Productivity development in Icelandic, Norwegian and Swedish fisheries

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PLEASE SCROLL DOWN FOR ARTICLE
Productivity development in Icelandic, Norwegian and Swedish fisheries

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This article analyses the Total Factor Productivity (TFP) performance of fisheries in Iceland, Norway and Sweden during the period 1973 to 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 had the highest annual TFP growth. Accounting for stock changes, it amounts to 3\%, while the corresponding figures for Sweden and Norway are 2.8\% and 0.8\%, 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 Classification: D24; O47; Q22

I. 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 article, we measure the long-term productivity development for the fisheries in Iceland, Norway and Sweden during the period 1973 to 2003. Measuring productivity of nations’ fisheries is basically similar to the approach for any other industry. The use of capital, labour 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 fisheries1 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 fish stock measures in order to examine long-term productivity development in the Icelandic fisheries, estimating an annual TFP growth of 3.5% during the period 1974 to 1995. Recently, Hannesson (2007a) used an industry-wide approach to study TFP development in Norway over a long period of time, accounting for fish stock inputs, and arrived at estimates of annual TFP growth of 1.7–4.3% during the period 1961 to 2004.

This study is to our knowledge the first to explore potential differences in the productivity development of fisheries in several countries. An additional objective is to assess the general economic issue of convergence or divergence (Bernard and Jones, 1996b), i.e. whether differences in fisheries productivity between countries tend to diminish or increase over time. The effects of stock input and of the quality of landed fish on productivity are analysed. We use a national account data approach like Arnason (2003) measuring output as real gross value added combined with the methodology developed by Squires (1992) and Hannesson (2007a). We find positive average annual productivity growth in all countries in the interval 0.8–3.0%. Iceland had the highest productivity growth, while Norway experienced the lowest growth. We explicitly test for productivity convergence among the three countries over time, which is rejected for all reasonable levels of significance.

II. Background

While the three studied countries do differ in several respects concerning their economies, they also hold a lot in common. For instance, United Nations Development Programme (UNDP)'s Human Development Index, which weighs Gross Domestic Product (GDP) per capita together with aspects such as life expectancy, literacy and educational level, ranks Norway, Iceland and Sweden first, second and fifth in the world, respectively (UNDP, 2007). The importance of the fisheries sector for GDP and employment differs widely among the three countries. In 2003, fisheries directly contributed 7% of the total Icelandic GDP. However, if we consider the multiplier effects on the service and manufacturing sectors it contributes a larger share directly and indirectly. The corresponding figures for Norway and Sweden were 0.7% and 0.04%, respectively (FAO, 2009). In some regions in Norway, with a total population similar to Iceland's, the direct and indirect contributions of fisheries to GDP total well above 10%. In Iceland, the performance of the fisheries sector is regarded as critical for the economy as a whole, while in Norway the sector's performance is seen as critical only for some regions. In terms of the Swedish economy, it is hard to argue that the sector is of critical importance at either level, nationally or regionally.

Some of the research on convergence across countries has focused on labour productivity (Bernard and Jones, 1996a). In the Nordic countries' fisheries sectors, there are differences in labour 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.

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1 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).

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

III. Productivity Growth Measurement Methodology

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)

\[
Y_t = f(K_t, L_t, E_t, M_t, t)
\]

where \(Y\) is physical output quantity, \(f()\) is the production function, \(K\) is the capital input quantity, \(L\) is the labour input quantity, \(E\) is the energy input quantity, \(M\) is the 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). TFP growth can, under the assumption of competitive markets, be represented as

\[
d\ln A = d\ln Y - \alpha_K d\ln K - \alpha_L d\ln L
\]

where \(\alpha\)’s are the cost shares of inputs.

The production technology can also be represented in gross value added form as (Jorgenson et al., 1987, pp. 49–51)

\[
VA_t = g(K_t, L_t, t)
\]

where \(VA\) is gross value added (i.e. gross output value minus the intermediate inputs energy and materials) and \(g()\) is the value added function. The existence of the value added aggregate requires that time and labour and capital inputs are separable from the intermediate inputs energy and materials.

