Subsidies, Fisheries Management and Stock Depletion

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Abstract

This paper investigates the impact of fishery subsidies on resource stocks in 23 OECD countries during 1996-2011. I find the effect of subsidies depends on both the type of subsidy and the management regime in place. Cost reducing subsidies have no effect on stocks if management is quota-based but have negative effects if management uses traditional input/output restrictions. Subsidies for improving fishery management and infrastructure produce small beneficial effects on stocks under traditional management, but no effect with quota-based management. These results suggest that global efforts to reform fishery subsidies should be carried out in a highly selective manner.

Keywords: Fishery subsidies, infrastructure, monitoring, OECD, overfishing, quota-based management, WTO

JEL Classification: Q22, Q28

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Introduction

The debate over possible new rules for fishery subsidies has not been settled in spite of a decade of discussion in the Doha Round of the World Trade Organization (WTO)\textsuperscript{1}. Complicating the debate is the common-property nature of the fishery resources since the state of regulation may be a key factor determining whether subsidies exacerbate or ameliorate the overexploitation of fish stocks. This is a real concern because annual fishery subsidies are large - with one estimate suggesting a figure of 34 US$ billion worldwide\textsuperscript{2}. While subsidies lowering the costs of fishing are generally perceived as harmful, subsidies related to fishery management are more controversial. Given the overexploited state of many fishery resources, a resolution to this debate should not wait any longer.

As a step towards resolution, this paper uses a panel of data from 23 OECD countries for the 1996-2011 period to estimate the impact of subsidies on fish stocks. To do so, I match country level subsidy data with a resource stock index prepared by the Sea Around Us Project (SAUP)\textsuperscript{3}. Since the impact of subsidies is likely to vary by type, subsidies are grouped into three categories: income related Direct Payments, Cost Reducing Transfers, and subsidies to management and infrastructure investments that represent General Services\textsuperscript{4}. Finally, as the debate has made clear the impact of subsidies is likely a function of existing fisheries management policies \textsuperscript{(UNEP, 2004)}, I allow for two different management regimes: quota-based and traditional input/output management. This distinction is likely to be important since quota-based management requires stricter monitoring and enforcement, and is expected to be more effective in

\textsuperscript{1}The WTO has no clear definition of fishery subsidies. A broad range of government spending is discussed as potential subsidies, including spending for research and management of the fishery.

\textsuperscript{2}This amounts to more than one third of the world fishery production value. See Sumaila & Pauly (2006) and FAO (2009).

\textsuperscript{3}http://www.seaaroundus.org/

\textsuperscript{4}Due to data limitation, management and infrastructure investments cannot be separated.
protecting resource stocks than traditional input/output management (Munro, 2009, OECD, 2006a).

There are a number of difficulties in identifying the effect of fishery subsidies on resource stocks. The first difficulty concerns data availability. Because stock assessment is available for only a limited number of fish stocks, we have to use harvests or harvest oriented indices for resource stocks. These measures, however, require special care with regard to when the effect will materialize. Subsidies could boost the harvest in the short-term, but decrease it in the longer-term through resource degradation (and vice versa). If we do not distinguish between these short- and long-term changes, we may mistakenly interpret the short-term increase in harvest as a resource recovery. To deal with this issue, the relationship is examined between current resource stocks and past subsidies using different lag structures. As the number of lags increases, the long-term effect of subsidies should emerge in the parameter estimate.

Second, subsidies and resource stocks may both be correlated with another variable. For example, economic fluctuations could affect both the budget for subsidies and the demand for fishery products (which affects resource stocks). To deal with this issue, the panel structure of the data is exploited and used to control for both country and year fixed effects. Country fixed effects control for any time-invariant difference across countries such as the nature of fishing grounds and public preferences over fishery products. Year fixed effects control for any secular changes over time including global business fluctuations and technological advances. Even with these controls in place, it is possible for other unobservable country-specific time-varying factors may also play a role; for example, change in input or output prices may affect fishers’ behaviour and also affect fishery policies. Therefore I include both import price of oil products and fishery products in the estimation to control for input and output price fluctuations.

Finally, there are potential issues with reverse causality that need to be addressed.
Fishery subsidies might cause resource decline, while at the same time resource decline might in turn call for government interventions such as subsidies. For example, after the collapse of Northern Atlantic Cod stocks in the late 1980s, the Canadian government established a number of programs including income maintenance to support the fishing industry (Schrank & Wijkström, 2003). Although one cannot entirely exclude the possibility of reverse causality, it seems less of a concern in the present work. Since the paper examines the relationship between past subsidies and current resource stocks, reverse causality means that current resource stocks affect past subsidies. This can happen when fishers demand subsidies based on the expectation of future resource stocks. As the number of lags becomes larger, however, the magnitude of uncertainty becomes larger and is likely to dominate the effect of expectations. Hence, reverse causality should produce minimal bias in the present context. The validity of this assumption is examined in a robustness check.

