the economic impact of new final demand as measured by jobs created, increased household earnings, value added generated, etc., rather than simply gross output by sector.

Then income type II multipliers of all sectors in Tianjin are summarized in table 7. Within ocean industries economy, marine fishery (1.80), seawater utilization industry (1.58), coastal tourism (1.35) are the top three sectors with the highest income type II multipliers in Tianjin. It should be noted here that marine fishery has both the highest output type II multiplier and income multiplier within the ocean industries in Tianjin.

Marine fishery ranked the 10th within the whole economy of Tianjin. One can see that one dollar initial input in marine fishery can boost the whole economy income to 1.80 dollars when direct, indirect and induced effects are taken into account.

**Table 7** Type II income multipliers of sectors in Tianjin

| Rank | Sector | Type II income multiplier |
|---|---|---|
| 1 | Insurance | 3.54 |
| 2 | Social welfare | 2.09 |
| 3 | Forestry | 2.08 |
| 4 | Environmental management | 2.02 |
| 5 | Public management and social organization | 2.00 |
| 6 | Education | 1.93 |
| 7 | Farming | 1.84 |
| 8 | Animal Husbandry | 1.82 |
| 9 | Marine fishery | 1.80 |
| 10 | Software | 1.79 |
| 11 | Urban public transport | 1.72 |
| 12 | Cultural and art activities | 1.72 |
| 13 | Corn milling | 1.67 |
| 14 | Social security | 1.65 |
| 15 | Real estate broker business | 1.64 |
| 16 | Sports activities | 1.63 |
| 17 | Broadcasting, television, movies and audiovisual activities | 1.62 |
| 18 | Health | 1.62 |
| 19 | Management of Public facilities | 1.61 |
| 20 | Seawater Utilization Industry | 1.58 |
| 21 | Journalism and publishing activities | 1.53 |
| 22 | Animal slaughtering & meat processing | 1.52 |
| 23 | Sugar manufacturing | 1.51 |
| 24 | Services of science and technology exchanges and promotion | 1.51 |
| 25 | Research and experimental development | 1.46 |
| 26 | Post | 1.46 |
| 27 | Geologic prospecting | 1.45 |
| 28 | Feed processing | 1.45 |
| 29 | Air transport | 1.44 |
| 30 | Professional technical services | 1.43 |
| 31 | Hemp, silk and thin silk weaving processing | 1.40 |
| 32 | Alcohol and wine industry | 1.39 |
| 33 | Liquid dairy and dairy products manufacturing | 1.39 |
| 34 | Wholesale trade | 1.38 |
| 35 | Production and supply of Gas | 1.37 |
| 36 | Retail trade | 1.36 |
| 37 | Coastal Tourism | 1.35 |
| 38 | Timber processing, bamboo, cane, palm fiber and straw products | 1.35 |
| 39 | Services to households | 1.34 |
| 40 | Business services | 1.34 |
| 41 | Instrument and meter manufacturing | 1.32 |
| 42 | Entertainment | 1.31 |
| 43 | Shipbuilding Industry | 1.31 |
| 44 | other services | 1.31 |
| 45 | Management of water conservancy | 1.30 |
| 46 | balata product manufacturing | 1.30 |

