# A BENEFIT/COST ANALYSIS OF THE BRAZILIAN FISHERY FISCAL INCENTIVE POLICY[1]

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## ABSTRACT

This paper evaluates the fiscal incentive program used between 1967 and 1986 to stimulate Brazil's fish industry. The program's financial resources were directed toward fish harvesting, processing, and marketing operations. No investment was made in research or data collection, and no controls to regulate the harvest of native fish stock (fishable biomass) were put into place. Based on the concept of economic surplus, the social benefit from the program was more than the social cost (benefit/cost stayed between 1.05 and 2.06). The program also caused several fish species to be overfished, the principal cause of the decrease found in Brazilian fishery production since 1986. This paper makes some proposals to increase and sustain native fishery production, primarily through aquaculture (especially, fish farming).

**Key words**: fishery activity, Brazil, traditional benefit/cost model.

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## 1. Introduction

A social benefit/cost analysis is used in this paper to evaluate the Brazilian Government's fiscal incentive policy to stimulate the country's "fishery activity" from 1967 until 1986. The social benefit/cost analysis is derived from a model based on economic surplus and adapted to Brazilian fishery activity.

In this case, a "fishery activity" is any action involved with the harvest and sale of fresh fish. Fishery activities are part of the Fish Agro-food System (FAS), a system that unites fishery activities (harvest and sale of fresh fish), provision of fishing inputs (ships and nets, mainly), and the industrial manufacture and marketing of processed fish and fish products. "Fishery policy" is understood to be those actions intended to regulate and/or to stimulate fishery activity.

In 1967, the FAS was first affected by a fiscal incentive policy. Decree-law number 221/67 granted a fiscal incentive to increase Brazil's fishery production. Since then, the FAS has changed significantly, fish stocks have shriveled, and the development of fishery activity in Brazil has been retarded.

Given the importance of the fish as a natural, economically exploitable resource, an evaluation of Brazil's fishing incentive program is fundamental. This paper analyses the fishing incentive policy's effect on the evolution of Brazilian fishery production and makes a social benefit/cost evaluation of that policy, using the concepts of producer and consumer economic surplus.

## 2. The fiscal incentive policy to stimulate fishery production in Brazil

On February 28th, 1967, Brazilian Decree-law number 221/67 was promulgated. It allowed enterprises to take tax deductions for investment in fishery projects (that mechanism is known in the literature as the "fishing fiscal incentive program") and remained in effect until

1972. Enterprises registered in Brazil could deduct no more than 25% their income tax burden to compensate for investment expenditures on projects to improve the harvest, transport, processing, marketing, and sale of fish. The projects had to be approved by the Federal Fishing Development Office (SUDEPE), and the beneficiary firms had to provide investment capital matching one-third of the funds arising from the Government's fiscal incentive program.

The fishing fiscal incentive program was part of the Federal Government's policy to develop regions or sectors in Brazil. Thus, fiscal incentives were not only granted to fishery enterprises, but also for activities to development Brazil's North-East and Amazon regions, forestry enterprises, tourism activities, among others (Bacha, 1995).

From 1967 to 1973, there was no central authority exercising control over the allocation of these incentives; and according to Bacha (1995) the demand for fiscal incentives was bigger than the supply. That supply demand imbalance caused two serious problems for the fishing industry: planned investment was delayed due to the shortage of financial resources and usurious commissions were charged for access to investment capital.

To solve those problems, the Federal Government promulgated Decree-law number 1,376 on December 12, 1974, to create the Regional and Sectional Investment Fund (FISET). For the specific case of fishery enterprises, the Fishing Investment Fund (FISET/Fishing) was created, to be supervised by SUDEPE with the Banco do Brasil S/A as financial agent.

Decree-law number 1,217, enacted on May 09, 1972, extended the validity of the fishing fiscal incentives to 1977. According to Neiva (1990), the incentives were then extended to 1981, and then to 1986, but its upper tax deferment limit was reduced from 25% to 12.5%. The fishing incentive program was terminated at the end of 1986; though, since 1987 there have been occasional government exemptions from indirect taxes for the purchase of combustible oil used in fishery ships.

This paper will examine only those fishing fiscal incentives granted from 1967 to 1986.

## 3. The evolution of fishery production

Brazilian fishery production grew impressively from 1960 to 1994, increasing from 281,512 tons to 697,577 tons. Nevertheless, that production showed variable behavior patterns defining two tendencies. From 1960 to 1985, production grew; and since 1986 production has followed a decreasing trend (Figure 1). The first jump in Brazilian fishery production took place from 1960 to 1962. From 1963 to 1967, fishery production remained relatively stable. A new production growth phase began in 1968 and lasted until 1974, and was followed by fluctuations without a defined tendency from 1975 to 1980. Fishery production went through a third growth phase from 1981 to 1985, then fell strongly until 1990. In the first half of the '90s production showed a slight upward tendency but stayed below the annual average obtained in the second half of '80s.

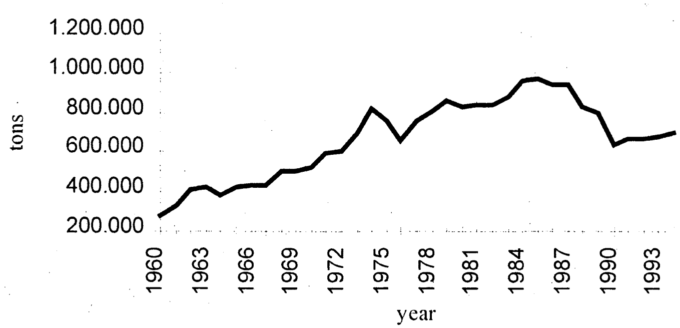


Figure 1 - Brazilian Fishery Production.
Source: Statistical Yearbook of Brazil, several numbers.

