



**HAL**  
open science

## Productivity Development in Icelandic, Norwegian, and Swedish Fisheries

Håkan Eggert, Ragnar Tveteras

► **To cite this version:**

Håkan Eggert, Ragnar Tveteras. Productivity Development in Icelandic, Norwegian, and Swedish Fisheries. Applied Economics, 2011, 45 (06), pp.709-720. <10.1080/00036846.2011.610751>. <hal-00741506>

**HAL Id: hal-00741506**

**<https://hal.science/hal-00741506v1>**

Submitted on 13 Oct 2012

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



HAL Authorization



## Productivity Development in Icelandic, Norwegian, and Swedish Fisheries

Journal:	<i>Applied Economics</i>
Manuscript ID:	APE-2010-0198.R1
Journal Selection:	Applied Economics
Date Submitted by the Author:	08-Mar-2011
Complete List of Authors:	Eggert, Håkan; University of Gothenburg, Economics Tveteras, Ragnar; University of Stavanger, Business School
JEL Code:	D24 - Production Capital and Total Factor Productivity Capacity < D2 - Production and Organizations < D - Microeconomics, O47 - Measurement of Economic Growth Aggregate Productivity < O4 - Economic Growth and Aggregate Productivity < O - Economic Development, Technological Change, and Growth, Q22 - Fishery < Q2 - Renewable Resources and Conservation Environmental Management < Q - Agricultural and Natural Resource Economics
Keywords:	convergence, fisheries, growth accounting, natural resources, total factor productivity

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

SCHOLARONE™  
Manuscripts

For Peer Review

1  
2  
3 **Acknowledgement** Thanks to Bengt Sjöstrand, Institute of Marine Research,  
4  
5 Sweden, for help with stocks and landings. Advice on Icelandic data from  
6  
7 Sveinn Agnarsson, University of Iceland, is gratefully acknowledged. Financial  
8  
9 support from The Nordic Working Group on Fishery Research, The Adlerbert  
10  
11 Research Foundation, and support from Sida to the Environmental Economics  
12  
13 Unit at University of Gothenburg is acknowledged.  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

For Peer Review

## Productivity Development in Icelandic, Norwegian, and Swedish Fisheries

### Abstract

This paper analyzes the total factor productivity (TFP) performance of fisheries in Iceland, Norway, and Sweden during the period 1973-2003. We measure TFP growth using real gross value added as output and capital input, labour input and a stock input index based on the major fish stocks. In developed neighbouring countries, we expect rapid diffusion of fishing technology innovations contributing to productivity convergence. In addition, innovations in the public regulation and the industrial organization may also have influenced productivity growth during the period. We find that Iceland has had the highest annual TFP growth. Accounting for stock changes it amounts to 3 percent, while the corresponding figures for Sweden and Norway are 2.8 and 0.8 percent, respectively. Despite best-practice fishing technologies being widely available, we find no evidence of productivity convergence among the three countries.

Keywords: fisheries, growth accounting, natural resources, total factor productivity.

JEL codes: D24, O47, Q22.

## Introduction

Measures of productivity and technical change give important information about the performance of an industry. In fisheries, where regulation often is of the open-access or regulated open-access type, technical change or productivity growth may have ambiguous effects like speeding up of the dissipation of resource rent and depletion of already overexploited stocks (Smith and Krutilla, 1982). Still, accurate indices of development in a fishery can assist fisheries managers. Evaluation of changes in fisheries requires long time series since many important fish species are long lived and the stochastic element of changes in environmental conditions is substantial, which can have a significant effect on productivity performance in a short-term perspective.

In this paper, we measure the long-term productivity development for the fisheries in Iceland, Norway, and Sweden during the period 1973-2003. Measuring productivity of nations' fisheries is basically similar to the approach for any other industry. The use of capital, labor, and intermediate inputs, how it is organized, and how technological innovations are adopted, all in relation to output, determine the development. However, fisheries provide an additional feature. Fish stocks are important for capture fisheries<sup>1</sup> and excluding those would lead to biased estimates (Squires, 1992).

Squires (1992) developed a method to estimate total factor productivity (TFP) where stock changes are included, which Jin et al. (2002) used in a long-term study of the New England ground fish fishery employing vessel specific data finding an annual TFP growth of 4.4%. Arnason (2003) combined national account data with

---

<sup>1</sup> Capture fisheries in this article refer to commercial catching of fish living and growing in the sea without any control of the growth stages of the species (in aquaculture all stages are controlled but in between cases exist, but are not relevant for our study).

1  
2  
3 fish stock measures in order to examine long-term productivity development in the  
4  
5 Icelandic fisheries, estimating an annual TFP growth of 3.5% during 1974-1995.  
6  
7 Recently, Hannesson (2007a) used an industry-wide approach to study TFP  
8  
9 development in Norway over a long period of time, accounting for fish stock inputs,  
10  
11 and arrived at estimates of annual TFP growth of 1.7-4.3% during 1961-2004.  
12  
13  
14

15 This study is to our knowledge the first to explore potential differences in the  
16  
17 productivity development of fisheries in several countries. An additional objective is  
18  
19 to assess the general economic issue of convergence or divergence (Bernard and  
20  
21 Jones, 1996b), i.e. whether differences in fisheries productivity between countries  
22  
23 tend to diminish or increase over time. The effects of stock input and of the quality of  
24  
25 landed fish on productivity are analyzed. We use a national account data approach  
26  
27 like Arnason (2003) measuring output as real gross value added combined with the  
28  
29 methodology developed by Squires (1992) and Hannesson (2007a). We find positive  
30  
31 average annual productivity growth in all countries in the interval 0.8-3.0%. Iceland  
32  
33 had the highest productivity growth while Norway experienced the lowest growth.  
34  
35 We explicitly test for productivity convergence among the three countries over time,  
36  
37 which is rejected for all reasonable levels of significance.  
38  
39  
40  
41  
42  
43  
44  
45

## 46 **Background**

47  
48 While the three studied countries do differ in several respects concerning their  
49  
50 economies, they also hold a lot in common. For instance, UNDP's Human  
51  
52 Development Index, which weighs GDP per capita together with aspects such as life  
53  
54 expectancy, literacy, and educational level, ranks Norway, Iceland, and Sweden first,  
55  
56 second, and fifth in the world, respectively (UNDP, 2007). The importance of the  
57  
58 fisheries sector for GDP and employment differs widely among the three countries.  
59  
60

1  
2  
3 In 2003, fisheries directly contributed 7% of the total Icelandic GDP. However, if we  
4 consider the multiplier effects on the service and manufacturing sectors it contributes  
5 a larger share directly and indirectly. The corresponding figures for Norway and  
6 Sweden were 0.7% and 0.04%, respectively (FAO, 2009). In some regions in  
7 Norway, with a total population similar to Iceland's, the direct and indirect  
8 contributions of fisheries to GDP total well above 10%. In Iceland the performance  
9 of the fisheries sector is regarded as critical for the economy as a whole, while in  
10 Norway the sector's performance is seen as critical only for some regions. In terms  
11 of the Swedish economy it is hard to argue that the sector is of critical importance at  
12 either level, nationally or regionally.

13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
Some of the research on convergence across countries has focused on labor  
productivity (Bernard and Jones, 1996a). In the Nordic countries' fisheries sectors  
there are differences in labor productivity, here defined as value added per worker.  
Figure 1 shows the percentage difference in average value added per worker between  
fisheries and the total economy. It shows clearly that there is a dramatic gap in  
fisheries' relative labor productivity between Iceland on one hand, and Norway and  
Sweden on the other.<sup>2</sup> Icelandic fishers' productivity is significantly above the  
national overall average in most years. Norwegian and Swedish fisheries, on the  
other hand, are substantially below the average values in their respective economies.

### Productivity Growth Measurement Methodology

---

<sup>2</sup> These differences can only partly be explained by differences among the countries in terms of labor productivity in the general economy, where Norway has higher and Sweden lower labor productivity than Iceland. A higher capital-labor ratio in Iceland than in both Norway and Sweden can also explain the differences to some extent.

