THE FISHERY AS ECONOMIC BASE IN THE NEWFOUNDLAND ECONOMY

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ABSTRACT

Historically, the fishery has been the mainstay of the Newfoundland economy. Inevitably, its importance declined as economic development proceeded, but was still quite substantial at the time of Confederation with Canada in 1949. Since then, however, the census figures show a precipitous decline in the role of the fishery in providing employment to the local labour force. The census data suggest that only about five percent of the labour force now make a living as fishers. However, this statistical story flies in the face of a general view that the fishery is critically important to the Newfoundland economy. There have also been suggestions that the fishery acts as an economic base industry for the economy of Newfoundland and Labrador. The present paper attempts to evaluate the role of the fishing industry in that economy by embedding the output of the industry in a four-equation vector-error-correction model of the economy. It is found that the output of the fishing industry fits in the cointegration space of the model, and that after allowing for the effects of primary factors of production, the industry contributes significantly to the growth of the economy, with an elasticity slightly under 0.1. This result suggests that the fishing industry in Newfoundland and Labrador has an importance greater than its relative share of GDP would suggest.

Keywords: economic base, cointegration, Newfoundland, fishery, error correction model

INTRODUCTION

Thirty years ago, when one thought of Newfoundland, if one thought of it at all, two images came to mind: codfish and, if one had ever had even a passing interest in philately, stamps overprinted from 1919 to 1933 for pioneer trans-Atlantic flights. The latter was of minuscule value to the economy of Newfoundland, while the former dominated it.

Newfoundland had been settled from the early 1600s as a British outpost to supply dried cod to the home country and as a training ground for naval personnel. Despite efforts at economic diversification that started with the construction of the trans-island railway during the last two decades of the 19th century, the cod fishery continued to dominate the economy. Newfoundlanders were also poor, with good incomes only when wartime stimulated the demand for its main product.

After the prosperous period of World War II, unemployment returned to Newfoundland and, with the memory of the desperate 1930s still fresh in people’s minds, there was a fear of further impoverishment. A bitter political campaign followed during which the population was to decide on the future of the colony. Joseph R. Smallwood and his confederationist party won; in 1949 Newfoundland became the tenth province of Canada.

A number of events relevant to our story followed: the fishery was transferred to federal jurisdiction; sizable transfer payments were made from the federal government to Newfoundland; modern medical, educational, and government services were developed; and much effort was put into the diversification of the economy through the encouragement of small industry (e.g. boot, cement and chocolate factories, a shipyard) and massive mega-projects such as the building in Labrador, starting in the late 1960s, of one of the world’s largest hydroelectric stations. Still, the fishery continued to dominate the culture of Newfoundland, and its rural economy.

Yet its true role was debatable. During the provincial election that followed Confederation, Smallwood claimed that the value of Family Allowances and Old Age Pensions, programs of transfer payments from the federal government to individuals, exceeded the value of the fishery. Smallwood probably never said “burn your boats” as has often been claimed, but during his more then twenty years as premier of the province, he envisioned a Newfoundland in which the fishery would be only one important industry among many.

At the time of confederation with Canada, the fishery employed 28,000 people, one-third of the province’s workforce and accounted for 20% of the provincial GDP. Table I hows, for census years, the total number of fishermen, the total labour force and the number of fishermen as a percentage of the labour force. The table shows
the drastic changes that have occurred in the nature of the Newfoundland economy. From being totally dominated by the fishery 150 years ago, the percentage of the labour force fell steadily, reaching a figure below 10% by 1961 and then continuing to fall until it is less than 5% now.

<table>
<thead>
<tr>
<th>Year</th>
<th>Fishing Occupations</th>
<th>Total Labour Force</th>
<th>Percent Fishermen</th>
</tr>
</thead>
<tbody>
<tr>
<td>1857</td>
<td>38,578</td>
<td>42,671</td>
<td>90.4</td>
</tr>
<tr>
<td>1901</td>
<td>41,231</td>
<td>67,368</td>
<td>61.2</td>
</tr>
<tr>
<td>1945</td>
<td>31,634</td>
<td>101,899</td>
<td>31.0</td>
</tr>
<tr>
<td>1951</td>
<td>18,342</td>
<td>106,411</td>
<td>17.2</td>
</tr>
<tr>
<td>1961</td>
<td>8,183</td>
<td>112,310</td>
<td>7.3</td>
</tr>
<tr>
<td>1971</td>
<td>7,260</td>
<td>147,990</td>
<td>4.9</td>
</tr>
<tr>
<td>1981</td>
<td>12,030</td>
<td>222,475</td>
<td>5.4</td>
</tr>
<tr>
<td>1991</td>
<td>12,690</td>
<td>267,155</td>
<td>4.8</td>
</tr>
<tr>
<td>2001</td>
<td>11,070</td>
<td>241,495</td>
<td>4.6</td>
</tr>
</tbody>
</table>


Figure 1 shows that the value of landings as a percentage of provincial GDP since 1961 has not varied substantially, always falling below (and sometimes considerably below) 5%. Despite the cultural and social ambience of the province, and the dominant role of the fishery in the rural areas, the fishery overall apparently plays a relatively small role in the economy. The provincial economy is now dominated by services, health care, education and public administration.