Fishery production grow.h from 1968 to 1974 was linked with the Government's concession of fiscal incentives through the mechanism created by Decree-law 221. These incentives amounted to R$ 793.49 million (August 1994 R$), from 1967 to 1974 an annual average of R$ 99.19 million. According to Neiva (1990), the incentive policy facilitated the creation of a modern industrial park devoted to fish handling, expanded the range of domestic fishery ships, and contributing to increase Brazilian fishery production during the period. Giulietti & Assumpção (1995) found that 51% of the fishing fiscal incentives granted from 1967 to 1972 were invested in the industrial plant, 20% in the fish harvest, and the rest was invested in other FAS activities. But, nothing was invested for research on native Brazilian fish or to gather data on native fish stocks (native fishable biomass).

From 1975 to 1980, annual fiscal incentives granted to fishery activities averaged R$ 28.25 million annually (August 1994 R$). These resources proved insufficient to support domestic fishery production growth. According to IPEA/COMIF (1986), during this period SUDEPE prioritized the maintenance of enterprises that had received fiscal incentives in the 1967 to 1974 period.

From 1981 to 1985 (espe^ially, 1983, 1984, and 1985), barriers erected to hinder fish importation stimulated a great jump in domestic fish production. Domestic demand for fish compensated for the reduction in average annual fiscal incentives to R$9.37 million. During that period, overfishing reduced fish stocks; and in 1986 fish production began a steady decrease.

The problem of overfishing has been noted by many authors who study the exploitation of Brazil's fishery resources: Paez, 1993; Giulietti & Assumpção, 1995; Tremel, 1993, and Neiva, 1990). In these authors' opinions, the Brazilian Government did not consider the potential effect of its fishing fiscal incentive program on the marine fish resources[4] found off the Brazilian coast when the program was established in 1967.

The incentive policy expedited the creation of a large fishing fleet specialized in the harvest of specific fish species (devastating specific fishery resources) and created a large associated infrastructure. Industrial plant capacity was enlarged to the point that it exceeded maximum sustainable domestic fish production (Giulietti & Assumpção, 1995).

From 1960s to the 1980s, federal economic policy linked to fishery activity did not significantly impact fresh water fishing despite the 4th article of Decree-law number 221/67, which authorized fiscal incentives for freshwater fish projects. The majority of the program's financial resources went to stimulate marine fish projects (IPEA/COMIF, 1986).

From 1960 to 1994, domestic marine fish production represented around 78% of the country's fishery production from domestic stock, while freshwater fish made up around 22% of that production. Freshwater fish now make up nearly 30% Brazil's annual fishery production, due to the overfishing of marine fishery resources.

Studying the exploitation of fishery resources, Paez (1993) gives evidence that a great part of the fish species harvested commercially along the Brazilian coast comes from overfishing. According to the author, the species traditionally harvested in Brazil, other than in the country's North Region, are lobster, shrimp, croaker, sardine, weakfish, hake, and mullet, among others. In 1993, these species had been exploited to nearly the maximum sustainable level, and in some cases there had been overfishing.

As a typical example of overfishing, Paez (1993) mentions the

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4 According to Neiva (1990), the potential of the marine fish resources - the quality and the volume of those resources - are determined, largely, by the physical, oceanographic and climatic characteristics of different areas of the sea near the coast.

case of sardines. He writes that the total catch in Brazil's Southeast Region jumped from 38,772 tons in 1964 to 113,877 tons in 1969, reaching a maximum of 228,000 tons in 1973. Since 1974, the annual sardine catch has been decreasing. In 1990, only 32,000 tons of sardines were harvested, less than the amount caught in 1964. According to Paez (1993, p.58):

> *"In that case, we observe overfishing and partial use of the fishing fleet and related industrial plant, and the country's is now largely dependent on imports to maintain the domestic industry and to satisfy the domestic market."*

Brazilian lobster is another domestic resource that is being overused. According to Defesa da Lagosta... (1998), lobster production in the State of Ceará (the principal Brazilian lobster production area) fell 7.5% in 1997; and from 1991 to 1997 production decreased 46%. For all of Brazil, the estimated annual sustainable harvest is around 8,900 tons of lobster (complete body), and 3,000 tons of lobster tail (exported product). Until 1993/1994, lobster production showed a downward tendency, which stabilizing at around 8,000 tons/year. However, in 1995, production reached 10,838 tons, a harvest above the estimated sustainable level. Defesa da Lagosta... (1998), believes that the increase in production is a irrational exploitation of the resource, occurring despite laws that prohibit harvest during part of the year and restrict the harvest of lobsters below a minimum size.

From Figure 1, you can observe a pattern of general increase in Brazilian fishery production from 1960 to 1985, and a general production decline beginning 1986. In the '90s, annual fishery production has been a little above the level observed in 1976 (658,847 tons). However, this increase is due the growth of freshwater fishery production, stimulated by the federal government's renewed interest in aquaculture. The

Brazilian Environment and Natural Resources Institute (IBAMA) recently created specific regulations to organize aquaculture: IBAMA's Regulation 091/93 created the Commission of Environmental Licensing for the projects of salmon culture in a specific area; IBAMA's Regulation 095/93 establishes fish-farm registration norms; and Decree 1,695/95 regulates aquaculture projects in Federal waters (see: Abdallah, 1998).

Table 1 gives recent Brazilian aquaculture production statistics by region. As shown, in 1995 aquaculture was responsible for around 40,000 tons of fish a year.

Table 1 – Number of aquaculture farms and their production – Brazilian Regions – 1995.

| Brazilian regions | Aquaculture farms (numbe ) | Production (tons a year) |
|---|---|---|
| North | 3,582 | 2,079.5 |
| Northeast | 1,132 | 3,982.17 |
| Center-west | 726 | 6,056 |
| Southeast | 2,443 | 10,897.9 |
| South | > 29,000 | > 19000 |

Source: Data set collected from information available into the WORKSHOP para subsidiar... (1996).
Note: According to the data source, the data represent an estimate. It's important to keep in mind that these data are difficult to collect in Brazil.