The starting point for measuring technical change and productivity changes is the seminal contribution by Solow (1957) where labour and capital were used in an aggregate production function to detect technical change over time. A general form of the production function for a sector which can be used as a basis for productivity analysis is (Jorgenson et al., 1987)

$$(1) \quad Y_t = f(K_t, L_t, E_t, M_t, t),$$

where  $Y$  is physical output quantity,  $f()$  is the production function,  $K$  is capital input quantity,  $L$  is labour input quantity,  $E$  is energy input quantity,  $M$  is materials input quantity, and  $t$  represents the state of technology (time). This production function is often called a *KLEM* production function due to the four included inputs. The standard approach is to assume that the technology has constant returns to scale, which implies that input elasticities sum to unity (i.e. the production function is homogeneous of degree one in inputs), and that technical change improves marginal productivity of all inputs equally, shifting the production function by the same proportion at all combinations of inputs; i.e., it is Hick's neutral (Bernard and Jones, 1996a).<sup>3</sup> Total factor productivity growth can, under the assumption of competitive markets, be represented as

$$(2) \quad d \ln A = d \ln Y - \alpha_K d \ln K - \alpha_L d \ln L - \alpha_E d \ln E - \alpha_M d \ln M ,$$

---

<sup>3</sup> More general functional forms like the translog or a CES production function would call for more details in the data. To study productivity differences using the CES production function requires that the elasticity of substitution between factors can vary across countries and perhaps even over time and using the translog would ask for a test whether coefficients on labor and capital are equal across countries (Bernard and Jones, 1996a). The same applies for a Harrod neutral instead of a Hicks neutral productivity measure and due to data limitations we use the outlined standard approach (for an extensive discussion, see also Hulten, 2000). An area for future research could be to explore non-neutral technical change, which often has been documented in production frontier studies (e.g. Battese and Broca, 1997).

1  
2  
3  
4  
5  
6 where the  $\alpha$ 's are the cost shares of inputs.  
7

8 The production technology can also be represented in gross value added form  
9  
10 as (Jorgenson et al., 1987, pp. 49-51):  
11  
12

$$13 \quad (3) \quad VA_t = g(K_t, L_t, t),$$

14  
15  
16  
17  
18  
19

20 where  $VA$  is gross value added (i.e. gross output value minus the intermediate inputs  
21 energy and materials) and  $g()$  is the value added function. The existence of the value  
22 added aggregate requires that time and labor and capital inputs are separable from the  
23 intermediate inputs energy and materials.  
24  
25  
26  
27  
28

29 Total factor productivity growth in terms of the value added function can be  
30 represented as  
31  
32  
33

$$34 \quad (4) \quad d \ln A = d \ln VA - \alpha_K d \ln K - \alpha_L d \ln L,$$

35  
36  
37  
38  
39  
40  
41

42 where  $\alpha_K$  and  $\alpha_L$  are the average value added shares of capital and labour,  
43 respectively.  
44  
45  
46  
47  
48

#### 49 *Productivity growth measurement in a fishery*

50  
51  
52

53 The output of a fishery also depends on the state of the fish stocks that are exploited.  
54 Fish stocks can be treated as inputs in the production process. Squires (1992)  
55 developed a procedure to account for changes in stocks when measuring multifactor  
56 productivity in fisheries. Hannesson (2007a) developed this approach further inter  
57  
58  
59  
60

alia to take into account that output elasticities with respect to demersal and pelagic stocks are different.

The relationship between fishing output and controlled and stock inputs can be specified as (Hannesson, 1983)

$$(5) \quad Y_{it} = F(K_{it}, L_{it}, t) S_{it}^{\alpha_i},$$

where  $Y_{it}$  is output (harvest) of species  $i$  in period  $t$ ,  $S_{it}$  is the stock of species  $i$  in period  $t$ ,  $\alpha_i$  is the elasticity of output with respect to stock input and assumed separability of stock and the other factors of production. Expression (5) implies that

$$(6) \quad \frac{\partial Y_{it}}{\partial S_{it}} \frac{dS_{it}}{dt} = \alpha_i Y_{it} \frac{d \ln S_{it}}{dt}.$$

Using this expression, the Tornqvist approximation of total factor productivity change in discrete time is given by

$$(7) \quad \frac{d \ln TFP}{dt} = \sum_i 0.5(s_{it} + s_{i,t-1})(\ln Y_{it} - \ln Y_{i,t-1}) - 0.5(c_{Kt} + c_{K,t-1})(\ln K_t - \ln K_{t-1}) \\ - 0.5(c_{Lt} + c_{L,t-1})(\ln L_t - \ln L_{t-1}) - \sum_i 0.5\alpha_i(s_{it} + s_{i,t-1})(\ln S_{it} - \ln S_{i,t-1}),$$

where  $s_i$  is the revenue share of species  $i$ , and  $c_K$  and  $c_L$  are cost shares of capital and labor, respectively.

Intermediate inputs like fuel, services, and materials represent an additional measurement issue as it is difficult to get such data. Arnason (2003) suggests measuring output change as change in gross value added, meaning that intermediate

inputs are netted out from output, and are excluded among inputs.<sup>4</sup> Then, a value added-based Tornqvist measure of productivity growth can be expressed as

(8)

$$\frac{d \ln VTFP}{dt} = \ln VA_t - \ln VA_{t-1} - 0.5 \sum (c_{Kt} + c_{K,t-1}) (\ln K_t - \ln K_{t-1}) - 0.5 (c_{Lt} + c_{L,t-1}) (\ln L_t - \ln L_{t-1}) - \sum_i 0.5 \alpha_i (s_{it} + s_{i,t-1}) (\ln S_{it} - \ln S_{i,t-1})$$

The total factor productivity level of the fishing fleet in country  $c$  can be assumed to evolve over time according to (Bernard and Jones, 1996):

$$(9) \quad \ln VTFP_{c,t} = \gamma_c + \lambda \ln VT\hat{F}P_{c,t-1} + \ln VTFP_{c,t-1} + \varepsilon_{c,t},$$

where  $\gamma_c$  is the asymptotic rate of growth of country  $c$ ,  $\lambda$  is the catch-up speed parameter, and  $\varepsilon_{c,t}$  is a country-specific stochastic productivity shock. The catch-up variable  $\ln VT\hat{F}P_{c,t}$  is the log of the productivity ratio between country  $c$  and country 1 in time period  $t$ , the most productive country (in our case Iceland), i.e.

$$VT\hat{F}P_{c,t} = VTFP_{1,t} / VTFP_{c,t}.$$

In this formulation productivity gaps between countries are a function of the lagged productivity gap. We then obtain the following equation for the time path of the TFP ratio:

$$(10) \quad \ln VT\hat{F}P_{c,t} = (\gamma_1 - \gamma_c) + (1 - \lambda) \ln VT\hat{F}P_{c,t-1} + \hat{\varepsilon}_{c,t}.$$

<sup>4</sup> Both the Tornqvist based TFP and the gross value added approach entail potential biases if intermediate inputs are not constant in share of inputs and outputs. Given our crude measures of labor and capital, which do not adjust for any change in intermediate input use, we prefer the gross value approach as it adjusts for changing intermediate input share of the output value.

1  
2  
3  
4  
5  
6 where  $\ln \widehat{TFP}_{c,t} = \ln VTFP_{1,t} - \ln VTFP_{c,t}$ . Our test of productivity convergence will  
7  
8 be based on this equation. A value  $\lambda > 0$  provide an impetus for catch-up in the sense  
9  
10 that productivity differentials between the two countries increase the growth rate of  
11  
12 the country with lower productivity. But only if  $\lambda > 0$  and  $\gamma_c = \gamma_1$ , i.e. the asymptotic  
13  
14 TFP growth rates are the same, will countries converge (Bernard and Durlauf, 1995).  
15  
16 The null hypothesis is  $H_0: \lambda = 0$  and  $\gamma_c \neq \gamma_1$ . In other words, we test the null  
17  
18 hypothesis of no convergence, which is defined to mean that the deviation in  
19  
20 productivity from the productivity leader is a nonstationary process with nonzero  
21  
22 drift.  
23  
24  
25  
26  
27  
28  
29

### 30 **Data issues**

31  
32  
33  
34 The data required according to equation (8) to undertake a TFP analysis is gross  
35  
36 value added, labour input and costs, capital input and costs, and fish stock quantities.  
37  
38 Our aim, to undertake a comparative analysis of the fisheries in the three countries  
39  
40 poses additional challenges, as collected data for each country must be compatible  
41  
42 with data for the other countries.  
43  
44  
45