This statistical story is sometimes used to justify the assertion that the fishery no longer constitutes an important part of the Newfoundland economy. This position nonetheless flies in the face of a popular view that the fishery remains economically critical. Certainly, the fishery is of significant regional importance within the province, in areas in which the fishery is the only major employer. In addition, however, the economic base theory suggests that the fishery might be a “fundamental” industry in the sense that taking its indirect as well as its direct economic impact into account, its overall contribution to the GDP of the region is higher than that measured by the provincial accounts. These indirect effects could be due to backward and forward linkages along the lines outlined by Hirschman [2], or through some other mechanism such as induced consumer demand. The fishery is, of course, a classic staples industry [3], and fits quite well into the paradigm of an economic base. A corollary of this idea is that the diminution of the base industry will have a disproportionately large detrimental effect on the economy.

The idea that some economic activities (often identified as primary production activities) act as a base for regional economies, on top of which other non-basic activities depending on the existence of such a base are established, is an old one, and is related to the staples theory of economic growth associated with Harold Innis. Much economic development analysis and policy depends on the identification of such basic activities that are appropriate to a particular economy. Unfortunately, in our view a coherent theoretical framework supporting the notion of an economic base has yet to be developed. As well, empirical and econometric verification of the concept of a basic activity has been limited. This paper seeks to advance our understanding of the concept in both directions.

The primary goal of this paper is to test the hypothesis that the fishery has an impact on the Newfoundland economy that is disproportionate to the value added it provides. One way to do this is to establish that the size of the
fishery is directly related to that of the gross domestic product of the economy even after the contribution of the primary factors of production, labour and capital, are taken into account, since these primary factors of production are enter directly into value added. This in turn can be accomplished through the estimation of an error-correction model of the Newfoundland economy, incorporating a role for the fishery as a base industry. Since the relationship between an economic base and general economic activity is a long-run one, cointegration analysis, which focusses on the long-run relationship among time series with common stochastic trends, is particularly well-suited to the extraction of long-run economic relationships from such time series — provided, of course, that stochastic trends are in fact present in the data. The general methodology may also be of interest for the purpose of identifying other economic sectors which may play the role of an economic base.

The next section of this paper outlines the theoretical underpinnings of the economic base model, while the subsequent section presents the statistical theory underlying the estimation of the macroeconomic model. The remaining sections describe the data, detail the statistical analysis, and present the conclusions.

BASE INDUSTRIES

Economies may be seen as a collection of industries. In the national accounts the contribution of each of these industries to the GDP is measured by their value-added. Thus, superficially, it may appear that the economic importance of each industry is also measured by the same number. However, casual observation suggests that some industries at least play a role in the overall economic activity that differs from this measure. In particular, certain industries appear to be more fundamental than others in the sense that taking their indirect as well as their direct economic impacts into account, their overall contribution to the GDP is higher than that measured by the national accounts. Removing such an industry would therefore lead, ceteris paribus, to a reduction in the GDP in excess of its direct contribution to GDP as measured by the national accounts. It is even possible that economies depend wholly on certain industries in that they came into being as a result of these industries and would collapse if those industries were removed. The various mining, fishing and other ghost towns around the world seem to provide compelling evidence of the existence of base industries: surely, these towns were not abandoned because the catering industry was closed.

Observations of this kind have given rise to the concept of the economic base [4,5]. The economic base is simply an industry or a collection of industries that are disproportionately important in a region’s (or, for that matter, country’s) economy in that other economic industries depend on the operation of the economic base but not vice versa, at least not to the same extent. Thus the base industry can be regarded as being autonomous (or basic) while
the other industries are dependent (non-basic). By implication, removing base industries would reduce the GDP more than their direct contribution to the GDP as measured by the national economic accounts and vice versa.

The idea of the economic base has a long history. Schaffer [5] traces the origins of this theory back to the Mercantilists, who regarded any activity conducive to a favourable balance of trade as the nation’s economic base, and later the Physiocrats who regarded agriculture as the national economic base. The modern concept of the economic base was initially formulated by the German economic historian, Werner Sombart [6] but has been refined by several researchers in the fields of economic history and regional economics including North [7] and Tiebout [4, 8-9].