| | | |
|---|---|---|
| 47 | Road transport | 1.29 |
| 48 | Other food processing | 1.29 |
| 49 | Marine Communications and Transportation Industry | 1.28 |
| 50 | Bank | 1.27 |
| 51 | Daily chemical product manufacturing | 1.26 |
| 52 | Cotton and chemical fiber spinning and weaving & dyeing refined processing | 1.26 |
| 53 | Knit fabric, knitting and product manufacturing | 1.26 |
| 54 | Other food manufacturing | 1.26 |
| 55 | Other financial activities | 1.26 |
| 56 | Marine Biomedicine Industry | 1.25 |
| 57 | Agriculture industry machinery manufacturing | 1.25 |
| 58 | Furniture manufacturing | 1.25 |
| 59 | Radar detectors, radio broadcasting equipment manufacturing | 1.25 |
| 60 | Stationery and office machinery manufacturing | 1.25 |
| 61 | Marine Electric Power Industry | 1.24 |
| 62 | Leasing | 1.24 |
| 63 | Printing and medium reproduction | 1.24 |
| 64 | Building installation | 1.23 |
| 65 | Spice, seasoning & fermented products manufacturing | 1.23 |
| 66 | Security activities | 1.23 |
| 67 | Rail transport equipment manufacturing | 1.23 |
| 68 | Chemical fertilizer manufacturing | 1.22 |
| 69 | Special chemical product manufacturing | 1.22 |
| 70 | Chemical, timber, non-metal processing equipment manufacturing | 1.22 |
| 71 | Instant food manufacturing | 1.22 |
| 72 | Real estate development and operation | 1.22 |
| 73 | Marine Engineering Building Industry | 1.22 |
| 74 | Other electrical machinery manufacturing | 1.22 |
| 75 | Computer manufacturing | 1.21 |
| 76 | Plastic product manufacturing | 1.21 |
| 77 | other general equipment manufacturing | 1.21 |
| 78 | Building decoration | 1.21 |
| 79 | Papermaking and paper products | 1.21 |
| 80 | Other construction | 1.21 |
| 81 | Motor and generator manufacturing | 1.21 |
| 82 | Cultural, educational and sports goods | 1.21 |
| 83 | Ceramic product industry | 1.21 |
| 84 | other environmental protection, social security special equipment manufacturing | 1.21 |
| 85 | Handicraft article | 1.20 |
| 86 | Marine Chemical Industry(25037,26039) | 1.20 |
| 87 | Steel smelting | 1.20 |
| 88 | Wool spinning, weaving and dyeing refined processing | 1.20 |
| 89 | Tobacco products | 1.20 |
| 90 | Property management | 1.20 |
| 91 | Marine salt industry | 1.20 |
| 92 | Storage | 1.20 |
| 93 | leather, furs, down and relate products | 1.20 |
| 94 | Textile product manufacturing | 1.20 |

| | | |
|---|---|---|
| 95 | Other real estate activities | 1.20 |
| 96 | Textile garments, shoes and caps products | 1.19 |
| 97 | Electronic components and devices producing | 1.19 |
| 98 | Soft drinks and refined tea processing industry | 1.19 |
| 99 | Cement and gypsum product manufacturing | 1.19 |
| 100 | Metal processing machine manufacturing | 1.19 |
| 101 | Steel rolling processing | 1.19 |
| 102 | Other electronic devices manufacturing | 1.19 |
| 103 | Communications equipment manufacturing | 1.19 |
| 104 | Metal smelting | 1.19 |
| 105 | Glass and glass product | 1.19 |
| 106 | Pesticide manufacturing | 1.19 |
| 107 | Boiler and motor manufacturing | 1.19 |
| 108 | Fireproof materials products | 1.18 |
| 109 | Telecommunication and other information transmission services | 1.18 |
| 110 | Relay and industrial control manufacturing | 1.18 |
| 111 | Computer services | 1.18 |
| 112 | Vegetable oil refining | 1.17 |
| 113 | Coat, printing ink and dyeing materials manufacturing | 1.17 |
| 114 | Metallurgy, mining, construction industrial equipment manufacturing | 1.17 |
| 115 | Household electrical and non-electrical appliance manufacturing | 1.16 |
| 116 | Pump, valve, compressor and similar machinery manufacturing | 1.16 |
| 117 | Iron alloy smelting | 1.16 |
| 118 | Nonferrous medaling roll processing | 1.16 |
| 119 | Cement, lime and gypsum manufacturing | 1.16 |
| 120 | Metal products | 1.15 |
| 121 | Black lead and other nonmetal mineral products | 1.15 |
| 122 | Tile, lime and light construction material manufacturing | 1.15 |
| 123 | Synthetic material manufacturing | 1.14 |
| 124 | Railway transport | 1.14 |
| 125 | Wire, cable, optical cable and electrical appliance manufacturing | 1.14 |
| 126 | Crane transportation equipment manufacturing | 1.14 |
| 127 | Coking processing | 1.14 |
| 128 | Nonferrous metal rolling processing | 1.13 |
| 129 | All other transportation equipment manufacturing | 1.13 |
| 130 | Offshore oil and gas industry | 1.13 |
| 131 | Waste product and material | 1.12 |
| 132 | Chemical fiber manufacturing | 1.12 |
| 133 | Household video and audio equipment manufacturing | 1.12 |
| 134 | Automobile manufacturing | 1.12 |
| 135 | Coal mining and dressing | 1.09 |
| 136 | Ferrous metals mining and dressing | 1.00 |
| 137 | Nonferrous metals mining and dressing | 1.00 |