46  
47 In this study we deflate nominal value added in domestic currency units with  
48  
49 the domestic consumer price index. We avoid using the procedure of first using the  
50  
51 exchange rate or purchasing power parity index in each year to convert into a  
52  
53 common currency of a numeraire country, and then deflate using a price index of the  
54  
55 numeraire country. The reason is that there have been exchange rate regimes in these  
56  
57 three countries that probably have created substantial exchange rate distortions  
58  
59 during the data period. This choice is also motivated by studies that find ample  
60

1  
2  
3 empirical evidence that exchange rates do not vary in a way that reflect differences in  
4 price levels across countries (Rogoff, 1996; Pardey, Roseboom and Craig, 1992).  
5  
6  
7

8 Labour input is approximated by the total number of active fishers in each  
9 country, where at least the initial years include a substantial minority of part-time  
10 fishers in Norway and Sweden. Concerning physical capital, particularly the Swedish  
11 data turned out to be problematic, which led to the measure of capital input as gross  
12 registered tons (GRT) of the total fleet. We assume that the renewal of the fleet  
13 followed similar patterns in the three countries and since new technologies are  
14 generally available on the international market this approach should not affect the  
15 comparisons between countries. Both labor and capital are measured as stocks and  
16 ideally we would have figures on intensity use for those over the years in the three  
17 countries, but such figures are not available. Hence, our use of stocks as measures of  
18 flows implicitly assume that intensity use of both capital and labor have been  
19 constant in each country over the years.  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35

36 Finally, we use fish stock data reported by the ICES working groups and  
37 compiled in collaboration with a former ICES fisheries biologist. Stock assessment is  
38 not an exact science and errors may lead to bias in productivity estimates. Another  
39 concern is that figures from ICES working groups often rely to some extent or even  
40 completely on commercial catches (Beare et al, 2005), which also may lead to bias.  
41 Still, ICES working groups represent state of the art and are to our knowledge the  
42 only provider of systematic stock assessment of all important species over a long  
43 time period. We use data on six species for Sweden and ten species for Iceland and  
44 Norway, which in catch value correspond to roughly 80% of each country's total  
45 landed value (see also Appendix A). The aggregate stock indices were constructed by  
46 giving each stock a weight corresponding to its share of each country's landed value.  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

1  
2  
3 The fisheries sectors in the three countries target similar species to a large extent, and  
4  
5 in some cases partly the same stocks. Cod and herring are the two most important  
6  
7 species, which represent two groups of fish demersal and pelagic species that differ  
8  
9 in terms of the “stock effect”. Bottom feeding, i.e. demersal species are often  
10  
11 assumed to have a maximum stock effect implying uniform distribution and catches  
12  
13 proportionate to stock size, following the classical Schaefer production function  
14  
15 (1957). Pelagic species like herring, mackerel, and capelin live higher up in the water  
16  
17 column and have a different distribution pattern. Despite its importance there are few  
18  
19 empirical studies of the stock effect, but existing ones indicate a significant stock  
20  
21 effect for demersal species like cod, haddock and saithe (Hannesson, 1983;  
22  
23 Hannesson, 2007b; Sandberg, 2006) while the stock effect for herring is very weak  
24  
25 (Bjørndal, 1987; Sandberg, 2006). Hence, explicitly accounting for this implies that  
26  
27 stock changes in pelagic species may have only a limited effect on productivity. This  
28  
29 is the rationale for employing output elasticities with respect to the pelagic species  
30  
31 stock index equal to 0.1 and the corresponding measure for demersal species equal to  
32  
33 1 in this paper and in Hannesson (2007a).  
34  
35  
36  
37  
38  
39  
40  
41  
42

### 43 **Empirical results**

44  
45  
46  
47  
48 In this section we analyze the development of output, inputs, prices, TFP growth, and  
49  
50 ultimately whether there has been convergence in productivity when comparing our  
51  
52 three Nordic countries. Figure 2 reports the value of landings during 1973-2003 in a  
53  
54 common currency, Norwegian kroner. Each country’s landed value is deflated by  
55  
56 national consumer price indices, which provide us with time series on the relation  
57  
58  
59  
60

1  
2  
3 between inputs and outputs for each country. We then converted to Norwegian  
4 kroner using the 2003 exchange rates.  
5  
6

7  
8 More than 60% of the total Swedish landed value came from pelagic species  
9 at the beginning of the studied period, while the corresponding figure was fully 40%  
10 at the end of the period. In the 1960s, pelagic catches were dominated by herring  
11 primarily sold for human consumption, while pelagic catches since the 1970s have  
12 been gradually more and more sold for reduction, implying a substantial drop in real  
13 price paid per kilogram. Norway had a fairly stable mix: almost 60% of the landed  
14 values came from demersal species both at the beginning and at the end of the  
15 period. This led to an increase in real landed value thanks to substantial increases in  
16 prices paid for demersal species like cod, haddock, saithe, redfish, and Greenland  
17 halibut.  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30

31  
32 Figure 3 shows the development of the real catch value per kilo in NOK from  
33 1973 to 2003, with the logarithmic trend for each country. Iceland and Norway  
34 experienced a roughly similar increase in average unit price according to the trend  
35 lines, while Sweden experienced a dramatic decline, with real unit prices in the later  
36 years that were roughly 50% of that in the early years. Iceland had a composition of  
37 60% demersal species in the early 1970s, while the value share from demersal  
38 species increased to about 70% at the end of the period. The increasing and  
39 dominating share of demersal species, which all increased substantially in real price,  
40 is a central explanation to the tremendous growth in real value of landings for  
41 Iceland during the period 1973-2003.  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54

55  
56 The explanation behind the increase in the average unit price cannot only be  
57 explained by changes in species composition. Table 1 presents the development of  
58 the cod real price index during the period; showing that Iceland's real price  
59  
60

1  
2  
3 development was better than Norway's and similar to Sweden's. When examining all  
4 relevant species we found that Iceland generally experienced a similar or better real  
5 price development than the two other countries over the period. Since the different  
6 species to a large extent are sold in integrated international markets, primarily the  
7 European market, this suggests that Iceland has been able to increase the quality of  
8 its product more than the other two countries.  
9

10  
11  
12  
13  
14  
15  
16  
17 Recent studies report that an initial effect of the introduction of ITQs was  
18 increased revenues thanks to increased quality (Fox et al., 2003; Dupont et al., 2005;  
19 Homans and Wilen, 2005). This could gain some support from the Icelandic data.  
20 However, real prices of Icelandic landings started to increase already in the late  
21 1960s, probably largely due to transportation technology innovations and reduced  
22 transportation costs, which resulted in better access to the large fish import markets  
23 in continental Europe and the UK and hence increased revenues from fish export. For  
24 example, transportation technology improvements have led to a shift from frozen cod  
25 to more higher valued fresh cod in the UK market.  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37

38  
39 Mundlak (2005) analyzes long-run trends in the US agricultural sector and  
40 points out that occupational migration from one sector to another is driven by the gap  
41 in income between sectors. Given the increase in real wages in other sectors of the  
42 economy and the real landed value decline, we would expect a substantial reduction  
43 in the number of Swedish fishers. This is also confirmed by Table 1, where we see a  
44 reduction in Swedish fishers from 1973 to 2003 by almost 70%.<sup>5</sup> Similarly, there was  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56

---

57  
58 <sup>5</sup> During the 1990s, Swedish fishermen had income substantially lower than unskilled labor in the  
59 manufacturing sector (Stigberg, 1997; Eggert and Ulmestrand, 1999), while Icelandic fishermen were  
60 highly paid (Danielsson, 1997). Norwegian fishermen on average had wages at par with wages in  
other sectors (Hannesson, 2007a), but wages vary substantially between groups of fishermen.  
Hannesson (1985) found that small scale fishermen in the North and the West of Norway earned  
substantially lower wages than those in large scale trawl and purse seine fisheries.