Overall, my results suggest the impact of subsidies is conditional on the management regime in place, as well as dependent on the exact form the subsidy takes. As a result, any reform needs to be targeted and quite nuanced. My empirical results show that all three types of fishery subsidies have little effect in countries with quota-based management. This indicates that subsidies do not affect resources if output restrictions are effective. However, in countries with traditional input/output management schemes, an additional 1 dollar in Cost Reducing Transfers today decreases the harvest of healthy stocks by 0.6 kilograms five years later, which is worth 1.23 dollars in future value. On the other hand, an additional 1 dollar in General Services today increases the harvest of healthy stocks by 0.2 kilograms five years later, which is worth 0.40 dollars in future value. Direct Payments also decrease resources, but the effect is only marginally

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5Healthy stocks refer to the stocks who are categorized as developing, exploited or rebuilding according to the SAUP criteria. The stated change in resource stocks occurs within a single year. The aggregate change in resource stocks over time will be larger, but that is beyond the scope of this paper.
These results are robust across a series of specifications and across different sub-samples. To further examine potential reverse causality problems, I re-estimate the model using the share of green parties in parliament in each of the OECD countries as an instrument for fishery subsidies. Green parties prefer fewer fishery subsidies following a widely shared notion that the subsidies are harmful. Hence, a larger share of green parties is expected to be negatively correlated with the amount of subsidies. On the other hand, the share of green parties is unlikely to be affected by resource stocks given the small size of fishing industries in the OECD countries. Further, the share of green parties is unlikely to affect resource stocks other than through subsidies again because such small industries are not the central issue in parliament in these countries. As green parties are expected to reduce all three types of subsidies, they are aggregated into one variable and this aggregate subsidy is instrumented in my estimation. One may question the validity of this instrument because green parties could potentially affect resource stocks through other fishery policies. If they affect other policies, the IV estimation is expected to give a lower-bound of the causal effect. The results show that an additional 1 dollar in the aggregate subsidy today increases the harvest of healthy stocks by 0.19 kilograms in five years, which is worth 0.39 dollars in future value. This is very close to 0.4 dollars found for General Services in the main results. Considering General Services make up as much as 65 percent of the aggregate subsidies in the data, this is suggestive evidence that the main results are not seriously biased by potential reverse causality.

There is a large volume of literature addressing the issues of fishery subsidies. Some of this literature is descriptive in categorizing and estimating the value of fishery subsidies generally (Milazzo 1998, Sumaila et al. 2010, Sumaila & Pauly 2006), or providing estimates for specific countries (Mesnil 2008, Sharp & Sumaila 2009). Estimates of
total subsidy values are upwards of 34 US$ billion. These papers typically assume open
access fisheries and argue that cost-reducing subsidies decrease resources stocks.

The second strand of literature advances toward identifying the conditions under
which subsidies affect resource stocks. This literature has developed using bio-economic
models of the fishery evaluated using comparative statics (Munro & Sumaila, 2002,
Sumaila et al., 2008). The general conclusion here is that subsidies lead to overex-
ploration of resources in open access fisheries. However, fisheries with a proper level
of harvest control can avoid overfishing. A corollary of this work is that the effect of
subsidies depends on fisheries management programs in place. An interesting extension
in international trade shows subsidies in one country may have spillover effects through

The empirical work on subsidies is not extensive but the work by Yagi et al. (2008),
Yagi et al. (2009) and Sumaila et al. (2013) are most closely related to the work at hand.
Yagi et al. (2008) evaluates the empirical effects of subsidies on fishery production. A
panel of 23 OECD countries, 1996-2002, is used to show that income subsidies increase
harvest while management and infrastructure subsidies have the opposite effect. Yagi
et al. (2009) uses a similar analysis for Japanese time series data for the period 1971-
2003 and finds a positive effect of “Government other general services” on production
value per fishers. Sumaila et al. (2013) use cross-section data of 37 island countries
and examine the effect of subsidies on fish stocks. They find a negative relationship
between “bad” subsidies and fish resources. Though suggestive, these studies either
ignore the long-term effect of subsidies or ignore unobservable heterogeneity across
countries. Moreover, none of them consider the potential role of fishery management.

The paper’s contributions are summarized as follows. First, the paper differentiates
between short- and long-term impacts of fishery subsidies. This allows measuring short
term increases in harvest as distinct from longer term decline in resource stocks and
lower harvest levels. Second, the heterogeneity of fishery subsidies are modelled and shown to be empirically important. Moreover, fisheries management is identified as an important factor in the causal link between subsidies and overfishing. Finally, an alternative aggregate subsidy model is estimated and used to validate and test robustness of the main empirical results. Taken together, this paper offers the cleanest evidence to date regarding the impact of fishery subsidies on resource stocks.

The paper is organized as follows. Section 2 describes the data used in the analysis. Section 3 presents the econometric model, identification assumptions and results. Section 4 introduces an aggregate subsidy model for validation and robustness testing. Section 5 discusses the interpretation of the results and Section 6 concludes.

Data

Subsidy data is available from a series of OECD Review of Fisheries publications.\(^6\) The data set covers the period 1996-2011 and includes three types of fishery subsidies: Direct Payments, Cost Reducing Transfers and General Services. Direct Payments are primarily directed at increasing the income of fishers, and thereby correspond to income subsidies. Examples include grants for new vessels and vessel decommissioning. Cost Reducing Transfers reduce fixed or variable costs of fishing. Interest subsidies and fuel-tax exemptions fall into this category. General Services corresponds to transfers for fisheries management and the development of infrastructure. Definitions and examples of each category are found in Table 1.