Brazil's South region contributes the largest part of domestic cultivated fish production, more than 19,000 tons in 1995, and contains more than 29,000 fish farms. The last is a consequence of the region's land tenure system, where small farms predominate. The South region states of Parana and Santa Catarina are responsible for over 90% of the cultivated fish produced in the region. The State of Parana has more than 19 thousand small farms dedicated to aquaculture, mainly producing tilapia (a type of fish).

The Southeast region produces the second largest volume of domestic cultivated fish. In 1995, the region was responsible for around 25% of Brazil's production. Fish farming in that region has grown due to the expansion of fishery enterprises geared for the leisure fishermen. Individuals indulge their fishing urge by paying to fish in stocked ponds and lakes. The southeastern state of São Paulo is responsible for the largest production from fish farms in the region; and there is a well-organized, expanding trout farming system in the southeastern state of Minas Gerais.

"Outlook" (1997) projects that fish farm production in Brazil could possibly total over one million tons in the next ten years. "Outlook" asserts that Brazil offers the worlds best aquaculture conditions because of its large internal fluvial net and over 8 thousand kilometers of coastline. The Amazon basin contains more than 5 million hectares of fresh waters restrained behind weirs (in the Northeast), and the country has a large complex of reservoirs built for the generation of hydroelectric energy or urban provisioning.

## 4. The social benefit/cost model and its application to Brazil's fishing fiscal incentive program

Social benefit/cost analysis has frequently been used in economic analysis to determine if the society, as a whole, will be bettered by the completion of a specific project or to ascertain which of several projects will most benefit society. The same analysis has been also used to evaluate, *ex post*, the overall benefit obtained from a specific project and to compare that benefit with the effective costs of that project.

A large number of papers have employed social benefit/cost analyses to evaluate agricultural projects, programs, or investments (such as, the impacts of technological innovation). Many of those papers use the concepts of consumer and producer economic surplus.

Norton & Davis (1981) studied several models that calculated the social benefit from investments in agricultural research by using the concepts of consumer and producer surplus. The social benefit/cost models developed by Schultz (1953), Griliches (1958), Peterson (1967), Akino & Hayami (1975), Lindner & Jarrett (1978), and Rose (1980) calculate the increase in total surplus when the supply curve shifts to the right due to the adoption of a technological innovation in agriculture. They compared the surplus increase with the costs incurred to generate the technological innovation. In Brazil, some authors have used similar models: Ayer & Schuh (1974), Monteiro (1975), Fonseca (1976), Ferreira (1993), Silva & Khan (1994), Santana & Khan (1992), and Bacha (1995). According to Tweeten (1989), the concepts of the consumer and producer surplus discussed by Marshall can be used to analyze economic policy effects.

### 4.1. The specific research model

In Figure 2, you can see the demand curve ($D_0D_0$) for fish from extractive and non-extractive fishing (from fish farms), and the supply curve of fish ($S_0S_0$) from extractive and non-extractive fishing. The total economic surplus is the sum of the producer surplus (area $P_0EAP_0$) and the consumer surplus (area $P_0EBP_0$).

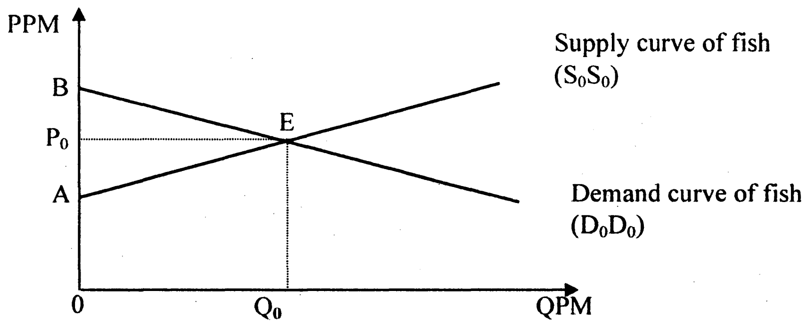


Figure 2– Fish market equilibrium

QPM = quantity of fish from extractive and non-extractive fishing;

PPM = price of fish from extractive and non-extractive fishing;

$P_0$ = equilibrium market price (per unit of fish);

$Q_0$ = equilibrium quantity of fish.

Fishing fiscal incentives reduce production costs, shifting the fish supply curve to the right (from $S_0S_0$ to $S_1S_1$ in Figures 3 and 4). The economic surplus will be modified according to the shift in the fish supply curve.

In Figure 3, we can observed the pivotal shift of the fish supply curve (note that the point on vertical axis does not change). The area EABCE gives the increment in total economic surplus.

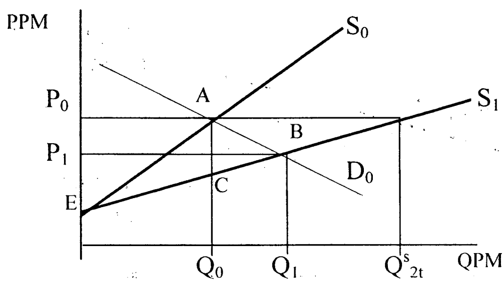


Figure 3 – Pivotal shift of the supply curve of fish.
Note: $S_0$ and $S_1$ show, respectively, the fish supply curves before and after the concession of fishing fiscal incentives; $P_0$ and $Q_0$ are, respectively, the equilibrium price and quantity of fish before the concession of fishing fiscal incentives; $P_1$ and $Q_1$ are, respectively, the equilibrium price and quantity of fish after the concession of fishing fiscal incentives.