1  
2  
3 more than a 50% reduction in Norway, while the number of Icelandic fishers actually  
4  
5 increased by 7%.  
6  
7

8 In Table 1 we report the development of GRT for each country's fishing fleet.  
9  
10 Iceland increased its fleet size by 60%, while Sweden had a small increase of 20%  
11  
12 and Norway experienced a fleet reduction of 20%. As noted earlier, GRT is not an  
13  
14 ideal measure of physical capital. Hannesson (2007a) used real capital investment  
15  
16 figures from Statistics Norway and found an increase in capital for Norway of about  
17  
18 20% for the period 1973-2003, while our GRT measure indicates a 20% reduction.  
19  
20 Arnason (2003) used total real value of fleet and found an increase of Icelandic  
21  
22 capital of about 70% from 1974 to 1995, while our GRT measure indicates a 23%  
23  
24 increase over the same period. Hence, in comparison with the previous studies, we  
25  
26 would expect a slight upward bias in productivity growth using GRT figures.  
27  
28  
29  
30  
31

32 Next, we introduce fish stock input into the productivity analysis. The  
33  
34 development in the fish stock index from 1973 is shown in table 1. For all three  
35  
36 countries we see that the trend growth for the fish stock index is negative. One  
37  
38 noteworthy feature of the fish stock index for all three countries is the substantial  
39  
40 volatility over time, a volatility which is much higher than for the 'controllable'  
41  
42 inputs labour and capital. For Iceland fish stock input declined by around 45% from  
43  
44 1973 to 2003, for Norway the decline was 25%, and for Sweden 60%. If we separate  
45  
46 between demersal and pelagic stocks, we find that demersal stocks have been slightly  
47  
48 reduced in all countries. Pelagic stocks are a bit larger in Iceland and Sweden, but  
49  
50 smaller in Norway  
51  
52  
53  
54

55 Figure 4 shows labor productivity measured by real landed value added per  
56  
57 fisher in the three countries in NOK. Despite the fact that Norway and Sweden  
58  
59 experienced a massive labor migration out of the fishing sector, there are still fishers  
60

1  
2  
3 in Sweden and most likely Norway who earn substantially less than the respective  
4 country average for unskilled labor. The development is different in Iceland. Due to  
5 increasing real revenues, the earnings of Icelandic fishers are high enough to attract  
6 labor to the industry. Similarly, capital is to a larger extent attracted to fisheries in  
7 Iceland than in Norway and Sweden. Only to some extent can the difference in value  
8 added be explained by a higher capital-labor ratio in Iceland than in the other two  
9 countries.  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19

20 We now turn to the measurement of total factor productivity growth. Table 2  
21 shows TFP growth rates and their components for the period 1974-2003. Overall,  
22 average TFP growth for the entire time period is found to be positive for all three  
23 countries. Iceland has the highest TFP growth with 3.0% annual average growth  
24 followed by Norway with 2.8% and then Sweden with 0.8%.<sup>6</sup>  
25  
26  
27  
28  
29  
30  
31

32 In figure 5 we show the annual VTFFP changes for the three countries. We  
33 note the high volatility with large swings from substantial negative to substantial  
34 positive productivity changes which is similar to what have been found in previous  
35 studies (Hannesson, 2007a; Jin et al., 2002; Squires, 1992). Figure 6 translates the  
36 annual VTFFP growth rates into a cumulative index which is normalized by the  
37 average for the data period 1973-2003. This index should not be interpreted as the  
38 VTFFP3 absolute level. Iceland started the period with a higher total factor  
39 productivity than Norway and Sweden, and the figure indicates that the two countries  
40 were not able to catch up with the productivity leader Iceland.  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52

53 We test formally for convergence using the augmented Dickey-Fuller (ADF)  
54 test. Our test is based on the first-difference transformation of equation (10). Table 3  
55 presents ADF test statistics of convergence between the productivity leader Iceland  
56  
57  
58  
59  
60

---

<sup>6</sup> When we exclude fish stock input, annual total factor productivity growth rates are 1.6%, 0.9%, and 0.3% for Iceland, Norway, and Sweden, respectively. See Appendix B for more information on this.

1  
2  
3 and the two other countries. Overall, we do not find support for convergence. For  
4  
5 both Norway and Sweden, the augmented Dickey-Fuller test statistic does not reject  
6  
7 the null hypothesis of nonstationarity.  
8  
9

10 Best-practice fishing technologies are available on the international market.  
11  
12 State-of-the-art fishing equipment has over time increasingly been manufactured and  
13  
14 sold by companies to fishers in many countries. This would likely contribute to  
15  
16 convergence in productivity over time. Permanent differences in biophysical  
17  
18 characteristics that determine the abundance and other characteristics of fish stocks  
19  
20 could potentially limit the degree of convergence in case of a traditionally regulated  
21  
22 open access fishery. In a rights-based fishery we would expect differences in  
23  
24 biophysical characteristics to be reflected by the price development for the catch  
25  
26 rights and per se not preventing convergence. Finally, various approaches in  
27  
28 government regulations over time may prevent convergence in TFP. If we divide the  
29  
30 period into two periods, splitting by the year 1990 when Iceland started its full scale  
31  
32 ITQ regime and Norway had introduced several IVQ regulations, we find that  
33  
34 Norway after 1990 had the highest productivity growth, closely followed by Iceland  
35  
36 while Sweden had a more modest productivity growth. However, given the  
37  
38 previously noted high volatility between years, figures for a shorter time period are  
39  
40 more uncertain than those based on the whole period.  
41  
42  
43  
44  
45  
46  
47  
48  
49

### 50 **Concluding Remarks**

51  
52  
53  
54

55 This is as far as we know the first comparative study of total factor productivity  
56  
57 development in fisheries involving several countries. We use comparable data for  
58  
59 Iceland, Norway, and Sweden and analyze their 1973-2003 productivity development  
60

1  
2  
3 on an aggregate level. The accomplishment of making the data on the three countries  
4 compatible came at the expense of some loss in accuracy of measuring the inputs.  
5  
6 We do not have information on capacity utilization and cannot adjust for this  
7  
8 potential source of bias as in Jin et al. (2002). We calculated TFP growth based on  
9  
10 output measured by value added, labor and capital use, and with fish stock input  
11  
12 included. Including fish stocks, we found average annual total factor productivity  
13  
14 growth rates of 3.0, 0.8, and 2.8% for Iceland, Norway, and Sweden, respectively.  
15  
16 Several recent studies also indicate that there is scope for further productivity  
17  
18 increases in these countries (Nøstbakken, 2006; Eggert and Tveterås, 2007; Asche et  
19  
20 al, 2009).

21  
22  
23  
24  
25  
26  
27 During the initial years of our study Iceland had a substantially higher  
28  
29 level of productivity in terms of value added per worker adjusting for capital input.  
30  
31 We found that the null hypothesis of no convergence against the productivity leader  
32  
33 Iceland was supported for both Sweden and Norway. During the thirty year period  
34  
35 1973-2003, Iceland went from an open-access to a completely implemented ITQ  
36  
37 fishery, while Sweden relied on a traditional regulated open-access management  
38  
39 (Homans and Wilen, 1997).<sup>7</sup> Norwegian fisheries management has gradually  
40  
41 developed towards more rights-based fishing approaches, but the extent of individual  
42  
43 quotas is less than in Iceland and the transferability is more restricted as well. If  
44  
45 management regimes influence productivity growth we would expect highest growth  
46  
47 in Iceland and lowest in Sweden, which is supported by our results for the period  
48  
49 1990-2003. If we look at the period after 1990 when the ITQ system really came into  
50  
51 effect in Iceland growth slowed down in Iceland. Arnason et al (2004) studied cod  
52  
53 fisheries efficiency in Denmark, Norway and Iceland focusing on harvest rates and  
54  
55  
56  
57  
58  
59  
60

---

<sup>7</sup> Sweden introduced ITQs for its pelagic fleet in 2009.