Because each country has a different size of fishing industry, the amount of fishery subsidies must be normalized to make it comparable across countries. As reliable data

\(^6\)These reports contain data of government financial transfers, which are defined as “the monetary value of government interventions associated with fisheries policies”. Because there is no internationally agreed definition on fishery subsidies, the government financial transfers are treated as subsidies in this paper, following two closely related studies (Yagi et al. 2009, 2008).
on the number of fishers in each country is not available, the output value of fishing industry in each country is used for the normalization. One concern is that the output value itself can be endogenous in the present context. For example, meteorological conditions on fishing grounds may affect both output values and resource stocks, thereby potentially inducing omitted variable bias in estimation. To minimize this concern, fishery subsidies are normalized by the “average” output value over time in each country. The average output value is constant over time, so any factors that are correlated with them are controlled for by country fixed effects included in estimation. Specifically, the normalization is given by:

$$\hat{S}_{it} = \frac{S_{it}}{\sum_{t=1}^{T} O_{it}/T}$$

where $S_{it}$ is the amount of fisheries subsidies and $O_{it}$ is the output value for country $i$ at year $t$.

Measure for resource stocks

The measure of resource stocks used in empirical work is based on the Fish Stock Overexploited or Collapsed (FSOC) index developed by the SAUP and extended by the EPI. The index is defined for country $i$ at year $t$ and based on harvest in each country’s Economic Exclusive Zone (EEZ). The FSOC index function is written:

$$FSOC_{it} = \frac{\text{Harvest of stocks Overexploited or Collapsed in EEZ}_{it}}{\text{Total harvest of stocks in EEZ}_{it}}$$

7Simple normalization using the output values gives qualitatively similar results.
8The SAUP defines the number of “stocks” as a time series of a given species, genus or family (higher and pooled groups have been excluded) for which the first and last reported landings are at least 10 years apart, for which there are at least 5 years of consecutive catches and for which the catch in a given area is at least 1000 tonnes.
9The Environmental Performance Index of the Yale University.
Overexploited and Collapsed stocks are based on a five category stock classification used by the SAUP. For ease of interpretation, this paper uses the following modified version of the FSOC (MFSOC) index:

\[ MFSOC_{it} = (1 - FSOC_{it}) \times 100 \]  

Therefore, an increase in the MFSOC index corresponds to an increase in the harvest of developing, exploited, or rebuilding stocks, given the total harvest for country i at year t. The MFSOC has the advantage that an increase in the index corresponds to an increase in resource stocks.

Froese et al. (2012) argue that harvest-based resource indices perform reasonably well in capturing trends in biomass but respond to a decline in biomass in a delayed fashion. This means that short-term fluctuations in these indices do not necessarily reflect resource fluctuations. Fishery subsidies possibly boost harvests in the short-term but decrease them in the long-term through resource degradation (and vice versa). Short-term changes in the index should capture the effect on harvest, but not on resource stocks. Therefore, this paper focuses on the long-term changes in the MFSOC index.

The interpretation of MFSOC index requires further caution because it changes both at the intensive and extensive margins. At the intensive margin, harvest of stocks in each category (as defined by the SAUP) changes without re-categorizing these stocks. At the extensive margin, changes in harvest lead to re-categorizing of these stocks. For

\(^{10}\)The SAUP notes that stock-status categories are defined using the following criteria (all referring to the maximum catch [peak catch] or post-peak minimum in each series): Developing (catches ≤ 50% of peak and year is pre-peak, or year of peak is final year of the time series); Exploited (catches ≥ 50% of peak catches); Over-exploited (catches between 50% and 10% of peak and year is post-peak); Collapsed (catches < 10% of peak and year is post-peak); and Rebuilding (catches between 10% and 50% of peak and year is after post-peak minimum).
example, when the harvest of an overexploited stock increases, the MFSOC index first
decreases (intensive margin), and when the harvest exceeds a certain threshold and the
stock is re-categorized as "Rebuilding", the index increases (extensive margin). De-
tailed data is not available, however, to distinguish between the intensive and extensive
margins. Hence, all changes in the index are defined from the extensive margin. This
may be reasonable given that the focus of this paper is the long-term effect of subsidies.

The 23 countries used in this study are divided into two groups; Quota countries,
with fisheries management based on individual quota (IQ) or individual transferable
quota (ITQ) systems, and Non-Quota countries with fisheries management based on
traditional input/output restrictions. Quota based fisheries management allocates a
fixed amount of fishing quota to individual agents thus avoiding the common-pool
resource problem. Quota based systems require strict monitoring and enforcement
of the total output restriction to avoid overfishing. The following 15 countries are
classified as Quota countries: Australia, Canada, Denmark, France, Germany, Iceland,
Italy, Netherlands, New Zealand, Norway, Poland, Portugal, Spain, UK, USA. The rest
are classified as Non-Quota countries: Finland, Greece, Ireland, Japan, Korea, Mexico,
Sweden Turkey.

Summary statistics are provided in Table 2, where all prices are in 2009 US$. The
MFSOC index shows that on average over all countries, 83 % of fish stocks are at the
developing, exploited, or rebuilding stage. The lowest value 75.91 is observed in the
UK in 2008 while the highest value 91.74 is observed in Greece in 1996. The total

\footnote{According to \cite{OECD2006b}, "The enforceability issue is indeed one of the salient challenges
faced by IQs systems. It depends on Monitoring, Control and Surveillance (MCS) capacities...".}
\cite{Copeland2009} argue that the regulators enforcement power is a key to determine success
in resource management. \cite{Munro2009} argues that quota-based management makes it easier to
monitor harvests. Nevertheless, there are examples where quota-based management collapsed under
an inability to monitor harvests (\cite{Cancino2007}).