### 5.3 Forward linkages

Table 8 shows forward linkages of industries of Tianjin for 2007 based on the Rasmussen method. It also summarized the ranking of forward linkages. What is interesting is that 3 of ocean industries are in the top 10 highest forward linkage industries. Marine Chemical industry (5.94) has the highest forward linkages. The second and third ranking in forward linkages are marine electric power industry; steel rolling processing. Furthermore, 6 of 11 ocean industries have forward linkages that are greater than one. That means the forward linkages of these 6 ocean sectors are above the average. Ocean industries in Tianjin have strong forward linkages.

**Table 8** Forward linkage of sectors in Tianjin

| Rank | Sector | Forward Linkage |
|---|---|---|
| 1 | Marine Chemical Industry | 5.94 |
| 2 | Marine Electric Power Industry | 5.79 |
| 3 | Steel rolling processing | 5.00 |
| 4 | Marine Communications and Transportation Industry | 4.16 |
| 5 | Road transport | 3.44 |
| 6 | Retail trade | 3.38 |
| 7 | Metal products | 3.24 |
| 8 | Wholesale trade | 2.92 |
| 9 | Coal mining and dressing | 2.69 |
| 10 | Bank | 2.68 |
| 11 | Electronic components and devices producing | 2.46 |
| 12 | Storage | 2.39 |
| 13 | Farming | 2.33 |
| 14 | Nonferrous metal rolling processing | 2.31 |
| 15 | Plastic product manufacturing | 2.19 |
| 16 | Coastal Tourism | 2.02 |
| 17 | Nonferrous medaling roll processing | 1.96 |
| 18 | Papermaking and paper products | 1.94 |
| 19 | Railway transport | 1.91 |
| 20 | Business services | 1.80 |
| 21 | Synthetic material manufacturing | 1.65 |
| 22 | Leasing | 1.62 |
| 23 | Waste product and material | 1.57 |
| 24 | Offshore oil and gas industry | 1.55 |
| 25 | Automobile manufacturing | 1.53 |
| 26 | Steel smelting | 1.50 |
| 27 | Special chemical product manufacturing | 1.33 |
| 28 | Real estate development and operation | 1.32 |
| 29 | Vegetable oil refining | 1.27 |
| 30 | Coking processing | 1.24 |
| 31 | other general equipment manufacturing | 1.17 |
| 32 | Timber processing, bamboo, cane, palm fiber and straw products | 1.16 |
| 33 | Seawater Utilization Industry | 1.11 |
| 34 | Metal smelting | 1.10 |
| 35 | other services | 1.09 |
| 36 | Insurance | 0.98 |
| 37 | Coat, printing ink and dyeing materials manufacturing | 0.97 |

| | | |
|---|---|---|
| 38 | Animal Husbandry | 0.96 |
| 39 | balata product manufacturing | 0.95 |
| 40 | other environmental protection, social security special equipment manufacturing | 0.93 |
| 41 | Telecommunication and other information transmission services | 0.86 |
| 42 | Cotton and chemical fiber spinning and weaving & dyeing refined processing | 0.85 |
| 43 | Feed processing | 0.83 |
| 44 | Textile product manufacturing | 0.83 |
| 45 | Marine salt industry | 0.82 |
| 46 | Corn milling | 0.81 |
| 47 | Health | 0.79 |
| 48 | Marine Biomedicine Industry | 0.78 |
| 49 | Handicraft article | 0.77 |
| 50 | Chemical fertilizer manufacturing | 0.77 |
| 51 | Glass and glass product | 0.76 |
| 52 | Wire, cable, optical cable and electrical appliance manufacturing | 0.75 |
| 53 | Air transport | 0.73 |
| 54 | Instrument and meter manufacturing | 0.72 |
| 55 | Other electrical machinery manufacturing | 0.72 |
| 56 | Cement, lime and gypsum manufacturing | 0.71 |
| 57 | Animal slaughtering & meat processing | 0.71 |
| 58 | Cultural, educational and sports goods | 0.71 |
| 59 | leather, furs, down and relate products | 0.70 |
| 60 | Black lead and other nonmetal mineral products | 0.70 |
| 61 | Security activities | 0.68 |
| 62 | Chemical fiber manufacturing | 0.68 |
| 63 | Forestry | 0.68 |
| 64 | Pump, valve, compressor and similar machinery manufacturing | 0.67 |
| 65 | Computer manufacturing | 0.66 |
| 66 | Entertainment | 0.66 |
| 67 | Building decoration | 0.65 |
| 68 | Printing and medium reproduction | 0.65 |
| 69 | Marine fishery | 0.64 |
| 70 | Relay and industrial control manufacturing | 0.64 |
| 71 | Other food processing | 0.63 |
| 72 | Production and supply of Gas | 0.63 |
| 73 | Wool spinning, weaving and dyeing refined processing | 0.61 |
| 74 | Education | 0.61 |
| 75 | Textile garments, shoes and caps products | 0.59 |
| 76 | Daily chemical product manufacturing | 0.55 |
| 77 | Tile, lime and light construction material manufacturing | 0.55 |
| 78 | Motor and generator manufacturing | 0.54 |
| 79 | Other food manufacturing | 0.54 |
| 80 | Fireproof materials products | 0.53 |
| 81 | Pesticide manufacturing | 0.53 |
| 82 | Urban public transport | 0.52 |
| 83 | Metal processing machine manufacturing | 0.51 |
| 84 | Boiler and motor manufacturing | 0.51 |
| 85 | Research and experimental development | 0.50 |
| 86 | Post | 0.49 |
| 87 | Computer services | 0.48 |