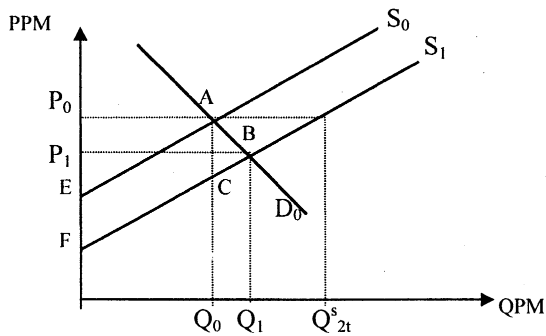


Figure 4 – The parallel shift of supply curve of fish.
Note: $S_0$ and $S_1$ show, respectively, fish supply curves before and after the concession of fishing fiscal incentives; $P_0$ and $Q_0$ are, respectively, the equilibrium price and quantity of fish before the concession of fishing fiscal incentives; $P_1$ and $Q_1$ are, respectively, the equilibrium price and quantity of fish after the concession of fishing fiscal incentives.

The increase of the economic surplus is a measure of the total social benefit coming from fishing fiscal incentives.

The Total Social Benefit (BST) can be measured by using the following equations (according to Lindner & Jarret, 1978; and, Rose, 1980):

$$BST = 0.5\, K\, P_0 Q_0 \,(1+Z\varepsilon^{d}) \qquad (1)$$

for the pivotal shift of the supply curve

or

$$BST = 0.5\, K P_0 Q_0\, (2+Z\varepsilon^d) \tag{2}$$

for the parallel shift of the supply curve.

Where:

$P_0$ and $Q_0$ are the equilibrium fish price and quantity for fish from extractive and non-extractive fishing, respectively, before the concession of fishing fiscal incentives.

$\varepsilon^d$ = price-elasticity of the demand for fish from extractive and non-extractive fishing (in absolute values);

According to Rose (1980), Z is calculated by the following equation:

$$Z = \frac{K.\varepsilon^s}{\left(\varepsilon^s + \varepsilon^d\right)} \tag{3}$$

$\varepsilon^s$ = price-elasticity of the supply for fish from extractive and non-extractive fishing;

$K$ = is the size of the supply curve shift (see figures 2 and 3) and is measured by the proportional reduction of costs. Its equation is:

$$K = \frac{\overline{AC}}{P_0} \tag{4}$$

Taking the point ($Q^s_{2t}$, $P_0$) in Figure 2, the price-elasticity in the supply curve ($\varepsilon^s$) can be calculated using:

$$\varepsilon^s = \frac{\left(\dfrac{Q^s_{2t} - Q_0}{Q^s_{2t}}\right)}{\left(\dfrac{\overline{AC}}{P_0}\right)} \quad \therefore \quad \varepsilon^s = \frac{\left(1 - \dfrac{Q_0}{Q^s_{2t}}\right)}{K} \quad \therefore \quad K = \frac{\left(1 - \dfrac{Q_0}{Q^s_{2t}}\right)}{\varepsilon^s} \tag{5}$$

The last equation tells us that $K$ can be measured by the proportional change in production divided by the price-elasticity of supply ($\varepsilon^s$). Therefore, to calculate *K* it is necessary to have an estimate of the amount of product supplied before and after the concession of the fishing fiscal incentive if the price at $P_0$ remains fixed

In order to calculate the price-elasticity of the demand and supply for fish from extractive and non-extractive fishing ($\varepsilon^d$ and $\varepsilon^s$, respectively), we suggest the use of following model[5]:

$$\mathrm{L}QD_t = a_0 + a_1 \mathrm{L}P_t + a_2 \mathrm{L}PS_t + a_3 \mathrm{L}R_t \qquad \text{demand equation} \qquad (6)$$

$$\mathrm{L}QS_t = b_0 + b_1 \mathrm{L}P_t + b_2 \mathrm{L}IF_{t-k} \qquad \text{supply equation} \qquad (7)$$

$$\mathrm{L}QD_t = \mathrm{L}QS_t - \mathrm{L}X_t \qquad \text{equilibrium equation} \qquad (8)$$

Where: $QD_t$ = domestic demanded quantity of fish from extractive and non-extractive fishing at time t, measured in kg per person; $QS_t$ = supplied quantity of fish from extractive and non-extractive fishing at time t, in kg per person; $P_t$ = price of fish from extractive and non-extractive fishing at time t, in Brazilian currency ("*Real*")[6], R$ per kg; $PS_t$ = price of the substitute good (beef or chicken) at time t, in Brazilian currency per kg; $R_t$ = Gross Domestic Product in Brazilian currency per person; $IF_t$ = fiscal incentives granted to fishing at time t, in Brazilian currency; $X_t$ = exported quantity of fish at time t, in kg.

The model above has two behavior equations, the fish demand equation (6) and the fish supply equation (7), and one fish equilibrium equation in Brazil (8).

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[5] As an alternative to that model, we estimated models with integral values of $LQD_t$, $LQS_t$ and $LR_t$ and also using the total population as an explanatory variable in the demand equation. Nevertheless, those equations did not have good econometric results (see Abdallah, 1998).

The model was considered also with $QD_t$, $QS_t$ and $R_t$ in *per capita* values, but placing the $LQS_{t-1}$ as an explanatory variable in the supply equation. The idea was to harvest the lag effect of the fiscal incentives and the fish stocks on the supplied quantity in the current period. Nevertheless, the econometric results found for the supply equation was unsatisfactory (the coefficients of $LP_t$ and $LIF_t$ were not significant, and the estimated coefficient of the $LP_t$ was negative, that is, contrary to the expected).

[6] The nominal prices are transformed in Real and those are put in purchasing power of a specific month (August 1994).