1  
2  
3 biomass levels. They did not find differential effects of the different management  
4 systems in the three countries up to year 2000 and hypothesized that the impact of  
5 the ITQ system was yet to emerge. We also found an Icelandic fish stock decline  
6 from 1973 to 2003. If there are forces at work to increase stock levels in Iceland,  
7 they are certainly slow and have met substantial institutional obstacles so far.  
8  
9  
10  
11  
12  
13  
14  
15  
16

## 17 **References**

- 18  
19  
20 Acemoglu, D. and Zilibotti, F. 2001. Productivity Differences. *Quarterly Journal of*  
21 *Economics* 116(2): 563-606.  
22  
23  
24 Arnason, R. 2003. On Productivity and Productivity Growth in the Icelandic  
25 Fisheries. In Gudmundsson and Valtysson Eds. *Competitiveness within the*  
26 *Global Fisheries*. Proceedings of a conference held in Akureyri, Iceland, April  
27 6-7, 2000. University of Akureyri.  
28  
29  
30  
31  
32  
33 Arnason, R., L.K. Sandal, S.I. Steinshamn, and N. Vestergaard. 2004. Optimal  
34 Feedback Controls: Comparative evaluation of the cod fisherik  
35 es in Denmark, Iceland, and Norway. *Amer. J. Agr. Econ.* 86(2): 531–542.  
36  
37  
38  
39  
40 Battese, G.E. and S.S. Brocca. 1997. Functional forms of stochastic frontier  
41 production functions and model for technical inefficiency effects: a  
42 comparative study for wheat farmers in Pakistan. *Journal of Productivity*  
43 *Analysis* 8: 395–414.  
44  
45  
46  
47  
48  
49  
50 Beare, D.J., C.L. Needle, F. Burns and D. G. Reid. 2005. Using survey data  
51 independently from commercial data in stock assessment an example using  
52 haddock in ICES Division Via. *ICES Journal of Marine Science* 62: 996-1005.  
53  
54  
55  
56  
57  
58  
59  
60

- 1  
2  
3 Bernard, A.B., and C.I. Jones. 1996a. Comparing Apples to Oranges: Productivity  
4  
5 Convergence and Measurement Across Industries and Countries. *American*  
6  
7 *Economic Review* 86: 1216-1238.  
8  
9
- 10 Bernard, A.B., and C.I. Jones. 1996b. Productivity Across Industries and Countries:  
11  
12 Time Series Theory and Evidence. *The Review of Economics and Statistics* 78:  
13  
14 135-146.  
15  
16
- 17 Bernard, A.B., and S.N. Durlauf. 1995. Convergence in International Output. *Journal*  
18  
19 *of Applied Econometrics* 10: 97-108.  
20  
21
- 22 Bjørndal, T. 1987. Production Economics and Optimal Stock Size in a North Atlantic  
23  
24 Fishery. *Scandinavian Journal of Economics* 89: 145-164.  
25  
26
- 27 Danielsson, A. 1997. Fisheries management in Iceland. *Ocean and Coastal*  
28  
29 *Management* 35(2-3): 121-135.  
30  
31
- 32 Dupont, D.P., K.J. Fox, D.V. Gordon, and R.Q. Grafton 2005. Profit and price  
33  
34 effects of multi-species individual transferable quotas. *Journal of Agricultural*  
35  
36 *Economics* 56(1): 31-57.  
37  
38
- 39 Eggert, H. and M. Ulmestrand. 1999. A Bioeconomic Analysis of the Swedish  
40  
41 Fishery for Norway lobster (*Nephrops norvegicus*). *Marine Resource Economics*  
42  
43 14:225-244  
44  
45
- 46 Eggert, H. and R. Tveterås. 2007. Potential Rent and Overcapacity in the Swedish  
47  
48 Baltic Sea Trawl Fishery. *ICES Journal of Marine Science* 64(3): 439-445  
49  
50
- 51 FAO. 2009. Fishery and Aquaculture Country Profiles. <http://www.fao.org/fishery/en>  
52
- 53 Fox, K.J., R.Q. Grafton, J. Kirkley, and D. Squires 2003. Property rights in a fishery:  
54  
55 regulatory change and firm performance. *Journal of Environmental Economics*  
56  
57 *and Management* 46:156-177.  
58  
59  
60

- 1  
2  
3 Hannesson, R. 1983. The Bioeconomic Production Function in Fisheries: A  
4  
5 Theoretical and Empirical Analysis. *Canadian Journal of Fisheries and*  
6  
7 *Aquatic Sciences*, 40(7): 968-982.  
8  
9  
10 Hannesson, R. 1985. Inefficiency Through Government Regulations: The Case of  
11  
12 Norway's Fishery Policy. *Marine Resource Economics* 2(2): 115-141.  
13  
14  
15 Hannesson, R. 2007a. Growth Accounting in a Fishery. *Journal of Environmental*  
16  
17 *Economics and Management*, 53(3): 364-76.  
18  
19  
20 Hannesson, R. 2007b. A Note on the Stock Effect. *Marine Resource Economics*  
21  
22 22(1): 69-75.  
23  
24  
25 Homans, F. R., and J. E. Wilen. 1997. A Model of Regulated Open Access Resource  
26  
27 Use. *Journal of Environmental Economics and Management* 32, 1-21.  
28  
29  
30 Homans, F. R., and J. E. Wilen. 2005. Markets and rent dissipation in regulated open  
31  
32 access fisheries. *Journal of Environmental Economics and Management* 49(2):  
33  
34 381-404.  
35  
36  
37 Hulten, C.R. 2000. Total Factor Productivity: a short biography. *NBER Working*  
38  
39 *paper* 7471.  
40  
41  
42 Jin, D., E. Thunberg, H. Kite-Powell and K. Blake 2002. Total Factor Productivity  
43  
44 Change in the New England Groundfish Fishery 1964-1993. *Journal of*  
45  
46 *Environmental Economics and Management* 44: 540-556.  
47  
48  
49 Jorgenson, D., F.M. Gollop, and B.M. Fraumeni, Productivity and U.S. Economic  
50  
51 Growth, Harvard University Press, Cambridge, 1987.  
52  
53  
54 Mundlak. Y. 2005. Economic Growth: Lessons from Two Centuries of American  
55  
56 Agriculture. *Journal of Economic Literature* 43: 989-1024.  
57  
58  
59 Nøstbakken, L. 2006. Cost structure and capacity in the Norwegian pelagic fisheries.  
60  
*Applied Economics* 38(16): 1877 — 1887.

- 1  
2  
3 Pardey, P.G., Roseboom, J. and Craig, B.J. (1992). A yardstick for international  
4 comparisons: An application to national agricultural research expenditures.  
5  
6 *Economic Development and Cultural Change*, 40(2), 333-349.  
7  
8  
9  
10 Rogoff, K. (1996). The purchasing power parity puzzle. *Journal of Economic*  
11  
12 *Literature*, 34(2), 647-668.  
13  
14  
15 Sandberg, P. 2006. Variable Unit costs in Output-Regulated Fisheries. *Applied*  
16  
17 *Economics* 38: 1007-18.  
18  
19  
20 Schaefer, M. B. (1957) 'Some considerations of population dynamics and economics  
21 in realtion to the management of marine fish' *Journal of the fisheries Research*  
22 *board of Canada* 14: 669-81.  
23  
24  
25  
26  
27 Smith, V.K. and J.V. Krutilla. 1982. Toward Reformulating the Role of Natural  
28  
29 Resources in Econmic Models. In V.K. Smith and J.V. Krutilla, eds.,  
30  
31 *Exporations Natural Resource Economics*. Baltimore: Johns Hopkins  
32  
33 University Press.  
34  
35  
36 Solow, R.A. 1957. Technical Change and the Aggregate Production Funtion. *Review*  
37  
38 *of Economics and Statistics* 39(3): 312-320.  
39  
40  
41 Squires, D. 1992. Productivity measurement in common property resource industries:  
42  
43 an application to the Pacific coast trawl fishery. *Rand Journal of Economics*  
44  
45 23:221-236.  
46  
47  
48 Stigberg, D. 1997. Swedish Fisheries – efficiency, subsidies, and control (in  
49  
50 Swedish) in L. Hultkrantz (ed.). *Fishy Fishing: Decision-Making and Economic*  
51  
52 *Performance in Swedish Fishery Policy (Fisk och Fusk in Swedish)*.  
53  
54 Stockholm: Ministry of Finance.  
55  
56  
57 UNDP. 2007. <http://hdr.undp.org/hdr2006/statistics/>  
58  
59  
60

## Appendix A. Sources of data

Data for this study was collected from Statistics Norway and The Norwegian Directorate of Fisheries, Statistics Sweden and The Swedish Board of Fisheries, and from Statistics Iceland and the Icelandic Marine Institute. Below, we indicate some of the various issues arising for each group of variables when creating compatible data sets for the three countries.

The general approach for various types of prices and values has been to use the consumer price index provided by each country's official statistics body for deflation into 2003 prices, and to convert Swedish kronor (SEK) and Icelandic kronor (ISL) into Norwegian kroner (NOK) using the 2003 exchange rates. It is not obvious which exchange rate that is the appropriate one to use. Some studies use purchasing power parity (PPP) based exchange rates, e.g. Acemoglu and Zilibotti (2001). It should be noted that the choice of exchange rate has no effect on the TFP estimates that we present here, but only matter for cross-country comparisons of monetary variables in levels, such as value added per fisher.