| | | |
|---|---|---|
| 88 | Real estate broker business | 0.48 |
| 89 | Management of water conservancy | 0.48 |
| 90 | Household video and audio equipment manufacturing | 0.47 |
| 91 | All other transportation equipment manufacturing | 0.47 |
| 92 | Services of science and technology exchanges and promotion | 0.47 |
| 93 | Ceramic product industry | 0.47 |
| 94 | Shipbuilding Industry | 0.46 |
| 95 | Communications equipment manufacturing | 0.46 |
| 96 | Agriculture industry machinery manufacturing | 0.45 |
| 97 | Ferrous metals mining and dressing | 0.45 |
| 98 | Stationery and office machinery manufacturing | 0.44 |
| 99 | Alcohol and wine industry | 0.44 |
| 100 | Professional technical services | 0.44 |
| 101 | Metallurgy, mining, construction industrial equipment manufacturing | 0.44 |
| 102 | Journalism and publishing activities | 0.43 |
| 103 | Sugar manufacturing | 0.43 |
| 104 | Cement and gypsum product manufacturing | 0.43 |
| 105 | Other real estate activities | 0.42 |
| 106 | Furniture manufacturing | 0.42 |
| 107 | Other financial activities | 0.41 |
| 108 | Spice, seasoning & fermented products manufacturing | 0.41 |
| 109 | Iron alloy smelting | 0.41 |
| 110 | Environmental management | 0.41 |
| 111 | Hemp, silk and thin silk weaving processing | 0.41 |
| 112 | Property management | 0.41 |
| 113 | Services to households | 0.41 |
| 114 | Crane transportation equipment manufacturing | 0.40 |
| 115 | Rail transport equipment manufacturing | 0.40 |
| 116 | Other electronic devices manufacturing | 0.40 |
| 117 | Liquid dairy and dairy products manufacturing | 0.40 |
| 118 | Public management and social organization | 0.39 |
| 119 | Knit fabric, knitting and product manufacturing | 0.39 |
| 120 | Nonferrous metals mining and dressing | 0.39 |
| 121 | Household electrical and non-electrical appliance manufacturing | 0.38 |
| 122 | Tobacco products | 0.38 |
| 123 | Chemical, timber, non-metal processing equipment manufacturing | 0.38 |
| 124 | Soft drinks and refined tea processing industry | 0.37 |
| 125 | Other construction | 0.37 |
| 126 | Software | 0.37 |
| 127 | Management of Public facilities | 0.36 |
| 128 | Instant food manufacturing | 0.35 |
| 129 | Broadcasting, television, movies and audiovisual activities | 0.34 |
| 130 | Marine Engineering Building Industry | 0.34 |
| 131 | Geologic prospecting | 0.34 |
| 132 | Building installation | 0.34 |
| 133 | Cultural and art activities | 0.33 |
| 134 | Radar detectors, radio broadcasting equipment manufacturing | 0.33 |
| 135 | Social security | 0.33 |
| 136 | Social welfare | 0.33 |
| 137 | Sports activities | 0.33 |

## 5.4 Back ward linkage

Table 8 provides the backward linkage of sectors in Tianjin. Most ocean industries do not have strong backward linkages. The marine engineering industry has the strongest backward linkage in ocean sectors of Tianjin, ranking 16 within the whole sectors in Tianjin. 4 of 11 ocean sectors' backward linkages are above the average, which are marine engineering building Industry (1.22), shipbuilding industry (1.12), marine salt industry (1.06), marine communications and transportation industry (1.05).