**L** indicates that the variable has had its value taken in neperian logarithm, so that the price-elasticity of the demand and supply for fish in Brazil can be obtained directly. These demand and supply elasticities are represented by the coefficient of $P_t$ in equations (6) and (7), which are $a_1$ and $b_1$, respectively.

The hypothesis adopted to build the model above is related to economic and statistical factors. The structure of the demand for fish in Brazil is formed by the price of fish, the price of a fish substitute (beef or chicken), and by consumer income. The fish supply determinants are the price of fish and a variable that measures the government policy to stimulate fishery activity.

In its current form, our model does not evaluate the direct effects of the fishing fiscal policy on industrial activities or on the generation of income and employment in the Fish Agro-food System[7]. It would be better if it were possible to add a variable to the social benefit/cost model that would measure the environmental cost of irrational natural resource exploitation. However, due to the lack of an adequate database, the model will be kept in a simple form.

$QD_t$ (quantity of fish demanded from extractive and non-extractive fishing) expresses the apparent domestic consumption of fish; that is, the quantity of domestic fish produced added to the quantity of fish imported quantity, less the quantity of fish exported.

$QS_t$ (quantity of fish supplied from extractive and non-extractive fishing) expresses the apparent supply of fish; that is, it is the quantity of domestic fish produced added to the quantity of fish imported.

[7] Those effects are analyzed partially in Abdallah (1998).

In the equation below, $P_t$ (price of fish at time t) is the average of various fish specie prices[8]:

$$P_t = \frac{\sum_{i=1}^{n} p_{i_t} q_{i_t}}{\sum_{i=1}^{n} q_{i_t}}; \tag{9}$$

Where: $p_{i_t}$ and $q_{i_t}$ respectively represent prices and quantities of the different fish groups; [i = (1... n) represents the five different fish specie groups [n = 5], at time t. Prices are measured in Reals per kg and quantities are measured in kg.

$PS_t$, the substitute good price at time t, represents the price of beef or chicken at time t, in *Reals* per kg.

The demanded quantity of fish at time t (QDt) varies inversely to the variation of the price of that product (Pt), the price of a substitute good (PSt), and domestic income (Rt). In the case of the supply equation, it is assume that the variations in quantity of fish supplied at time t are directly related to the price of fish (Pt) and to the fiscal production incentives (IFt-k). Thus, the signs expected for the coefficients of equations (6) and (7) are a1 < 0, a2 > 0, a3 > 0, b1 > 0 and b2 > 0. It is known that $\varepsilon^d = |a_1|, \varepsilon^s = b_1$. Observe that the coefficient of the income-elasticity of demand (h) is given by $a_3$.

The two-stage least square method and the RATS program were used[9] to resolve the fish demand and supply equations [equation (6) and (7)].

[8] In this study, the classification of fish in different groups is the same as that from the Statistical Yearbook of Brazil, from which those data were collected. Five different groups are considered: fish, crustaceans, mollusks, aquatic mammals and turtles.

[9] The two-stage least square (2SLS) method has been chosen based on the identification of the model proposed in this study. Once analyzed, the fish demand and supply equation showed superidentities. According to Hoffmann & Vieira (1987, p.294) and Kmenta (1978, p.604), the parameters of those equations can be estimated using the 2SLS method.

The Total Social Benefit (BST) - calculated through equations (1) and (2) - should be compared with the Total Social Cost (CST). The Total Social Cost (CST) is measured by the cost of the fiscal incentives granted to the fishery activity. Using the BST and the CST a social benefit/cost evaluation of the fishing fiscal incentive policy can be made.

## 5. Data

In order to estimate the model composed by equations (6), (7), and (8), public data are used for each year from 1960 to 1994, though fishing fiscal incentives were granted from 1967 to 1986 only. Table 2 shows these data. The model was tested considering the price of the chicken ($PF_t$) as a substitute good, but the econometric results were not good.

Table 2: Data set used to estimate demand and supply equiation for fish in Brazil - from 1960 to 1994