\footnote{The country classification is based on an overview of fisheries management in each country but may
not precisely reflect actual practice for each fishery in each country \cite{OECD2006b}. In the absence of
a country level fisheries management database, the classification is not unreasonable.}
value of subsidies is on average 27% of the total landing value. The breakdown across subsidies from smallest share is 4% Cost Reducing, 5% Direct Payments and by far the largest at 18% is General Services. Also, General Services have the largest coefficient of variation 0.75, in contrast to 0.5 for the other two categories. Note the very large standard deviation for General Services caused by Japan reporting more than 10 times the average value in the sample. Finally, the Quota-based management indicates that 67 percent of the sample countries are categorized as quota regulated countries.

Three types of subsidies

Econometric model

This section examines the effect of three types of fishery subsidies on resource stocks. The equation of interest and the identification assumption are respectively given by:

\[
MFSOC_{it} = \rho_{1k} DP_{it-k} \times Quota_i + \rho_{1k}' DP_{it-k} \times (1 - Quota_i) \\
+ \rho_{2k} CRT_{it-k} \times Quota_i + \rho_{2k}' CRT_{it-k} \times (1 - Quota_i) \\
+ \rho_{3k} GS_{it-k} \times Quota_i + \rho_{3k}' GS_{it-k} \times (1 - Quota_i) \\
+ \gamma X_{it-k} + \alpha_i + \mu_t + u_{it} \quad \text{for } k \in \{0, 1, 2, ..\} \tag{4}
\]

\[
E[u_{it} | \alpha_i, \mu_t, DP_{it-k}, CRT_{it-k}, GS_{it-k}, X_{it-k}] = 0 \quad \text{for } k \in \{0, 1, 2, ..\} \tag{5}
\]

The outcome of interest is the MFSOC index for country i at year t. Three vari-

\[\text{One potential reason is that the entire infrastructure-related budget is managed by the fishery agency in Japan, while some of the infrastructure-related budgets are managed by other agencies in other countries} \cite{Yagi2008}.

\[\text{An alternative specification is to estimate the equation separately for two groups of countries without the quota dummy variable. Results are similar, but less precise when estimated separately due to the small sample.} \]
ables of interest, \( DP_{it-k} \), \( CRT_{it-k} \), and \( GS_{it-k} \) are respectively \( \ln \) Direct Payments per output value, \( \ln \) Cost Reducing Transfers per output value, and \( \ln \) General Services per output value for country \( i \) at year \( t-k \). \( Quota_i \) is an indicator variable that takes 1 if a country is categorized as a Quota country and 0 otherwise. \( X_{it-k} \) is a vector of covariates, \( \alpha_i \) and \( \mu_t \) are country and time fixed effects, respectively, and \( u_{it} \) is the unobserved error term. Since Japan is a clear outlier in terms of General Services, an interaction term of Japan Dummy and General Services is also included in the equation.

I estimate the model using a different number of lags to examine the short- and long-term effects.\(^{16}\) Due to the short time-dimension of the data, up to 6 lags are considered. One may question this specification in that subsidies in different time periods are not included together in the model; if subsidies have both short- and long-term effects, it is more appropriate to include subsidies at different time periods together in the model to separately identify these effects. This does not seem to be a serious issue in the present context, however, because serial correlations in subsidies are not so strong as to significantly affect results. Adding various lags at the same time does not change the conclusion of this paper. Further, subsidies with short time lags are more likely to be affected by reverse causality, so it is better not to include them to identify the effect of subsidies with longer time lags.

The equation includes country fixed effects so that a given country is compared to itself across years that have higher or lower amounts of subsidies. These fixed effects therefore eliminate sources of omitted variable bias generated by across-country differences that are constant over time and may be correlated with different amounts of subsidies. Difference in the productivity of fishing grounds and the public tolerance

\(^{15}\)For observations that take 0, I added 1 before the \( \ln \) transformation. This does not change the results qualitatively, but allows more precise inferences.

\(^{16}\)Another approach for examining the timing is to use the aggregated data over a different number of years, while keeping the number of lags in the estimation as 1. See \( \text{Acemoglu et al. (2008)} \) as an example. Unfortunately, due to the short time dimension and , this approach is infeasible.
for subsidy are therefore controlled for in estimation.

The identification assumption means that subsidies are allocated as good as random after controlling for the fixed effects and other covariates. This assumption excludes the possibility of reverse causality. Because the independent variables are lagged, reverse causality means that fishers and fishery managers ask or allocate subsidies based on the expectation of the future resource. As the number of lags become larger, however, the magnitude of uncertainty becomes larger and likely dominate the effect of future expectation. Therefore, reverse causality is expected to produce minimal bias in the present context. The validity of this assumption is examined in the next section.

Results

The results are shown in Table 3. The first three rows correspond to Quota countries while the next three correspond to Non-Quota countries. As we move from left to right in the table, the lag of subsidies (k) increases from 1 to 6.