### *A.1. Catches*

Data on total catches of fish, in volume and value, and prices of different types of fish were cross-checked and calibrated with data from Working Group Reports from the International Council for the Exploration of the Sea (ICES) with the assistance of a former ICES biologist (see also discussion under stocks). Swedish catches included the following species: shrimp, cod, Norway lobster, herring, and sprat. Norwegian catches included: Greenland halibut, shrimp, saithe, cod, redfish, haddock, capelin, mackerel, and herring. Icelandic catches included: Greenland halibut, shrimp, saithe, cod, redfish, haddock, Norway lobster, capelin, herring, and blue whiting.

### *A.2.Labor*

Statistics Sweden and The Swedish Board of Fisheries provided annual numbers of professional fishers, except for some of the interior years of the period where interpolated means were used. Statistics Norway and Statistics Iceland provided full time series of annual numbers of fishers for each country.

### *A.3.Capital*

Time series on gross registered tons were obtained from Statistics Sweden and The Swedish Board of Fisheries, The Norwegian Directorate of Fisheries and Statistics Norway, and by Statistics Iceland and the Icelandic Directorate of Fisheries.

### *A.4.Stocks and stock-specific catches*

We used the 2005 reports of the following ICES working groups: For stocks exploited by Swedish fishers, Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak, Pandalus Assessment Working Group, Working Group on Nephrops Stocks, The Herring Assessment Working Group for the Area South of 62°N, and the Baltic Fisheries Assessment Working Group. For Norwegian fisheries, Pandalus Assessment Working Group, Herring Assessment Working Group for the Area South of 62°N, the Northern Pelagic Working Group, and the Arctic Fisheries Working Group. For the stocks exploited by Icelandic fishers, we used the report by the ICES North-Western Working Group.

Stock assessments for shrimp (*Pandalus* in IIIa and IVaE) started in 1984, and the previous years were assumed to equate an average of the first ten years, 1984-93. Similarly, an average of the first ten years of stock assessments for Norwegian

1  
2  
3 shrimp (Pandalus in I and II) was used for 1973-1979. The same approach was also  
4  
5 applied to the Norwegian North Atlantic blue whiting stock for the years 1973-80,  
6  
7 and for Norwegian redfish during 1973-85. For Icelandic stocks, an average of the  
8  
9 first available ten years provided stock figures for Icelandic shrimp (Pandalus Va)  
10  
11 1973-1986, capelin 1973-78, Greenland halibut 1973-75, redfish 1973-84, and blue  
12  
13 whiting 1973-80.  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

For Peer Review

## Appendix B. TFP Growth excluding fish input

For reference we also present value added based TFP growth devoid of fish stock input, i.e. with the last term in equation (7) omitted. When we exclude fish stock input, average annual total factor productivity growth rates are 1.6%, 0.9%, and 0.3% for Iceland, Norway, and Sweden, respectively. Including fish stocks, we found earlier average annual total factor productivity growth rates of 3.0, 0.8, and 2.8% for Iceland, Norway, and Sweden, respectively.

**Table B.1. Value Added-Based TFP Growth Rates (in %) and Their Components 1973-2003**

	Iceland	Norway	Sweden
Fishers	0.0016	-0.0183	-0.0268
Capital	0.0047	-0.0021	0.0009
Value added	0.0222	-0.0112	-0.0234
VTFP ex. fish stock	0.0160	0.0092	0.0025

Table 2 presents ADF test statistics of convergence between the productivity leader Iceland and the two other countries for TFP growth excluding fish stock input. Overall, we do not find support for convergence, as the ADF test statistic for both Norway and Sweden does not reject the null hypothesis of nonstationarity.

**Table B.2. Augmented Dickey-Fuller tests of convergence - Iceland vs Norway and Sweden**

	Constant	Coeff. of $\ln \hat{TFP}_{c,t-1}$	DF test-stat	p-value**
Norway	0.279	-0.275	-2.185	0.212
Sweden	0.151	-0.122	-1.306	0.627

\*Augmented Dickey-Fuller statistics lag length chosen by the BIC criterion. \*\*MacKinnon approximate p-value for the DF test statistic.

**Table 1. Time Series of Miscellaneous Variables**

Year	Real Price Index Cod <sup>a</sup>			Number of Fishers			Total Fleet size (GRT)			Fish Stock Input Index		
	Ice	Nor	Swe	Ice	Nor	Swe	Ice	Nor	Swe	Ice	Nor	Swe
1973	67.6	100.1	68.1	4772	37537	6503	92483	353911	47874	100.0	100.0	100.0
1974	69.3	131.0	84.5	5055	36406	6493	97778	359152	45539	93.4	75.3	121.3
1975	65.5	108.1	70.3	5139	35261	6319	98979	367533	46598	95.7	70.6	109.2
1976	76.9	121.8	65.1	5257	33264	5846	97063	367448	40204	83.9	69.9	98.9
1977	79.4	88.1	67.2	5319	32589	5961	102698	377812	40524	99.1	82.6	105.1
1978	79.8	83.5	89.6	5336	33599	5778	101962	396812	40843	104.3	68.0	105.1
1979	81.7	88.0	79.9	5823	33955	5541	102885	377947	44077	132.7	59.0	108.5
1980	73.3	93.0	71.9	5946	34798	5409	104419	362403	45173	136.1	55.3	108.9
1981	70.6	91.0	67.7	6037	35311	5224	106218	342784	46064	102.3	59.5	105.7
1982	72.4	79.0	77.7	6143	35311	5039	112036	341435	46245	70.7	70.6	112.7
1983	74.3	75.6	90.2	6207	28046	4856	112880	330100	46426	62.4	77.5	119.4
1984	78.1	76.1	86.1	6363	29632	4675	112885	333777	46607	71.0	65.8	129.7
1985	79.8	85.2	90.4	6641	29559	4304	111540	330329	46787	76.9	43.8	119.3
1986	86.7	98.2	113.9	6921	29981	4323	112892	331901	49908	84.7	31.8	91.9
1987	91.9	110.4	117.5	6545	29915	4152	120007	329454	50165	77.2	26.8	85.8
1988	88.3	93.3	105.3	7006	29350	3987	126244	325530	52337	76.1	36.1	76.2
1989	90.5	89.5	97.2	6929	28655	3828	124915	304245	54731	76.7	36.3	70.5
1990	111.2	114.5	122.7	7502	27518	3463	124419	301176	56153	77.5	43.4	67.0
1991	122.6	120.8	112.2	7480	26966	3528	123292	293424	56746	62.9	55.7	51.4
1992	115.2	102.3	115.0	7010	26752	3390	122164	285547	57399	64.6	58.5	39.3
1993	104.8	84.2	99.7	7550	25396	3260	122254	291928	55127	58.1	48.0	43.1
1994	109.2	86.2	86.3	6400	22920	3140	123985	286902	53056	63.7	44.3	49.9
1995	109.2	86.6	85.5	7000	23653	2999	120193	283328	56228	65.6	43.0	53.7
1996	106.8	78.2	76.8	7100	23397	2930	122003	293506	54686	70.2	49.5	53.6
1997	110.3	77.4	97.6	6300	22916	2841	119454	310139	54072	70.8	52.4	53.9
1998	129.3	111.1	134.6	6200	21298	2765	121557	323817	53691	59.1	45.1	41.1
1999	144.2	134.4	144.1	7200	24274	2629	119679	315424	53944	59.5	36.5	40.5
2000	144.7	134.5	144.4	6100	20094	2562	118353	304074	55097	54.6	33.7	41.0
2001	157.2	135.7	155.0	6000	18954	2576	123103	312111	52567	52.3	37.5	42.8
2002	160.7	121.1	153.3	5300	18648	2227	112828	307933	51325	61.8	41.5	41.1
2003	148.4	101.2	130.1	5300	17259	2066	147555	286390	50708	62.8	41.5	42.3

<sup>a</sup>Calculated around its average for the period 1973-2003.