**Table 9** Backward linkage of sectors in Tianjin

| Rank | Sector | Backward Linkage |
|---|---|---|
| 1 | Insurance | 1.88 |
| 2 | Nonferrous medaling roll processing | 1.42 |
| 3 | Wire, cable, optical cable and electrical appliance manufacturing | 1.40 |
| 4 | Automobile manufacturing | 1.30 |
| 5 | Nonferrous metal rolling processing | 1.30 |
| 6 | Storage | 1.29 |
| 7 | Building installation | 1.27 |
| 8 | Metallurgy, mining, construction industrial equipment manufacturing | 1.26 |
| 9 | leather, furs, down and relate products | 1.26 |
| 10 | Vegetable oil refining | 1.26 |
| 11 | Metal products | 1.26 |
| 12 | Household video and audio equipment manufacturing | 1.25 |
| 13 | Communications equipment manufacturing | 1.25 |
| 14 | Computer manufacturing | 1.23 |
| 15 | Pump, valve, compressor and similar machinery manufacturing | 1.23 |
| 16 | Marine Engineering Building Industry | 1.22 |
| 17 | Synthetic material manufacturing | 1.22 |
| 18 | Building decoration | 1.21 |
| 19 | Other construction | 1.21 |
| 20 | Handicraft article | 1.21 |
| 21 | Boiler and motor manufacturing | 1.20 |
| 22 | Relay and industrial control manufacturing | 1.20 |
| 23 | Other electrical machinery manufacturing | 1.19 |
| 24 | Chemical, timber, non-metal processing equipment manufacturing | 1.18 |
| 25 | Plastic product manufacturing | 1.17 |
| 26 | Furniture manufacturing | 1.17 |
| 27 | Pesticide manufacturing | 1.16 |
| 28 | Household electrical and non-electrical appliance manufacturing | 1.15 |
| 29 | Feed processing | 1.15 |
| 30 | Cultural, educational and sports goods | 1.15 |
| 31 | Textile product manufacturing | 1.15 |
| 32 | All other transportation equipment manufacturing | 1.15 |
| 33 | Steel rolling processing | 1.15 |
| 34 | Special chemical product manufacturing | 1.14 |
| 35 | Stationery and office machinery manufacturing | 1.14 |
| 36 | Road transport | 1.14 |
| 37 | Electronic components and devices producing | 1.14 |
| 38 | Crane transportation equipment manufacturing | 1.13 |
| 39 | other environmental protection, social security special equipment manufacturing | 1.13 |
| 40 | Knit fabric, knitting and product manufacturing | 1.13 |