Table 3 exhibits a number of interesting features. First of all, fishery subsidies have significant effects only in Non-Quota countries. This is an indication of the heterogeneous effects of subsidies across management. In Quota countries, only Cost Reducing Transfers (CRTs) with a 4-year lag show a significant effect. CRTs with 3-year or 5-year lags, however, do not show any effects. Further, point estimates for these lags are notably different from that of the 4-year lag. Hence, this could be an artifact of the large missing observations in CRTs.

Second, in Non-Quota countries, Direct Payments (DPs) show a significant and negative association with resource stocks with 4 and 5-year lags. This seems reasonable since DPs include many effort-enhancing subsidies. DPs also include vessel buyback programs that are generally believed to be beneficial for resource conservation. As Clark et al. (2005) argues, however, these subsidies could be harmful if vessel buyback
programs are anticipated by fishers and induced investment for the fishing capacity occurs. The result is in line with their argument.

Third, Cost Reducing Transfers (CRTs) show a strong negative effect with 3 - 5 year lags. It is worth pointing out that the point estimate with a 1-year lag is positive. This seems reasonable if CRTs boost harvest in the short-term but decrease it in the long-term through resource degradation. The MFSOC index increases with the first boost in harvest, but decreases later with resource degradation.

Finally, General Services (GSs) show the opposite of CRTs. It has a significant and negative effect with a 1-year lag, but a significant and positive effect with 4 - 6 year lags. This seems reasonable if GSs are spent on the stricter enforcement of fishery management. This could reduce harvest in the short-term, but increase it in the long-term through resource recovery. The MFSOC index decreases with stricter management, but later increases with the resource recovery.

**Robustness and magnitude**

In this section, I check the robustness of the estimated impacts of fishery subsidies on resource stocks. I treat the main result with a 5-years lag as a base line. In Column 1 of Table 4, I include a 5-years lagged dependent variable as an additional control. If fishery managers decide the amount of subsidies in each period based on resource stocks in the respective period, the resource stocks in that period can be a source of omitted variable bias. The estimate is quite similar to the main result.

In column 2, I re-categorize Japan and Korea as Quota countries. These two countries do not implement IQ or ITQ management, but they do implement community-based quota management (OECD, 2006b). If communities can manage fishery well, these countries may have more effective output restrictions than the other Non-Quota countries. The result does not change qualitatively, though the point estimate for GSs
is somewhat smaller.

In column 3, I exclude Australia, France, Netherlands, the United Kingdom, and the United States from the estimation because they report “bad” harvest data for one or more EEZ (Hsu et al., 2014). As all of these countries are categorized as Quota-countries, the parameter estimates for Non-Quota countries changes little.

In column 4, I use data only up to 2006 because the method used for constructing the FSOC (and MFSOC) index is different before and after 2006 (Hsu et al., 2014). Up to 2006, the index is calculated by the SAUP. It has, however, not published the index after 2006, so the EPI calculates the index using an “ad-hoc” method. This raises a concern for the consistency of the data. Using the data up to 2006 does not change the result qualitatively.

Finally, in column 5, I use an alternative outcome variable for the estimation. The outcome variable here (MFSOC2 index) is the share of the “number” of fish stocks in an EEZ that are developing, exploited, or rebuilding. As discussed, the MFSOC index changes both at the intensive and extensive margins. This introduces some ambiguity in the interpretation of the results. The new index here, has the advantage that it changes only at the extensive margin\(^\text{17}\). Therefore, if the result using this index is similar in terms of signs, it supports the presumption that the main results capture the changes at the extensive margin. The result is quite similar in terms of signs of parameter estimates.

Results are quite similar across the columns. Overall, the point estimates for CRTs and GSs are respectively about -0.1 and 0.7 for Non-Quota countries. Assuming that prices of the marginal stocks are equal to the average price of all stocks, these point estimates suggest that an additional 1 dollar for GSs today increases the harvest of healthy stocks by 0.2 kilograms five year later, which is worth 0.40 dollar in future

\(^{17}\)A drawback is that this index is available only up to 2006.
value; and an additional 1 dollar for CRTs today decreases the harvest of healthy stocks by 0.6 kilograms five year later, which is worth 1.23 dollar in future value for an average country\textsuperscript{18}.

**Aggregate subsidies**

**Econometric model**

Estimations in the previous section presume that reverse causality is less of a concern since lagged subsidies are used. To examine the validity of this assumption, this section aggregates subsidies over three categories to create one value and uses this as the only subsidy variable in the model. With the only one endogenous variable in the model, it is possible to discuss the direction of the potential bias. In fact, reverse causality is likely to lead to an underestimate of the causal effect in this model, because fishers are expected to ask for subsidies when they face or anticipate resource decline. The sample is limited to Non-Quota countries. The equation of interest and the identification assumption are given by

\[
MFSOC_{it} = \alpha_i + \mu_t + \rho \ AGG_{it-5} + \gamma X_{it-5} + u_{it} \tag{6}
\]

\[
E[u_{it}|\alpha_i, \mu_t, AGG_{it-5}, X_{it-5}] = 0 \tag{7}
\]

where AGG is ln aggregate fishery subsidies per output value.