TFP growth in terms of the value added function can be represented as

\[
d\ln A = d\ln VA - \alpha_K d\ln K - \alpha_L d\ln L
\]

where \(\alpha_K\) and \(\alpha_L\) are the average value added shares of capital and labour, respectively.

Productivity growth measurement in a fishery

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

\[
Y_{it} = F(K_{it}, L_{it}, t)S^{w}_{it}
\]

where \(Y_{it}\) is output (harvest) of species \(i\) in period \(t\), \(S^{w}_{it}\) is the stock of species \(i\) in period \(t\) and \(\alpha_{i}\) 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

\[
\frac{\partial Y_{it}}{\partial S^{w}_{it}} = \alpha_{i} Y_{it} \frac{d\ln S^{w}_{it}}{dt}
\]

Using this expression, the Tornqvist approximation of TFP change in discrete time is given by

\[
\frac{d\ln TFP}{dt} = \sum_{i} 0.5(s_{it} + s_{i,t-1})(\ln Y_{it} - \ln Y_{i,t-1})
\]

\[
- 0.5(c_{K_i} + c_{K,t-1})(\ln K_t - \ln K_{t-1})
\]

\[
- 0.5(c_{L} + c_{L,t-1})(\ln L_t - \ln L_{t-1})
\]

\[
- \sum_{i} 0.5\alpha_{i}(s_{it} + s_{i,t-1})(\ln S^{w}_{it} - \ln S^{w}_{i,t-1})
\]
where \( s_i \) is the revenue share of species \( i \), and \( c_K \) and \( c_L \) are the cost shares of capital and labour, 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.\(^4\) Then, a value added-based Tornqvist measure of productivity growth can be expressed as

\[
\frac{\ln VTFP}{dt} = \ln VA_t - \ln VA_{t-1} - 0.5 \sum (c_{K,t} + c_{K,t-1}) \\
+ (\ln K_t - \ln K_{t-1}) - 0.5(c_{L,t} + c_{L,t-1}) \\
+ (\ln L_t - \ln L_{t-1}) - 0.5\alpha (s_{K,t} + s_{L,t-1}) \\
+ (\ln S_t - \ln S_{t-1})
\]

The TFP level of the fishing fleet in country \( c \) can be assumed to evolve over time according to (Bernard and Jones, 1996a):

\[
\ln VTFP_{c,t} = \gamma_c + \lambda \ln VTFP_{c,t-1} + \ln VTFP_{c,t-1} + \varepsilon_{c,t}\]

(9)

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 \( \ln VTFP_{c,t} \) 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. \( VTFP_{c,t} = VTFP_{1,t}/VTFP_{c,t} \).

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:

\[
\ln VTFP_{c,t} = (\gamma_1 - \gamma_c) + (1 - \lambda) \ln VTFP_{c,t-1} + \varepsilon_{c,t}
\]

(10)

where \( \ln VTFP_{c,t} = \ln VTFP_{1,t} - \ln VTFP_{c,t} \). Our test of productivity convergence will be based on this equation. A value \( \lambda > 0 \) provide an impetus for catch-up in the sense that productivity differentials between the two countries increase the growth rate of the country with lower productivity. But only if \( \lambda > 0 \) and \( \gamma_c = \gamma_1 \), i.e. the asymptotic TFP growth rates are the same, will countries converge (Bernard and Durlauf, 1995). The null hypothesis is \( H_0: \lambda = 0 \) and \( \gamma_c \neq \gamma_1 \). In other words, we test the null hypothesis of no convergence, which is defined to mean that the deviation in productivity from the productivity leader is a nonstationary process with nonzero drift.

### IV. Data Issues

The data required according to Equation 8 to undertake a TFP analysis is gross value added, labour input and costs, capital input and costs and fish stock quantities. Our aim, to undertake a comparative analysis of the fisheries in the three countries poses additional challenges, as collected data for each country must be compatible with data for the other countries.