**Table 2. Average Annual TFP Growth Rates (in %) and Components 1973-2003**

	Iceland	Norway	Sweden
Fishers	0.0016	-0.0183	-0.0268
Capital	0.0047	-0.0021	0.0009
Demersal stock	-0.0147	0.0026	-0.0261
Pelagic stock	0.0077	-0.0175	0.0044
Value added	0.0222	-0.0112	-0.0234
VTFP	0.0300	0.0084	0.0282
VTFP <sub>1973-1990</sub>	0.0340	-0.0045	0.0438
VTFP <sub>post 1990</sub>	0.0247	0.0253	0.0077

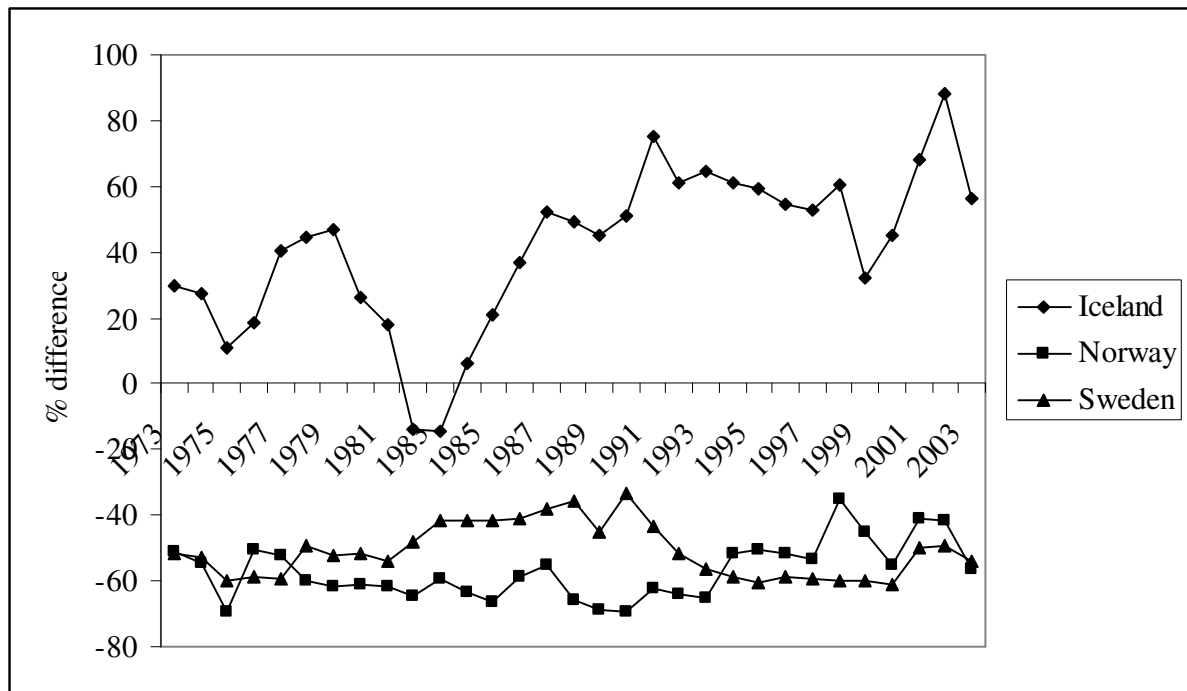
**Table 3. Augmented Dickey-Fuller tests of convergence - Iceland vs Norway and Sweden**

	Constant	Coeff. of $\ln VT\hat{FP}_{c,t-1}$	DF test-stat	p-value**
Norway	0.330	-0.247	-2.186	0.211
Sweden	0.271	-0.263	-2.163	0.220

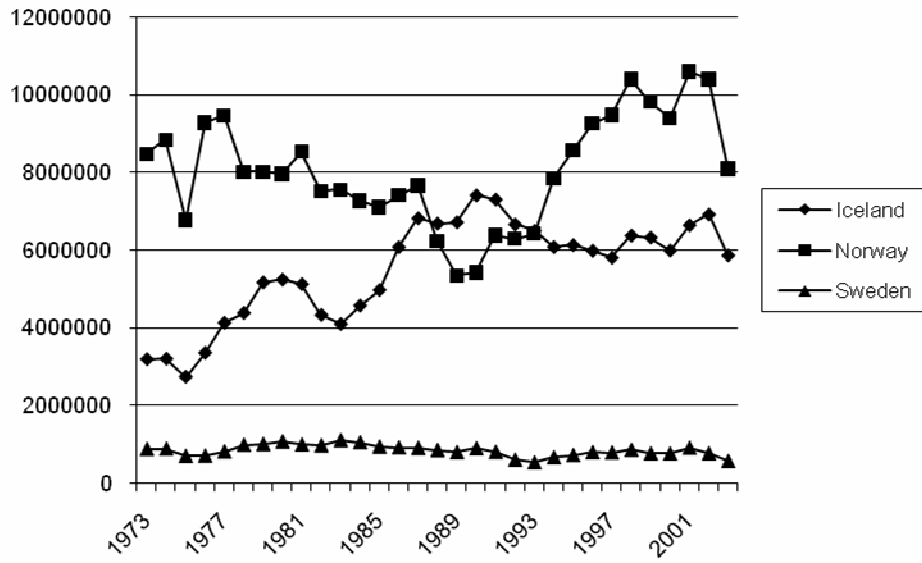
\*Augmented Dickey-Fuller statistics lag length chosen by the BIC criterion. \*\*

MacKinnon approximate p-value for the DF test statistic.

For Peer Review



**Figure 1. Percentage Difference in Average Value Added per Worker between Fisheries and the Total Economy** (Sources: *Statistics Iceland, Statistics Norway and Statistics Sweden*).



**Figure 2. Value of Fish Landings in Iceland, Norway, and Sweden, 1960-2003 (Deflated by National CPI and Converted at 2003 Exchange Rates, i.e., NOK 1 = SEK 1.14 = ISK 9.23).**