\textsuperscript{18}The mean value of GSs per output value is 0.17, and the mean value of GSs is 134.91 US$ million excluding Japan. This means that a 1 percent increase in GSs per output value amounts to 0.17 * 0.01 * 134.91* 1000 = 229.347 US$ thousand. A (0.7/100) point increase in the MFSOC index amounts to 770*0.83*(0.7/100)*0.01=44.737 ton, given the average output of 770 ton excluding Japan. The average price of fishery products is 2.09 US$/kg, so this amounts to 44.737*2.09=93.5 US$ thousand. Therefore, an additional 1 dollar for GSs increases the output value by 93.5/229.347=0.40 dollar. Similarly, an additional 1 dollar for CRTs decreases the output value by (770*0.83*(0.1/100)*0.01*2.09*1000)/(0.04*0.01*27.20*1000)=1.23 dollar.
To obtain further insight, an instrumental variable estimation is implemented. The instrument used is the share of seats in parliament for green parties (Lane et al., 1992). Green parties emerged in the 1970s and 1980s and their main concerns were and continued to be the environment and social justice. As fishery subsidies are generally believed to be harmful, with a larger share of green parties less fishery subsidies can be expected.\footnote{For example, policies of England and Wales green party includes “MC327; The Green Party would press at EU level for an end to all subsidies that can result in increased fishing pressure, including concessionary tax rates for fuel, vessel modification and improving port and fish processing facilities.” Note that this policy aims to reduce all of the three types of subsidies.}

To be a valid instrument, the share of green parties must not be affected by resource stocks. As fishing industries in OECD countries are extremely small, they are less likely to be the main reason for people to vote for green parties. Hence, this condition seems satisfied.\footnote{The mean ratio of output value to GDP is less than 0.01 in the sample countries.} In addition, the share of green parties must not affect resource stocks other than through fishery subsidies. This is also likely to be satisfied with the same reason: given the small size of these fishing industries, fishery policies are unlikely to be of central importance in parliament. Note, however, that if green parties affect other fishery policies to enhance resource conservation, the resulting IV estimate is an underestimate of the causal effect. The identification assumptions for the IV estimation are given by:

\[
\text{Cov}[u_{it}, Z_{it}|\alpha_{i}, \mu_{t}, S_{it-k}, X_{it}] = 0 \quad (8)
\]
\[
\text{Cov}[S_{it}, Z_{it}] \neq 0 \quad (9)
\]

where \(Z_{it}\) is the share of green parties in country \(i\) at year \(t\).
Results

The results are shown in Table 5. Column 1 shows the result using a simple OLS. The parameter estimate is positive but not significant. Considering the small sample, this is probably reasonable. Column 2 shows the result including a 5-year lagged dependent variable. The point estimate becomes 7 times larger, but it remains insignificant. The first two columns, though insignificant, suggest that the causal effect of aggregate subsidies is positive. Column 3 shows the result of the IV estimation and Column 4 shows the corresponding first stage estimation. As expected, the share of green parties is negatively correlated with the aggregate subsidies. The parameter estimate for the aggregate subsidies is now statistically significant and much larger than the OLS estimates in Column 1 and 2. Column 5 and 6 show the IV estimation including the 5-year lagged dependent variable. These results are similar to those in Column 3 and 4, though the point estimate for the aggregate subsidies becomes somewhat larger.

As discussed above, if green parties try to preserve resource stocks through other fishery policies, the IV estimates should be underestimates of the causal effect. In this regard, the results suggest that fishery subsidies are, on average, beneficial for resource stocks. Recall that, among the three categories, General Services is by far the largest both in terms of magnitude and standard deviation. Therefore, the results in this section imply that the causal effect of General Services is positive.

The magnitude of the point estimate remains to be discussed. In Table 5, the point estimate for the aggregate subsidies is three times larger than the point estimate for General Services in Table 5. However, if the effect is converted in monetary terms, the result here suggests that an additional 1 dollar in the aggregate subsidies today increases the harvest of healthy stocks by 0.19 kilograms five years later, which is worth 0.39 dollars in future value. This is only slightly smaller than the effect of General Services of 0.4 found in the previous section. Hence, the result in this section is quite
consistent with that in the previous section. More importantly, this indicates that the main results do not seriously suffer from the reverse causality problem.

**Discussion**

The previous two sections suggest that in countries with traditional input/output management, Direct Payments and Cost Reducing Transfers are harmful while General Services are beneficial for resource stocks. Since Direct Payments and Cost Reducing Transfers both reduce the cost of fishing operations, it seems reasonable to observe the negative effects of these categories. However, the beneficial effect found for General Services requires an explanation.

General Services correspond to investments in management, research, and enforcement (hereafter collectively described as management investments) and investments in infrastructure (hereafter infrastructure investments) (OECD, 2000, 2006a). These two investments are comparable in magnitude and neither type of them can be ignored when interpreting the overall beneficial effect of General Services. While management investments are generally perceived as beneficial, infrastructure investments generate more controversy (UNEP, 2004). Hence, the beneficial effect of General Services could be driven by the beneficial effect of management investments dominating the negative effect of infrastructure investments. Instead, it could also be the case that both management and infrastructure investments are beneficial for resource stocks, thus leading to the overall beneficial effect of General Services. Although the available data does not allow us to distinguish these two possibilities, it is worthwhile to explore the effect of infrastructure investments from a theoretical point of view given their controversial status.