| | | |
|---|---|---|
| 41 | Motor and generator manufacturing | 1.13 |
| 42 | Cement and gypsum product manufacturing | 1.12 |
| 43 | Black lead and other nonmetal mineral products | 1.12 |
| 44 | other general equipment manufacturing | 1.12 |
| 45 | Fireproof materials products | 1.12 |
| 46 | Shipbuilding Industry | 1.12 |
| 47 | Ceramic product industry | 1.12 |
| 48 | Printing and medium reproduction | 1.10 |
| 49 | Metal processing machine manufacturing | 1.10 |
| 50 | Coking processing | 1.10 |
| 51 | Coat, printing ink and dyeing materials manufacturing | 1.10 |
| 52 | Other food processing | 1.10 |
| 53 | Textile garments, shoes and caps products | 1.10 |
| 54 | Spice, seasoning & fermented products manufacturing | 1.09 |
| 55 | Metal smelting | 1.09 |
| 56 | balata product manufacturing | 1.08 |
| 57 | Marine Chemical Industry | 1.08 |
| 58 | Cotton and chemical fiber spinning and weaving & dyeing refined processing | 1.08 |
| 59 | Radar detectors, radio broadcasting equipment manufacturing | 1.08 |
| 60 | Instant food manufacturing | 1.08 |
| 61 | Animal slaughtering & meat processing | 1.08 |
| 62 | Tile, lime and light construction material manufacturing | 1.08 |
| 63 | Timber processing, bamboo, cane, palm fiber and straw products | 1.07 |
| 64 | Chemical fertilizer manufacturing | 1.07 |
| 65 | Production and supply of Gas | 1.07 |
| 66 | Computer services | 1.07 |
| 67 | Corn milling | 1.07 |
| 68 | Other electronic devices manufacturing | 1.07 |
| 69 | Instrument and meter manufacturing | 1.06 |
| 70 | Iron alloy smelting | 1.06 |
| 71 | Marine salt industry | 1.06 |
| 72 | Wool spinning, weaving and dyeing refined processing | 1.06 |
| 73 | Other food manufacturing | 1.05 |
| 74 | Marine Communications and Transportation Industry | 1.05 |
| 75 | Cement, lime and gypsum manufacturing | 1.05 |
| 76 | Steel smelting | 1.04 |
| 77 | Geologic prospecting | 1.04 |
| 78 | Hemp, silk and thin silk weaving processing | 1.04 |
| 79 | Post | 1.04 |
| 80 | Sugar manufacturing | 1.04 |
| 81 | Chemical fiber manufacturing | 1.04 |
| 82 | Rail transport equipment manufacturing | 1.04 |
| 83 | Papermaking and paper products | 1.04 |
| 84 | Entertainment | 1.02 |
| 85 | Other real estate activities | 1.02 |
| 86 | Soft drinks and refined tea processing industry | 1.02 |
| 87 | Leasing | 1.01 |
| 88 | Coal mining and dressing | 1.00 |
| 89 | Marine Electric Power Industry | 1.00 |
| 90 | Journalism and publishing activities | 1.00 |
| 91 | Services of science and technology exchanges and promotion | 1.00 |

| | | |
|---|---|---|
| 92 | Glass and glass product | 1.00 |
| 93 | Marine Biomedicine Industry | 1.00 |
| 94 | Alcohol and wine industry | 0.99 |
| 95 | Daily chemical product manufacturing | 0.99 |
| 96 | Sports activities | 0.99 |
| 97 | Liquid dairy and dairy products manufacturing | 0.98 |
| 98 | Agriculture industry machinery manufacturing | 0.97 |
| 99 | Air transport | 0.95 |
| 100 | Health | 0.94 |
| 101 | Social security | 0.94 |
| 102 | other services | 0.92 |
| 103 | Animal Husbandry | 0.91 |
| 104 | Urban public transport | 0.90 |
| 105 | Marine fishery | 0.89 |
| 106 | Business services | 0.88 |
| 107 | Research and experimental development | 0.87 |
| 108 | Seawater Utilization Industry | 0.86 |
| 109 | Coastal Tourism | 0.85 |
| 110 | Farming | 0.85 |
| 111 | Professional technical services | 0.82 |
| 112 | Services to households | 0.77 |
| 113 | Broadcasting, television, movies and audiovisual activities | 0.75 |
| 114 | Cultural and art activities | 0.74 |
| 115 | Forestry | 0.70 |
| 116 | Retail trade | 0.69 |
| 117 | Real estate broker business | 0.68 |
| 118 | Tobacco products | 0.67 |
| 119 | Public management and social organization | 0.67 |
| 120 | Offshore oil and gas industry | 0.67 |
| 121 | Environmental management | 0.66 |
| 122 | Management of water conservancy | 0.65 |
| 123 | Education | 0.63 |
| 124 | Social welfare | 0.60 |
| 125 | Telecommunication and other information transmission services | 0.58 |
| 126 | Waste product and material | 0.57 |
| 127 | Wholesale trade | 0.54 |
| 128 | Other financial activities | 0.52 |
| 129 | Software | 0.52 |
| 130 | Management of Public facilities | 0.52 |
| 131 | Property management | 0.52 |
| 132 | Railway transport | 0.50 |
| 133 | Bank | 0.46 |
| 134 | Real estate development and operation | 0.39 |
| 135 | Security activities | 0.37 |
| 136 | Ferrous metals mining and dressing | 0.33 |
| 137 | Nonferrous metals mining and dressing | 0.33 |

### 5.5 Key ocean sectors

In order to find out the key ocean sectors of Tianjin, the results of table 7 and table 8 are taken into account. It had been found out that in 2007 in the Tianjin economy there were 3 sectors that belonged to the category of key sectors. A sector is defined as the key sector if one sector shows strong backward

and forward linkages. In 2007 in Tianjin, these key sectors are: Marine communications and transportation, marine electric power, and marine chemicals.