| YEAR | R | QD | QS | X | POP | PS | PF | P | IF |
|---|---|---|---|---|---|---|---|---|---|
| 1960 | 1.10976E+11 | 280.306.000 | 281.512.000 | 1,206,000 | 70.070.457 | 2.14 | 2.93 | 0.99 | 0 |
| 1961 | 1.18340E+11 | 328.299.000 | 330.140.000 | 1,841,000 | 72.095.493 | 2.27 | 2.58 | 0.92 | 0 |
| 1962 | 1.24670E+11 | 412.566.000 | 414.640.000 | 2,074,000 | 74.179.053 | 2.25 | 2.67 | 0.93 | 0 |
| 1963 | 1.28733E+11 | 419.564.000 | 421.365.000 | 1,801,000 | 76.322.828 | 2.09 | 2.53 | 0.90 | 0 |
| 1964 | 1.32590E+11 | 397.079.000 | 398.898.000 | 1,819,000 | 78.528.557 | 1.83 | 2.10 | 0.83 | 0 |
| 1965 | 1.36747E+11 | 436.581.000 | 439.019.000 | 2,438,000 | 80.798.033 | 1.83 | 2.46 | 0.86 | 0 |
| 1966 | 1.45308E+11 | 461.617.000 | 464.585.000 | 2,968,000 | 83.133.096 | 2.52 | 2.25 | 0.85 | 0 |
| 1967 | 1.48950E+11 | 464.900.000 | 468.269.000 | 3,369,000 | 85.535.642 | 2.02 | 2.08 | 0.89 | 16,072,329.35 |
| 1968 | 1.66778E+11 | 539.272.000 | 545.356.000 | 6,084,000 | 88.007.622 | 1.80 | 2.07 | 0.87 | 61,810,937.94 |
| 1969 | 1.82591E+11 | 542.906.000 | 552.267.000 | 9,361,000 | 90.551.043 | 1.70 | 1.64 | 1.01 | 180,679,397.49 |
| 1970 | 1.96672E+11 | 570.635.000 | 580.769.000 | 10,134,000 | 93.139.037 | 1.96 | 1.97 | 0.95 | 213,618,603.87 |
| 1971 | 2.17321E+11 | 619.656.000 | 631.048.000 | 11,392,000 | 95.448.885 | 2.36 | 1.84 | 1.21 | 138,422,250.40 |
| 1972 | 2.48444E+11 | 622.043.000 | 639.465.000 | 17,422,000 | 97.816.017 | 2.57 | 2.01 | 1.32 | 78,188,630.07 |
| 1973 | 3.19263E+11 | 743.228.000 | 755.780.000 | 12,552,000 | 100.241.855 | 3.30 | 2.37 | 1.55 | 64,325,752.21 |
| 1974 | 3.61361E+11 | 848.343.000 | 862.075.000 | 13,732,000 | 102.727.853 | 3.44 | 2.11 | 1.27 | 40.372,888.48 |
| 1975 | 3.97590E+11 | 844.404.000 | 859.261.000 | 14,857,000 | 105.275.503 | 2.88 | 1.96 | 1.08 | 43,561,258.02 |
| 1976 | 4.39024E+11 | 722.012.000 | 735.780.000 | 13,768,000 | 107.886.336 | 2.53 | 1.82 | 1.32 | 34,325,725.06 |
| 1977 | 4.69991E+11 | 790.253.000 | 814.458.000 | 24,205,000 | 110.561.917 | 2.47 | 1.70 | 1.10 | 29,675,713.51 |
| 1978 | 4.91245E+11 | 841.946.000 | 868.364.000 | 26,418,000 | 113.303.853 | 3.24 | 1.79 | 1.07 | 24,616,074.43 |
| 1979 | 5.25781E+11 | 920.244.000 | 947.741.000 | 27,497,000 | 116.113.788 | 4.39 | 1.91 | 1.56 | 23,495,159.76 |
| 1980 | 5.45978E+11 | 855.015.000 | 889.477.000 | 34,462,000 | 119.002.706 | 3.79 | 1.56 | 1.42 | 13,866,656.98 |
| 1981 | 5.00991E+11 | 833.445.000 | 878.555.000 | 45,110,000 | 121.299.458 | 2.69 | 1.40 | 1.18 | 11,855,446.75 |
| 1982 | 5.17796E+11 | 844.605.000 | 890.448.000 | 45,843,000 | 123.640.538 | 2.30 | 1.19 | 1.30 | 9,201,719.78 |
| 1983 | 4.57006E+11 | 875.109.000 | 922.475.000 | 47,366,000 | 126.026.800 | 2.85 | 1.40 | 1.19 | 10,929,973.55 |
| 1984 | 4.50935E+11 | 953.561.000 | 990.547.000 | 36,986,000 | 128.459.117 | 3.09 | 1.45 | 1.22 | 8,178,094.39 |
| 1985 | 5.23260E+11 | 954.510.000 | 1.007.760.000 | 53,250,000 | 130.938.378 | 2.71 | 1.47 | 1.24 | 6,707,685.64 |
| 1986 | 5.76253E+11 | 996.978.000 | 1.039.529.000 | 42,551,000 | 133.465.489 | 3.13 | 1.64 | 1.54 | 5,921,255.53 |
| 1987 | 5.64945E+11 | 998.772.000 | 1.039.750.000 | 40,978,000 | 136.041.373 | 2.61 | 1.18 | 1.42 | 0 |
| 1988 | 5.23196E+11 | 848.083.000 | 891.654.000 | 43,571,000 | 138.666.971 | 2.35 | 1.22 | 1.33 | 0 |
| 1989 | 5.34897E+11 | 880.710.000 | 925.064.000 | 44,354,000 | 141.343.244 | 2.19 | 1.11 | 1.45 | 0 |
| 1990 | 4.85322E+11 | 813.024.000 | 847.789.000 | 34,765,000 | 144.071.169 | 1.88 | 0.91 | 1.47 | 0 |
| 1991 | 4.93324E+11 | 783.138.000 | 828.377.000 | 45,239,000 | 146.825.475 | 1.89 | 0.80 | 1.49 | 0 |
| 1992 | 4.87754E+11 | 712.611.000 | 767.848.000 | 55,237,000 | 148.851.667 | 1.84 | 0.82 | 1.51 | 0 |
| 1993 | 4.86477E+11 | 773.719.000 | 825.358.000 | 51,639,000 | 150.905.820 | 1.87 | 0.76 | 1.53 | 0 |
| 1994 | 5.14381E+11 | 815.053.000 | 854.811.000 | 39,758,000 | 152.988.320 | 1.76 | 0.70 | 1.55 | 0 |

Source: $R_t$, $QD_t$, $QS_t$, $X_t$, $POP_t$, and $P_t$ were taken out from Statistical Yearbook of Brazil; $PS_t$ and $PF_t$ were taken out from Statistical Yearbook of IEA/SP; and $IF_t$ were collected by Brazilian Northeast Bank (BNB).

Note: $R_t$ is the gross domestic product, in R$ with purchasing power of August 1994. $QD_t$ is the demanded quantity of fish in Brazil and $QS_t$ is the supplied quantity of fish in Brazil, both in Kg. $X_t$ is the exported quantity of fish, in Kg. $POP_t$ is the resident population in Brazil, in number of inhabitants. $PS_t$ is the price of beef in the State of São Paulo, and $PF_t$ is the price of the chicken in the State of São Paulo, both in R$ of August 1994 per Kg. $P_t$ is the price of fish in Brazil, in R$ of August 1994 per Kg. $IF_t$ is the fiscal incentives granted to the fishing, in R$ of August 1994.