If we focus on ports as a representative fishery infrastructure, a key insight is that
ports reduce the cost of landing for fishers, but at the same time allow governments to monitor harvests \citep{UNEP2004}. Consider a fishery that has an official port where fishers must land their harvests by law, and that has a total output restriction. There is also a private port, where fishers can land their harvests illegally. The government-funded port allows landing with a cost of $c_g$, while the private port has relatively higher costs of landing $c_p$ ($>c_g^21$). If a fisher chooses to land at the government-funded port, his harvest will be below the profit-maximizing level due to the output restriction and competition with other fishers. If instead he chooses the private port to land, he can harvest up to the profit-maximizing level but with the probability $q$ of being caught and imposed a fine. In effect, each fisher faces a trade-off between the lower landing costs and the smaller harvest.

Under these circumstances, governments can effectively protect resource stocks by investing in their port to lower the landing costs. The effect of such investment on resource stocks differs by the monitoring ability of the government. If a government has high monitoring ability (i.e., large $q$), fishers choose to land at the government-funded port in the first place to avoid fines. In this case, investments in ports to lower the landing costs do not affect resource stocks. On the other hand, if a government has low monitoring ability (i.e., small $q$), fishers choose to land at the private port because the risk of being caught is minimal. In this case, lowering the landing costs at the government-funded port will make fishers switch from the private port to the government-funded port; now it is beneficial for fishers to harvest less and land at the government-funded port where they can enjoy lower landing costs. This demonstrates a potential benefit to invest in fishery infrastructure for countries with traditional input/output management.

\footnote{Costs may include actual fees as well as the loss in value of harvests due to lower freshness or damages caused by the lack of appropriate facilities.}
Conclusion

In policy circles, the discussion on potential international discipline in regulating fishery subsidies has been active for more than a decade. In spite of this, no firm consensus has been reached. One of the reasons for this plight is the striking lack of empirical evidence about the effect of subsidies on resource stocks. The aim of this paper was to provide such evidence.

The paper has two main findings. First, fishery subsidies have little effect on stocks in countries with quota-based management. Second, subsidies do affect resource stocks in countries without such management. In these countries, Cost Reducing Transfers are harmful while management and infrastructure subsidies are beneficial for resource stocks. Direct Payments also seem harmful, but this result is not statistically robust. These results are largely consistent with the predictions of simple theory, and serve as the cleanest empirical evidence to date regarding the effect of fishery subsidies on resource stocks.

The policy implication of this paper is threefold. First, improving overall management practices should be of the highest priority in each country since subsidies result in no harm once effective monitoring and enforcement are established. Further, even in countries without quota-based management, the effect of subsidies is measurable but small. This suggests that subsidies may not be the main driver of overfishing. Rather, establishing proper management systems seem more important.

Second, countries should keep up their effort to reduce cost-reducing subsidies. Although these subsidies are generally perceived as harmful, there has been no empirical evidence supporting such a view. My results consistently indicate that such subsidies reduce resource stocks in countries without quota-based management.

Third, management and infrastructure subsidies should not be regarded as harmful, especially in countries with imperfect monitoring systems. At the Doha Round of the
WTO, a group of countries insisted on universal or near-universal prohibitions of fishery subsidies. The result of this paper, however, opposes such an idea. Subsidies used for management and infrastructure should not be reduced, and perhaps should even be increased.
References


<table>
<thead>
<tr>
<th>Type</th>
<th>Definition</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Payment</td>
<td>Payments from government to fishers and are primarily directed at increasing the income of fishers.</td>
<td>Price support, Grants for new vessels, Grants for modernization, Grants for temporary withdrawal of fishing vessels, Vessel decommissioning, Income support, Unemployment insurance</td>
</tr>
<tr>
<td>Cost Reducing Transfer</td>
<td>Payments aimed at reducing the costs of fixed capital and variable inputs.</td>
<td>Subsidized loans for vessel construction/modernization, Interest subsidies, Fuel tax exemption, Government payments of access to other countries’ water</td>
</tr>
<tr>
<td>General Service</td>
<td>Payments which are not necessarily received directly by fishers but nevertheless reduce the costs faced by fishers.</td>
<td>Management expenditure, Enforcement expenditure, Expenditure for information collection and analysis, Aid for restocking of fish resource, Support to build port facilities for commercial fisheries</td>
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<td>Variable</td>
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<td>Mean</td>
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<td>----------------------------------------------------</td>
<td>-----</td>
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<tr>
<td>MFSOC index</td>
<td>368</td>
<td>83.32</td>
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<td>Total subsidies / average revenue</td>
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<td>0.27</td>
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<tr>
<td>Direct Payments / average revenue</td>
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<td>0.05</td>
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<tr>
<td>Cost Reducing Transfers / average revenue</td>
<td>280</td>
<td>0.04</td>
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<td>General Services / average revenue</td>
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<td>0.18</td>
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<td>Import price of fish products (USD/kg)</td>
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<td>3.18</td>
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<tr>
<td>Import price of oil products (USD/kg)</td>
<td>368</td>
<td>1.43</td>
</tr>
<tr>
<td>Share of green party</td>
<td>368</td>
<td>1.59</td>
</tr>
<tr>
<td>Quota-based management</td>
<td>368</td>
<td>0.65</td>
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</table>

Notes: The sample covers the period 1996-2011, and consists of 23 OECD countries: Australia, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Korea, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Spain, Sweden, Turkey, UK, USA
Table 3: Three subsidies in both groups of countries