In this study we deflate nominal value added in domestic currency units with the domestic consumer price index. We avoid using the procedure of first using the exchange rate or Purchasing Power Parity (PPP) index in each year to convert into a common currency of a numeraire country, and then deflate using a price index of the numeraire country. The reason is that there have been exchange rate regimes in these three countries that probably have created substantial exchange rate distortions during the data period. This choice is also motivated by studies that find ample empirical evidence that exchange rates do not vary in a way that reflect differences in price levels across countries (Pardey et al., 1992; Rogoff, 1996).

Labour input is approximated by the total number of active fishers in each country, where at least the initial years include a substantial minority of part-time fishers in Norway and Sweden. Concerning physical capital, particularly the Swedish data turned out to be problematic, which led to the measure of capital input as Gross Registered Tons (GRT) of the total fleet. We assume that the renewal of the fleet followed similar patterns in the three countries and since new technologies are generally available on the international market, this approach should not affect the comparisons between countries. Both labour and capital are measured as stocks and ideally we would have figures on intensity use for those over the years in the three countries, but such figures are not available. Hence, our use of stocks as measures of flows implicitly assume that intensity use of both capital and labour have been constant in each country over the years. Finally, we use fish stock

\(^4\)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 labour 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.
data reported by the International Council for the Exploration of the Sea (ICES) working groups and compiled in collaboration with a former ICES fisheries biologist. Stock assessment is not an exact science and errors may lead to bias in productivity estimates. Another concern is that figures from ICES working groups often rely to some extent or even completely on commercial catches (Beare et al., 2005), which also may lead to bias. Still, ICES working groups represent state-of-the-art and are to our knowledge the only provider of systematic stock assessment of all important species over a long time period. We use data on 6 species for Sweden and 10 species for Iceland and Norway, which in catch value correspond to roughly 80% of each country’s total landed value (see also Appendix A). The aggregate stock indices were constructed by giving each stock a weight corresponding to its share of each country’s landed value. The fisheries sectors in the three countries target similar species to a large extent, and in some cases partly the same stocks. Cod and herring are the two most important species, which represent two groups of fish demersal and pelagic species that differ in terms of the ‘stock effect’. Bottom feeding, i.e. demersal species are often assumed to have a maximum stock effect implying uniform distribution and catches proportionate to stock size, following the classical Schaefer (1957) production function. Pelagic species like herring, mackerel and capelin live higher up in the water column and have a different distribution pattern. Despite its importance, there are few empirical studies of the stock effect, but existing ones indicate a significant stock effect for demersal species like cod, haddock and saithe (Hannesson, 1983, 2007b; Sandberg, 2006), while the stock effect for herring is very weak (Bjørndal, 1987; Sandberg, 2006). Hence, explicitly accounting for this implies that stock changes in pelagic species may have only a limited effect on productivity. This is the rationale for employing output elasticities with respect to the pelagic species stock index equal to 0.1 and the corresponding measure for demersal species equal to 1 in this article and in Hannesson (2007a).

V. Empirical Results

In this section, we analyse the development of output, inputs, prices, TFP growth and, ultimately, whether there has been convergence in productivity when comparing our three Nordic countries. Figure 2 reports the value of landings during the period 1973 to 2003 in a common currency, Norwegian kroner. Each country’s landed value is deflated by national consumer price indices, which provide us with time series on the relation between inputs and outputs for each country. We then converted to Norwegian kroner using the 2003 exchange rates.

More than 60% of the total Swedish landed value came from pelagic species at the beginning of the studied period, while the corresponding figure was fully 40% at the end of the period. In the 1960s, pelagic catches were dominated by herring primarily sold for human consumption, while pelagic catches since the 1970s have been gradually sold more for reduction, implying a substantial drop in real price paid per kilogram. Norway had a fairly stable mix: almost 60% of the landed values came from demersal species both at the beginning and at the end of the period. This led to an increase in real landed value, thanks to substantial increases in prices paid for demersal species like cod, haddock, saithe, redfish and Greenland halibut.