## 6. Benefit/cost analysis of the federal fishing fiscal incentive program

First, fish demand and supply equations were estimated. Then, the parameters of those equations are used to calculate the social benefits generated by the fishing fiscal incentive program. Finally, that social benefit is compared with the social cost of the program.

### 6.1. The estimates of demand and supply equation for fish in Brazil

The best estimates of the fish demand and supply equations are[10]:

[10] It is important to stand out that other estimates of that mod.l, but that do not present satisfactory econometric results (see footnote number 5), presented close values for the price-elasticities of supply and demand and for the coefficient of $LIF_t$. For example, considering the $LQS_{t-1}$ as an explanatory variable in the supply equation and keeping the other variables of the original model, was obtained 0.0026 as the coefficient of $LIF_t$ and -0.4322 as the price-elasticity of the demand. But the coefficient of $LP_t$ in the supply equation was negative (which is incoherent with the theoretical model).

Considering the accumulated values of fiscal incentives until each year (that is to say, $LIF_{tac}$ in the supply equation) and the original model, we met the following values of the price-elasticities of the demand, supply and fiscal incentives: -0.4428, 0.3893 and 0.0103, respectively.

Fish demand equation:

$$LQD_t = -0.6682 - 0.4322 \cdot LP_t + 0.3705 \cdot LPS_t + 0.2874 \cdot LR_t$$
$$(-0.595)^{n/s} \quad (-1.603)^{**} \quad (4.072)^{*} \quad (1.938)^{*}$$

$$R^2 = 0.8359 \qquad F = 50.9618^{*} \qquad DW = 2.2512^{\,s/a}$$

Fish supply equation:

$$LQS_t = 1.6856 + 0.4243 \cdot LP_t + 0.0113 \cdot LIF_{t-k}$$
$$(29.1136)^{*} \quad (2.4699)^{*} \quad (3.4418)^{*}$$

$$R^2 = 0.6822 \qquad F = 33.2834^{*} \qquad DW = 1.9207^{\,s/a}$$

Where:

a) variables are expressed in reperian logarithm (L); –0.6682 and 1.6856 are the demand and supply equations constants, respectively; $P_t$ is the price of fish in year t; $PS_t$ is the price of beef in year t; $R_t$ represents per capita income in year t; $IF_{t-k}$ is the amount of fiscal incentives granted to the fishing activity in year t-k ( k = 0).

b) subscript * indicates that the coefficient is significant at a 1% level; **, significant at 11%; n/s, not significant; s/a, without residual auto-correlation;

c) the numbers in parentheses under the coefficient are t-Student statistics.

The signs of the coefficients in the fish demand equation are the expected. The income variable ($R_t$) and substitute good price ($PS_t$) coefficients were significant at a 1% level of probability. The coefficient of the price of fish ($P_t$) is significant at a 11% level of probability. The determination coefficient ($R^2$) has been high (around 84%), indicating a good adjustment of the demand function and the F-statistic, indicating a high level of significance of the regression.

The price-elasticity of fish demand ($\varepsilon^d$), which is –0.4322, indicates that an increase of 10% in the price of fish would reduce the demanded quantity of fish by 4.3%, in *ceteries paribus* conditions. That value is smaller in absolute terms than the price-elasticity of sardine demand calculated by other researchers: Carvalho (1980), –0.519; Okawa (1985), –1.82 over the short term and –2.12 over the shortest term; and Morimoto (1975), –1.36. The differences between our study and the others is expected, as those studies considered the demand for only one fish specie, while the present study considers the demand for every consumed fish.

The signs of the supply equation regression coefficients are coherent with the economic theory. The estimated coefficients were significant at a 1% level of probability. The determination coefficient ($R^2$) and F-statistic indicate a good adjustment of the fish supply function.

The price-elasticity of fish supply is 0.4243, indicating that a variation of 10% in the price of fish causes a 4.2% variation in quantity of fish supplied. Both variations are in the same direction.

The coefficient of the fiscal incentive variable, 0.0113, indicates that the fishery incentive has a very small, positive effect on the quantity of fish supplied in Brazil. A 10% increment in the fiscal incentive would increase the quantity of fish supplied by 0.11%.

## 6.2. The valuation of social benefit and cost of the fiscal incentives granted to fishery activity in Brazil

Equations (1) and (2) were used to calculate the Total Social Benefit (BST) of the fishing fiscal incentive. Based on the estimates from the fish demand and supply equations in Brazil, we found that $\varepsilon^d =$ 0.4322 and $\varepsilon^s = 0.4243$.

The values of $Q^S_{2t}$ are calculated for every year under study. Considering 1966 as this study's first period (because it is the year before implementation of the fishing fiscal incentives program), the following equation is used to calculate $Q^S_{2t}$ for each year:

$$\mathrm{L}Q^S_{2t} = 1.6856 + 0.4243 \cdot \mathrm{L}P_t + 0.0113 \cdot \mathrm{L}IF_t \qquad (10)$$

The shift of the fish supply curve caused by the fiscal incentive can be measured using equation (10).

The annual values of K [size of the supply curve shift], in Table 3, are calculated using the annual values of $Q^{S}_{2t}$ [from equation (10)] With the values for K and the values of the price-elasticity of demand ($e^{d}$) and supply ($e^{s}$), the values of Z can be calculated [in Table 3].

Finally, using the annual values of *K* and *Z* from 1967 to 1986, and $e^{d}$, $P_0$ and $Q_0$, we calculate the annual values of the total social benefit generated by the fiscal incentives. Two different estimates are obtained: one considers a pivotal shift of the supply curve, and one considers a parallel shift of that curve (those values are in Table 3).

From the values found in Table 3, we observe that the sum of social benefits obtained from concession of fiscal incentives is larger than the sum of the social costs of those incentives. For the entire period from 1967 to 1986, the social benefits, considering the pivotal supply curve shift, were R$ 1,065,780,656.55 and considering to a parallel shift, those benefits were R$ 2,087,831,627.50 (August 1994 *Reais*). The social costs of the fiscal incentives amounted to R$ 1,014,593,576.56 (August 1994 *Reais*). Therefore, the benefit/cost ratio was 1.05 at least and 2.06 at most.