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<th>Lag 1</th>
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<th>Lag 4</th>
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<td>Quota:</td>
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<td>- DP</td>
<td>0.022</td>
<td>0.039</td>
<td>-0.104</td>
<td>-0.142</td>
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<td>(0.093)</td>
<td>(0.104)</td>
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<td>(0.163)</td>
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<tr>
<td>- CRT</td>
<td>0.010</td>
<td>0.031</td>
<td>0.078</td>
<td>0.272&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>(0.041)</td>
<td>(0.057)</td>
<td>(0.088)</td>
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<tr>
<td>- GS</td>
<td>0.168</td>
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<tr>
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<td>-0.251</td>
<td>-0.339&lt;sup&gt;b&lt;/sup&gt;</td>
<td>-0.408&lt;sup&gt;c&lt;/sup&gt;</td>
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<td>(0.212)</td>
<td>(0.248)</td>
<td>(0.207)</td>
<td>(0.123)</td>
<td>(0.212)</td>
<td>(0.274)</td>
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<td>- CRT</td>
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<td>-0.061&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>(0.026)</td>
<td>(0.026)</td>
<td>(0.022)</td>
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<tr>
<td>- GS</td>
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<td>-0.048</td>
<td>0.709&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.664&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.775&lt;sup&gt;a&lt;/sup&gt;</td>
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<td>(0.028)</td>
<td>(0.046)</td>
<td>(0.394)</td>
<td>(0.346)</td>
<td>(0.249)</td>
<td>(0.151)</td>
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<tr>
<td>- GS*Japan</td>
<td>0.048&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.016</td>
<td>-0.744&lt;sup&gt;c&lt;/sup&gt;</td>
<td>-0.714&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>0.061</td>
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<td>0.934</td>
<td>0.949</td>
<td>0.980</td>
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*Notes:* Standard errors are clustered at the country level. a, b, and c mean statistical significance at the 1%, 5%, and 10% levels, respectively. All the specifications include country and year fixed effects, and control variables. DP: Direct Payments, CRT: Cost Reducing Transfers, GS: General Services.
Table 4: Robustness check

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<tr>
<th>Quota:</th>
<th>MFSOC</th>
<th>MFSOC</th>
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<td>DP</td>
<td>-0.124</td>
<td>-0.158</td>
<td>0.350</td>
<td>0.033</td>
<td>-0.543</td>
</tr>
<tr>
<td>(0.152)</td>
<td></td>
<td></td>
<td>(0.202)</td>
<td>(0.149)</td>
<td>(0.565)</td>
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<tr>
<td>CRT</td>
<td>0.175c</td>
<td>0.081</td>
<td>0.194c</td>
<td>-0.064</td>
<td>0.522</td>
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<tr>
<td>(0.097)</td>
<td></td>
<td></td>
<td>(0.102)</td>
<td>(0.120)</td>
<td>(1.091)</td>
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<tr>
<td>GS</td>
<td>0.016</td>
<td>0.187</td>
<td>-0.413b</td>
<td>0.260</td>
<td>1.792b</td>
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<tr>
<td>(0.227)</td>
<td></td>
<td></td>
<td>(0.179)</td>
<td>(0.155)</td>
<td>(0.822)</td>
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<tr>
<td>Non-Quota:</td>
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<td>DP</td>
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<td>-0.398c</td>
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<td>0.689</td>
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<td>-0.102a</td>
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<td>(0.034)</td>
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<td>(0.029)</td>
<td>(0.049)</td>
<td>(0.180)</td>
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<td>(0.270)</td>
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<td>(0.262)</td>
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<td></td>
<td>(0.266)</td>
<td>(0.971)</td>
<td>(5.022)</td>
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</table>

| N                       | 177   | 177   | 143   | 93    | 93     |
| Countries               | 23    | 23    | 18    | 20    | 20     |
| R2                      | 0.048 | 0.029 | 0.073 | 0.003 | 0.019  |
| RMSE                    | 0.940 | 0.973 | 0.966 | 0.969 | 4.427  |

Notes: Standard errors are clustered at the country level. a, b, and c mean statistical significance at the 1%, 5%, and 10% levels, respectively. All the specifications include country and year fixed effects, and control variables. Subsidy variables are lagged by 5 years. DP: Direct Payments, CRT: Cost Reducing Transfers, GS: General Services. MFSOC2 stands for the share of the “number” of fish stocks in an EEZ that are developing, exploited or rebuilding.
Table 5: Aggregate subsidy in Non-Quota countries

<table>
<thead>
<tr>
<th></th>
<th>MFSOC</th>
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<th>Subsidy</th>
<th>MFSOC</th>
<th>Subsidy</th>
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<tr>
<td>Agg Subsidy</td>
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<td>0.074</td>
<td>2.368</td>
<td>2.647</td>
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<td></td>
<td>(0.151)</td>
<td>(0.206)</td>
<td>(0.682)</td>
<td>(0.779)</td>
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<td>(0.112)</td>
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<td>NO</td>
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<tr>
<td>R2</td>
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<td>0.152</td>
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<td>0.056</td>
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<td>0.029</td>
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<td>11.237</td>
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</table>

Notes: Standard errors are clustered at the country level. a, b, and c mean statistical significant at the 1%, 5%, and 10% levels, respectively. All the specifications include country and year fixed effects, and control variables. LagDep: Lagged dependent variable, Fstat: First stage F statistics.