Also, it has been found that for coastal tourism and the offshore oil and gas industry, only the forward linkages are greater than the average, so they can be called strong forward linkages sectors. For the marine salt industry, marine biomedicine industry, shipbuilding industry, marine engineering building industry, only the backward linkages of the sectors are greater than average, so they are strong backward linkages industries.

For marine fishery, both backward linkages and forward linkages are less than one, so the marine fishery industry is the only weak linkage industry in Tianjin's case.

**6. Discussion and conclusions**

This paper demonstrates how it is possible to use the Input-Output table from the existing government databases in China to analyze the ocean economy. Data was collected for 11 major ocean industries in Tianjin. Using a similar methodology to that developed in NOEP, it was found that marine fishery has the highest output type II multiplier and income type II multiplier within ocean sectors. Major ocean industries in Tianjin mostly have higher output type II multipliers than ocean industries of the USA. Marine fishery is also the only weak linkage industry. This analysis also found that Marine communications and transportation industry, marine electric power industry, marine chemical industry are key industries in Tianjin's economy.

While this paper has undertaken an input-output analysis of the Chinese Ocean economy, defining and quantifying the Coastal economy in China is an area worthy of further research. In this case, the Chinese Coastal economy could be defined as all activity which takes place in a predefined geographic or other unit along the coastal area would include all economic activity in the coastal region, however those areas and regions are defined. This task is all the more relevant given the five ocean economic development zones that have been established in a number of China's coastal provinces. Along with the ocean economy information described in this paper, such coastal economy statistics would allow policy makers, planners and government to make more informed coastal planning and marine environment management decisions.

Due to the rapid development of marine science and technology in recent years, new marine industries are emerging, expanding the scope of the marine economy. Therefore, further research is required in order to establish an appropriate methodology for the classification and collection of economic data for these emerging ocean industries – data that is very difficult to extract from national economic accounts. in view of the rapid coastal development as well as the prospects for climate change impacts from SLR and Storm surges.

The adoption of the "Developing the Ocean Economy" strategy and the establishment of five ocean economy pilot test sites by the Chinese government were in recognition of the importance of marine

related activity to the economy in China. This increased focus on the ocean economy means policy-makers require accessible and reliable information regarding the role of the ocean industries in the wider economy [18]. With the implementation of the ocean-related plans, the goal of "developing the ocean economy" is occurring at a rapid pace. This rapid development however requires detailed information on the marine activities that policy makers can use to ensure that the development is sustainable and does not jeopardize other marine related policy goals especially in relation to the marine environment and the conservation of marine species.

In the past, China's traditional model of development was characterized by the extensive exploitation of marine resources and spaces particularly in regards to the extraction of marine life for human consumption. Intense competition among coastal provinces in relation to the developing of traditional marine industries such as fishing, aquaculture and port activity was another feature of Chinese marine development in the past. Indeed it could be argued that the establishment of container terminals in all provinces has not been an efficient use of valuable coastal resources in China. The new model of marine development in China places a higher value on the management and conservation of marine resources and ecosystem functions and recognizes the importance of these resources to the new emerging marine industries and to coastal tourism in particular.

The collection, compilation and management of socio-economic data for the various marine-related sectors is an important element of the information system required for promoting this more sustainable approach to marine policy. Much work has been done internationally in establishing the value of these other marine resources (and/or ecosystem functions) so that they may be accounted for in marine policy decision making. This however has not generally been the case in China. If the country wishes to underpin the value of the marine economic activity and the many biotechnology and other opportunities associated with the quality of its marine environment then significant investment will be required in research aimed at establishing the non-market or public good element of the total economic value of marine resources in China.

**Acknowledgements**

This research was supported through the Chinese Ocean Economy Accounting System Project which was started by the Chinese National Marine Data & Information Service in 2006. Rui Zhao was based at the Center of the Blue Economy in the Monterey Institute of International Studies in Monterey, California during the writing up of this paper. The author would like to thank Judy Kildow, Charles Colgan, Fernando DePaolis, Jason Scorse, Monica Galligan and Pat Johnston for their assistance.