Table 3: Social benefit (BST) and social cost (CST) of fishing fiscal incentive program, from 1967 to 1986

| Year | K | Z | pivotal BST [R$ago/84] | parallel BST [R$ago/84] | CST [R$ago/84] |
|---|---|---|---|---|---|
| 1967 | 0.1854 | 0.0919 | 39,160,691.86 | 76,826,370.75 | 16,072,329.35 |
| 1968 | 0.2181 | 0.1081 | 47,719,973.61 | 93,311,116.40 | 61,810,937.94 |
| 1969 | 0.2438 | 0.1208 | 55,171,472.61 | 107,606,139.04 | 180,679,397.49 |
| 1970 | 0.2478 | 0.1228 | 57,722,261.40 | 112,536,756.05 | 213,618,603.87 |
| 1971 | 0.2375 | 0.1176 | 56,567,115.46 | 110,397,771.77 | 138,422,250.40 |
| 1972 | 0.2238 | 0.1109 | 54,476,862.36 | 106,463,314.65 | 78,188,630.07 |
| 1973 | 0.2191 | 0.1085 | 54,603,857.85 | 106,761,538.43 | 64,325,752.21 |
| 1974 | 0.2078 | 0.1030 | 52,962,365.91 | 103,668,740.67 | 40,372,888.48 |
| 1975 | 0.2097 | 0.1039 | 54,776,964.06 | 107,200,873.73 | 43,561,258.02 |
| 1976 | 0.2039 | 0.1010 | 54,524,919.16 | 106,769,416.71 | 34,325,725.06 |
| 1977 | 0.2004 | 0.0993 | 54,869,156.72 | 107,481,621.81 | 29,675,713.51 |
| 1978 | 0.1958 | 0.0970 | 54,902,505.69 | 107,596,132.12 | 24,616,074.43 |
| 1979 | 0.1947 | 0.0965 | 55,924,865.66 | 109,612,241.65 | 23,495,159.76 |
| 1980 | 0.1818 | 0.0901 | 53,380,900.08 | 104,762,154.49 | 13,866,656.98 |
| 1981 | 0.1779 | 0.0882 | 53,218,469.68 | 104,483,984.26 | 11,855,446.75 |
| 1982 | 0.1717 | 0.0851 | 52,279,091.82 | 102,704,488.78 | 9,201,719.78 |
| 1983 | 0.1759 | 0.0872 | 54,649,669.77 | 107,315,547.16 | 10,929,973.55 |
| 1984 | 0.1688 | 0.0836 | 53,365,404.41 | 104,869,497.43 | 8,178,094.39 |
| 1985 | 0.1639 | 0.0812 | 52,765,583.68 | 103,742,303.49 | 6,707,685.64 |
| 1986 | 0.1608 | 0.0797 | 52,738,524.75 | 103,721,618.10 | 5,921,255.53 |
| TOTAL | | | 1,065,780,656.55 | 2,087,831,627.50 | 1,014,593,576.56 |

Source: K, Z and pivotal BST and parallel BST are given by research; and the values of CST were supplied by BNB.

From 1969 to 1971, the social cost of the fishing fiscal incentives was more than the social benefits, according to both kind of the supply curve shift (pivotal or parallel). But, the continued allocation of fiscal incentives to the fishery enterprises (especially, after 1971) caused social benefits to surpass social costs.

## 7. Conclusion

The fiscal incentives granted to fishery enterprises from 1967 to 1986 contributed significantly to enlarge Brazilian fishery production. Of those incentives, 78% of the total resources were granted in the first period of the program (from 1967 to 1974). It is of note that from 1967 to 1972, 91% of all resources granted by this program were invested in industry, harvest, management, and commercialization. No investments were made in research or data collection. This percentile distribution reflects a specific euphoria that led the program's administrators to use the resources available to increase the fish harvest and install a modern fish processing industrial park; the administrators were unconcerned with the future of native fish stocks. Our benefit/cost analysis of the program from 1967 to 1986 found that the social benefits for fish producers and consumers were larger than the social costs incurred by the program. For each R$ 1.00 of fiscal incentive granted, a social benefit of from R$ 1.05 to R$ 2.06 was generated.

Notwithstanding this result, the overfishing of some fish species, the observed tendency toward decreased fish production since 1986, and the concentration of the program's resources in the industry and harvest of fish, give evidence of the fishery policy's lack of concern with the stock of native fish.

The fishing fiscal incentive policy contributed to the overfishing of specific fish species, thereby, negatively affecting today's FAS. It is observed, however, that the fishing fiscal incentive policy fails because of its lack of a guided plan to rationally exploit the fishery resource by providing for investment in research, technology, and specialized labor.

It is important to highlight that that result of this study's benefit/cost analysis of the fishing fiscal incentive policy was positive over the period that the policy's program was in effect. To the detriment of the fish culture, the program's investments were concentrated in fishery activity linked to extractive fishing. However, aquaculture was not in fashion in Brazil during the period of the fishing fiscal incentive program. Only in the 1990s, without the assistance of a national fishery policy, has aquaculture evolved, grown and prospered. Certainly, an incentive policy to support aquaculture in Brazil will add dynamism to that economic sector.

Based on our research, we suggest that Brazilian economic policy should address the specific case of fishing, supporting technological development that increases the productivity of marine fish resources and ensures appropriate management of that resource. Federal taxation and credit policies should work to stimulate sustainable aquaculture. In this regard, PRONAF (a subsidized rural loan program in Brazil) resources should be allocated to finance aquaculture projects, especially, fish culture projects.

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