Figure 3 shows the development of the real catch value per kilogram in Norwegian kroner (NOK) from 1973 to 2003, with the logarithmic trend for each country. Iceland and Norway experienced a roughly similar increase in average unit price according to the trend lines, while Sweden experienced a dramatic decline, with real unit prices in the later years that were roughly 50% of that in the early years. Iceland had a composition of 60% demersal species in the early 1970s, while the value share from demersal species increased to about 70% at the end of the period. The increasing and dominating share of demersal species, which increased substantially in real price, is a central explanation to the tremendous growth in real value of landings for Iceland during the period 1973 to 2003.
The explanation behind the increase in the average unit price cannot be explained only by changes in species composition. Table 1 presents the development of the cod real price index during the period, showing that Iceland’s real price development was better than Norway’s and similar to Sweden’s. When examining all relevant species, we found that Iceland generally experienced a similar or better real price development than the two other countries over the period. Since the different species to a large extent are sold in integrated international markets, primarily the European market, this suggests that Iceland has been able to increase the quality of its product more than the other two countries.

Recent studies report that an initial effect of the introduction of Individual Transferable Quotas (ITQs) increased the revenues, thanks to increased quality (Fox et al., 2003; Dupont et al., 2005; Homans and Wilen, 2005). This could gain some support from the Icelandic data. However, real prices of Icelandic landings started to increase already in the late 1960s, probably largely due to transportation technology innovations and reduced transportation costs, which resulted in better access to the large fish import markets in continental Europe and the UK and hence increased revenues from fish export. For example, transportation technology improvements have led to a shift from frozen cod to more higher valued fresh cod in the UK market.

Mundlak (2005) analyses long-run trends in the US agricultural sector and points out that occupational migration from one sector to another is driven by the gap in income between sectors. Given the increase in real wages in other sectors of the economy and the real landed value decline, we would expect a substantial reduction in the number of Swedish fishers. This is also confirmed in Table 1, where we see a reduction in Swedish fishers from 1973 to 2003 by almost 70%. Similarly, there was more than a 50% reduction in Norway, while the number of Icelandic fishers actually increased by 7%.

In Table 1, we report the development of GRT for each country’s fishing fleet. Iceland increased its fleet size by 60%, while Sweden had a small increase of 20% and Norway experienced a fleet reduction of 20%. As noted earlier, GRT is not an ideal measure of physical capital. Hannesson (2007a) used real capital investment figures from Statistics Norway and found an increase in capital for Norway of about 20% for the period 1973 to 2003, while our GRT measure indicates a 20% reduction. Arnason (2003) used total real value of fleet and found an increase of Icelandic capital of about 70% from 1974 to 1995, while our GRT measure indicates a 23% increase over the same period. Hence, in comparison with the previous studies, we would expect a slight upward bias in productivity growth using GRT figures.

During the 1990s, Swedish fishermen had income substantially lower than unskilled labour in the manufacturing sector (Stigberg, 1997; Eggert and Ulmestrand, 1999), while Icelandic fishermen were highly paid (Danielsson, 1997). Norwegian fishermen on average had wages at pair 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.
Next, we introduce fish stock input into the productivity analysis. The development in the fish stock index from 1973 is shown in Table 1. For all three countries, we see that the trend growth for the fish stock index is negative. One noteworthy feature of the fish stock index for all three countries is the substantial volatility over time, a volatility which is much higher than for the ‘controllable’ inputs labour and capital. For Iceland, fish stock input declined by around 45% from 1973 to 2003, for Norway the decline was 25% and for Sweden 60%. If we separate between demersal and pelagic stocks, we find that demersal stocks have been slightly reduced in all countries. Pelagic stocks are a bit larger in Iceland and Sweden, but smaller in Norway.