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

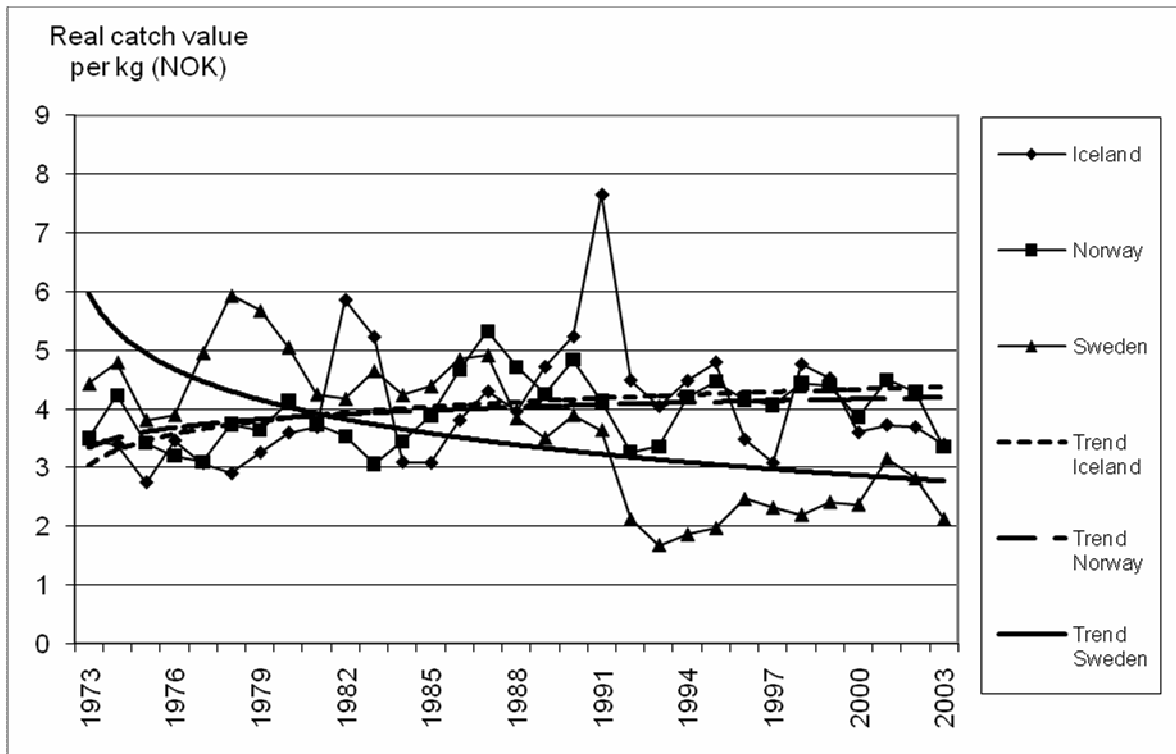


Figure 3. Real Average Unit Catch Value per Kg with Logarithmic Trend, in NOK

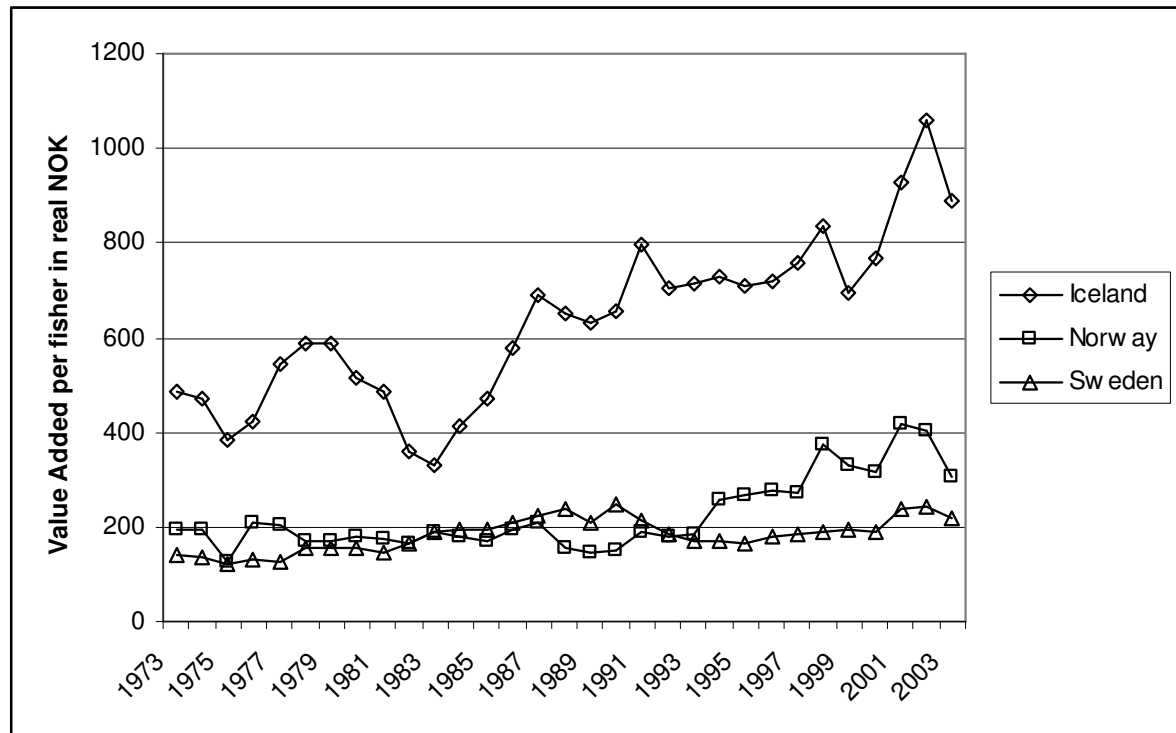


Figure 4. Labor Productivity Measured by Real Value Added per Fisher 1973-2003, in 1000 NOK (2003=100).

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60

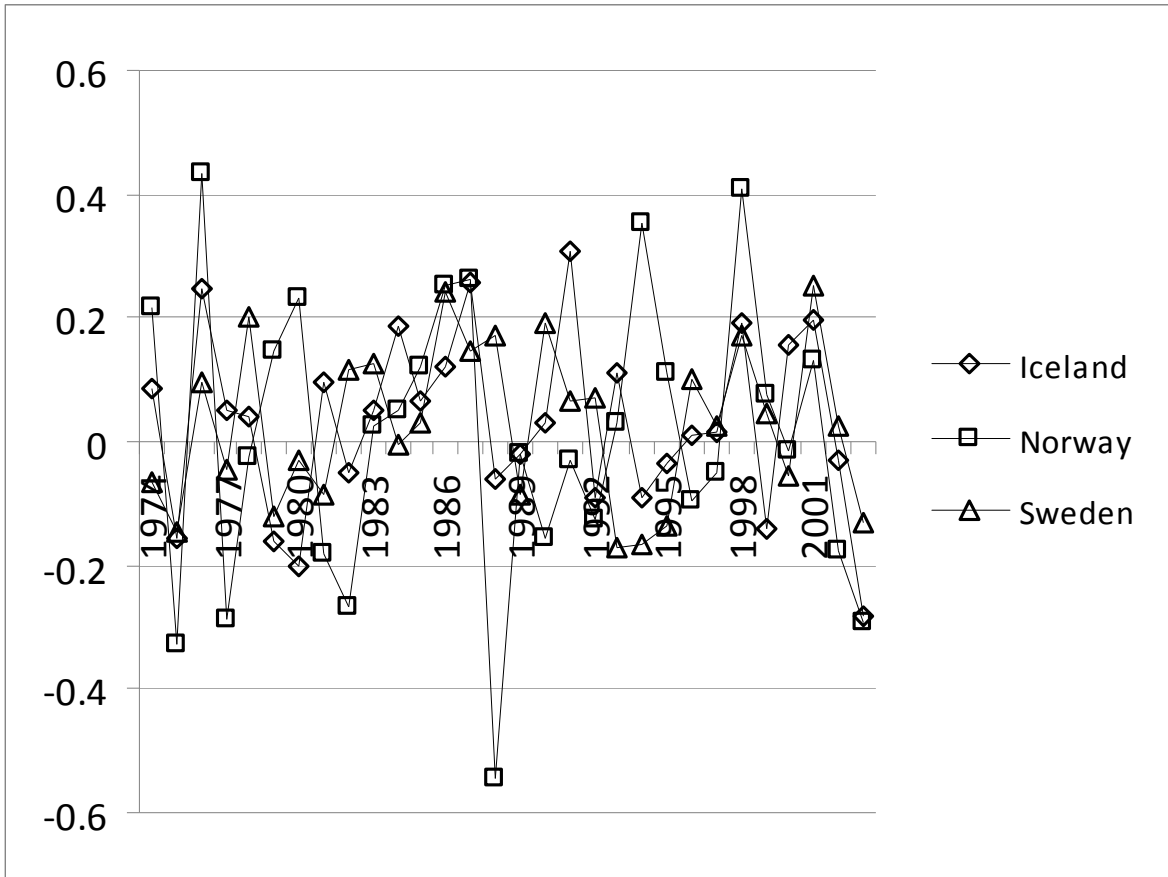


Figure 5. Annual Productivity Growth Rate Measured by VTFP in Iceland, Norway, and Sweden 1974-2003

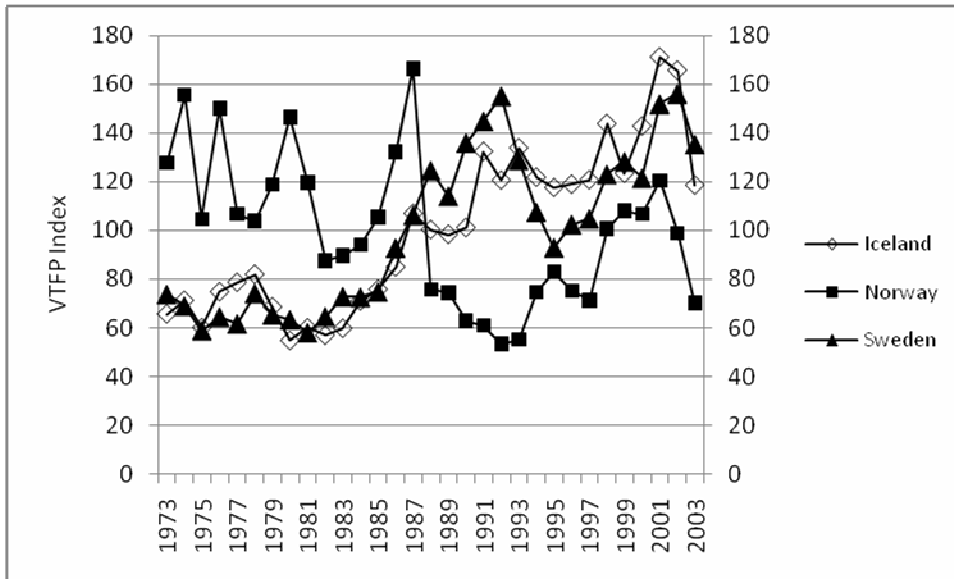


Figure 6. Cumulative VTFP Index in Iceland, Norway, and Sweden 1973-2003