## Reference


[1] Karyn Morrissey, Cathal O'Donoghue. The role of the marine sector in the Irish national economy: an input–output analysis. Mar Policy 2012;29(3):371–383.

[2] State Oceanic Administration of China. National Island Protection Plan. Beijing: State Oceanic Administration Publication; 2012.

[3] Ocean Development Strategy Research Study Group. China's Ocean Development Report State Oceanic Administration. Beijing: Maritime Publishing House; 2012.

[4] Yang YK. A Detailed explanation of national marine economic development pilot projects. Chinese Business Journal; 2011-12-11, A14.

[5] Colgan CS. Measurement of the ocean and coastal economy: Theory and methods, National Ocean Economics Project, USA; 2007.

[6] Junning Cai, PingSun Leung, and James Mak. Tourism's forward and backward linkages. Journal of Travel Research 2006 45:36-51.

[7] Cai J, Leung P. Linkage measures: a revisit and a suggested alternative. Econ Sys Res 2004;16:63–83.

[8]Ghosh, A. (1958). Input-output approach to an allocation system. Economics, 25: 58- 64.

[9]Chenery, H. B., and T. Watanabe.(1958) International comparison of the structure of production, Econometrica, 26, pp. 487-521.

[10]Hirschman, A. O. (1958) . The Strategy of Economic Development (New Haven: Yale University Press).

[11]Rasmussen, P.N. (1956). *Studies in inter-sectoral relations:* North-Holland.

[12]Wang and vomHofe research methods in urban planning. Springer(2007)_from Fernando

[13]Queensland Government. Overview of some alternative methodologies for economic impact analysis. http://www.oesr.qld.gov.au/products/publications/

[14] Fisheries and Oceans Canada. Economic impact of marine related activities in Canada. http://www.dfo-mpo.gc.ca/ea-ae/cat1/no1-1/no1-1-eng.pdf.

[15] SOA. The 2011 China Marine Economic Statistical Bulletin; March 2012 [inChinese only].

[16] SOA. China marine statistical yearbook 2011. Beijing: China Statistics Press; 2011 [in Chinese and English].

[17]Thijs Ten Raa. Input-Output Economics: Theory and Applications.World Scientific, 2009

[18] Kwak SJ, Yoo SH, Chang JI. The role of the maritime industry in the Korean national economy: an input–output analysis. Mar Policy 2005;29(3):371–383.

[19] J.T. Kildow, A. McIlgorm. The importance of estimating the contribution of the oceans to national economics. Marine Policy 2010: 367-374.

[20]Kildow JT, Colgan CS, Scorse J. State of the U.S. ocean and coastal economies 2009. Dublin: National Ocean Economics Program; 2009.

[21] Kalaydjian R. French marine-related economic data, 2007. Brest, France: Marine Economics Department, IFREMER; 2008.

[22] Ronald E. Miller and Peter D. Blair.Input-output Analysis Foundations and Extensions. Cambridge University Press, New York, 2009.

[23] Oosterhaven, J.: 1989, 'The supply-driven input-output model: a new interpretation but still implausible'. Journal of Regional Science 29, 459–465.

[24] Moore, Frederick T. 1955. "Regional Economic Reaction Paths" ,Ameirican Economic Review, 45, 133-145.

[25] Moore, Frederick T. and James. W. Petersen. 1955. "Regional Analysis: An Interindustry Model of Utah", Eeview of Economics and Statistics, 37, 368-371.

[26] Hirsh, Werner Z. 1959. "Interindustry Relations of a Methopolitan Area", Review of Economics and Statistics, 41, 360-369.

[27] Chenery H.B., and Watanabe T., (1958), International Comparisons of the Structure of Production Econometrica, 26 (4), October, pp 487-521.[28] Rasmussen, P.N. (1956), Studies in Inter-sectoral Relations, Amsterdam, NorthHolland.

[29] Hirschman A.O., (1958) Interdependence and Industrialization, in: The Strategy of Economic Development, New Haven, Yale University Press.

[30]TemurshoevUmed "Key sectors in the Kyrgystan Economy", Discussion Paper No. 2004 – 135 November 2004, Charles university.