Figure 4 shows labour productivity measured by real landed value added per fisher in the three countries in NOK. Despite the fact that Norway and Sweden experienced a massive labour migration out of the fishing sector, there are still fishers in Sweden and most likely Norway who earn substantially less than the respective country average for unskilled labour. The development is different in Iceland. Due to increasing real revenues, the earnings of Icelandic fishers are high enough to attract labour to the industry. Similarly, capital is to a larger extent attracted to fisheries in Iceland than in Norway and Sweden. Only to some extent can the difference in value added be explained by a higher capital–labour ratio in Iceland than in the other two countries.

We now turn to the measurement of TFP growth. Table 2 shows TFP growth rates and their components for the period 1974 to 2003. Overall, average TFP growth for the entire time period is found to be positive for all three countries. Iceland has the highest TFP growth with 3.0% annual average growth.
followed by Norway with 2.8% and then Sweden with 0.8%.\(^6\)

In Fig. 5 we show the annual VTFP changes for the three countries. We note the high volatility with large swings from substantial negative to substantial positive productivity changes which is similar to what have been found in previous studies (Squires, 1992; Jin et al., 2002; Hannesson, 2007a). Figure 6 translates the annual VTFP growth rates into a cumulative index which is normalized by the average for the data period 1973 to 2003. This index should not be interpreted as the VTFP absolute level. Iceland started the period with a higher TFP than Norway and Sweden, and the figure indicates that the two countries were not able to catch-up with the productivity leader Iceland.

We test formally for convergence using the Augmented Dickey–Fuller (ADF) test. Our test is based on the first-difference transformation of Equation 10. Table 3 presents ADF test statistics of convergence between the productivity leader Iceland and the two other countries. Overall, we do not find support for convergence. For both Norway and Sweden, the ADF test statistic does not reject the null hypothesis of nonstationarity.

\(^6\)When we exclude fish stock input, annual TFP growth rates are 1.6%, 0.9% and 0.3% for Iceland, Norway and Sweden, respectively. See Appendix B for more information on this.

### Table 2. Average annual TFP growth rates (in %) and components 1973 to 2003

<table>
<thead>
<tr>
<th></th>
<th>Iceland</th>
<th>Norway</th>
<th>Sweden</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fishers</td>
<td>0.0016</td>
<td>-0.0183</td>
<td>-0.0268</td>
</tr>
<tr>
<td>Capital</td>
<td>0.0047</td>
<td>-0.0021</td>
<td>0.0009</td>
</tr>
<tr>
<td>Demersal stock</td>
<td>-0.0147</td>
<td>0.0026</td>
<td>-0.0261</td>
</tr>
<tr>
<td>Pelagic stock</td>
<td>0.0077</td>
<td>-0.0175</td>
<td>0.0044</td>
</tr>
<tr>
<td>Value added</td>
<td>0.0222</td>
<td>-0.0112</td>
<td>-0.0234</td>
</tr>
<tr>
<td>VTFP</td>
<td>0.0300</td>
<td>0.0084</td>
<td>0.0282</td>
</tr>
<tr>
<td>VTFP(_{1973-1990})</td>
<td>0.0340</td>
<td>-0.0045</td>
<td>0.0438</td>
</tr>
<tr>
<td>VTFP(_{post \ 1990})</td>
<td>0.0247</td>
<td>0.0253</td>
<td>0.0077</td>
</tr>
</tbody>
</table>

### Table 3. ADF tests of convergence – Iceland versus Norway and Sweden

<table>
<thead>
<tr>
<th></th>
<th>Coefficient of ln VTFP(_{t-1})</th>
<th>DF test-statistic</th>
<th>p-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norway</td>
<td>0.330</td>
<td>-2.186</td>
<td>0.211</td>
</tr>
<tr>
<td>Sweden</td>
<td>0.271</td>
<td>-2.163</td>
<td>0.220</td>
</tr>
</tbody>
</table>

Notes: ADF statistics lag length is chosen by the BIC criterion. *MacKinnon approximate p-value for the DF test statistic.
Best-practice fishing technologies are available on the international market. State-of-the-art fishing equipment has over time increasingly been manufactured and sold by companies to fishers in many countries. This would likely contribute to convergence in productivity over time. Permanent differences in biophysical characteristics that determine the abundance and other characteristics of fish stocks could potentially limit the degree of convergence in case of a traditionally regulated open-access fishery. In a rights-based fishery, we would expect differences in biophysical characteristics to be reflected by the price development for the catch rights and per se not preventing convergence. Finally, various approaches in government regulations over time may prevent convergence in TFP. If we divide the period into two periods, splitting by the year 1990 when Iceland started its full scale ITQ regime and Norway had introduced several IVQ regulations, we find that Norway after 1990 had the highest productivity growth, closely followed by Iceland while Sweden had a more modest productivity growth. However, given the previously noted high volatility between years, figures for a shorter time period are more uncertain than those based on the whole period.

VI. Concluding Remarks

This is as far as we know the first comparative study of TFP development in fisheries involving several countries. We use comparable data for Iceland, Norway and Sweden and analyse their 1973 to 2003 productivity development on an aggregate level. The accomplishment of making the data on the three countries compatible came at the expense of some loss in accuracy of measuring the inputs. We do not have information on capacity utilization and cannot adjust for this potential source of bias as in Jin et al. (2002). We calculated TFP growth based on output measured by value added, labour and capital use, and with fish stock input included. Including fish stocks, we found average annual TFP growth rates of 3.0%, 0.8% and 2.8% for Iceland, Norway and Sweden, respectively. Several recent studies also indicate that there is scope for further productivity increases in these countries (Nøstbakken, 2006; Eggert and Tveterás, 2007; Asche et al., 2009).

During the initial years of our study Iceland had a substantially higher level of productivity in terms of value added per worker adjusting for capital input. We found that the null hypothesis of no convergence against the productivity leader Iceland was supported for both Sweden and Norway. During the 30-year period 1973 to 2003, Iceland went from an open-access to a completely implemented ITQ fishery, while Sweden relied on a traditional regulated open-access management (Homans and Wilen, 1997). Norwegian fisheries management has gradually developed towards more rights-based fishing approaches, but the extent of individual quotas is less than in Iceland and the transferability is more restricted as well. If management regimes influence productivity growth, we would expect highest growth in Iceland and lowest in Sweden, which is supported by our results for the period 1990 to 2003. If we look at the period after 1990 when the ITQ system really came into effect in Iceland, the growth slowed down in Iceland. Arnason et al. (2004) studied cod fisheries efficiency in Denmark, Norway and Iceland focusing on harvest rates and biomass levels. They did not find differential effects of the different management systems in the three countries up to year 2000 and hypothesized that the impact of the ITQ system was yet to emerge. We also found an Icelandic fish stock decline from 1973 to 2003. If there are forces at work to increase stock levels in Iceland, they are certainly slow and have met substantial institutional obstacles so far.

Acknowledgements

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References


Appendix A

Sources of data

Data for this study were 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 NOK using the 2003 exchange rates. It is not obvious which exchange rate that is the appropriate one to use. Some studies use 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.

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 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.

Labour. 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.

Capital. Time series on GRT 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.

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 10 years, 1984 to 1993. Similarly, an average of the first 10 years of stock assessments for Norwegian shrimp (Pandalus in I and II) was used for 1973 to 1979. The same approach was also applied to the Norwegian North Atlantic blue whiting stock for the years 1973 to 1980 and for Norwegian redfish during the period 1973 to 1985. For Icelandic stocks, an average of the first available 10 years provided stock figures for Icelandic shrimp (Pandalus Va) 1973 to 1986, capelin 1973 to 1978, Greenland halibut 1973 to 1975, redfish 1973 to 1984 and blue whiting 1973 to 1980.

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 TFP growth rates are 1.6%, 0.9% and 0.3% for Iceland, Norway and
Sweden, respectively. Including fish stocks, we found earlier average annual TFP growth rates of 3.0%, 0.8% and 2.8% for Iceland, Norway and Sweden, respectively.

Table B2 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.