It is easy to tell a convincing story about how a base industry works. Imagine for instance that a rich oil field is discovered in the middle of a frozen and unpopulated tundra. To develop the field requires labour in situ. The labour demands a range of local services. This gives rise to local economic activity which with its own labour and income will generate further demand and so on. The length of this chain of induced economic activity obviously depends on a range of economic, geographic and technical factors. However, with everything counted, it may easily amount to a significant multiple of the initial value-added in the oil industry. Thus, measured in the conventional way by its share in the GDP, the oil industry might not seem overwhelmingly important. The service industries, not to mention government services, might easily appear larger. However, the entire economy came into being as a result of the oil industry and it might well fold completely without it. In this sense, the oil industry is a base industry of this economy.

Obviously, there is nothing special about oil in this context. The base industry could as well be founded on some other natural resource or geographical feature discovered or rendered valuable by historical developments. It could even be based on a geographically strategic location made valuable by growing industries elsewhere. For example, many now obscure Mississippi basin port towns such as St. Joseph, Missouri got their start as a last supply point and jumping off point over the Mississippi and Missouri river toward the “Wild West.”

Note also that there is no need for a base industry to be an export industry. It could just as easily be an activity that makes habitation in the area possible. For instance the harnessing of a water reservoir in an arid but otherwise favourable area is often the foundation for a local economy. Finally, note that although the examples above are for simplicity in terms of base industries founded on natural resources, that does not appear to have to be the case at all. For instance, it seems that local ingenuity could in principle generate a base industry in the location.

STATISTICAL THEORY
As has already been noted, empirical and econometric verification of the concept of a basic economic activity has been limited. Our approach to this issue is based on the time series analysis of cointegrated economic variables. This method of analysis has come to dominate empirical macroeconomics over the past decade, and takes advantage of the fact that most macroeconomic time series contain stochastic trends. If different time series are found to have the same stochastic trends in common, this would suggest some causal link among these time series, since this commonality is not likely to have occurred by chance (particularly if the time series is long).

A stable relationship between production and the utilization of primary factors of production, usually labour and capital, has been a standard feature of empirical macroeconomics since the pioneering work of Paul Douglas [10, 11]. We hypothesize that if a particular activity acts as an economic base, it must affect this relationship in a positive way. In other words, production must depend, at least in the long run, on the size of the basic activity as well as the inputs of primary factors of production.

Our objective, then, is to establish a long-run relationship between the gross domestic product (GDP) of a region, the inputs of the primary factors labour and capital in the region, and the output of the economic base — here the fishery. One way to do this is through the definition of a vector autoregression (VAR) in the $4 \times 1$ vector $z_t = [Y, L, K, F]$ of logarithmic transformations of these variables, and including up to $k$ lags of $z_t$:

$$z_t = A_1 z_{t-1} + \ldots + A_k z_{t-k} + u_t$$

where $k$ matrices $A_i$ for $i = 1, \ldots, k$ are matrices of coefficients relating the 4 variables in $z_t$ to their lagged values. This type of VAR model has been advocated most prominently by Sims [12] as a way to estimate dynamic relationships among jointly endogenous variables without imposing strong a priori restrictions. (Eq. 1) can be reformulated into a vector error-correction (VECM) form, as follows:

$$\Delta z_t = \Gamma_1 \Delta z_{t-1} + \ldots + \Gamma_k \Delta z_{t-k+1} + \Pi z_{t-k} + u_t$$

(Eq. 2)
where $\Gamma_i = - (\mathbf{I} - A_1 - \ldots - A_k)$, $i = 1, \ldots, k - 1$, and $\Pi = - (\mathbf{I} - A_1 - \ldots - A_k)$ are all $4 \times 4$ matrices. This specification usefully separates the short-run and long-run adjustments to changes in the variables in $z_t$, capturing these in the matrices $\Gamma_i$ and $\Pi$ respectively. The short-run ($i$-period) multipliers relating changes in the variables in $z_t$ to changes in these variables $i$ periods in the past are contained in the matrix $\Gamma_i$. The error-correction characteristic of the VECM model captures the response of the variables in the model to the development of errors $\varepsilon_i$ in the long-run relationship(s) connecting these variables. Discrepancies in these relationships that develop over time can be specified as the $r \times 1$ vector $\varepsilon_t = \beta z_t$, where $\beta$ is a $4 \times r$ matrix of coefficients of the $r$ long-run relationships. Suppose the rate at which this error-correction takes place is represented as the $4 \times r$ matrix $\alpha$, where $\alpha_{ij}$ is the rate of response of the $j$th variable in $\Delta z_t$ to a change in the error $\varepsilon_i$ in the $i$th long-run relationship in the vector $\varepsilon$. The error-correction that takes place in the variables in $\varepsilon$ is therefore $\varepsilon_t = \alpha \beta z_t$, which is captured in the model (Eq. 2) as $\Pi z_{-1}$. Thus, $\Pi$ can be decomposed into two components as $\Pi = \alpha \beta$.

DATA

We use annual data on real Gross Domestic Product, employment, net capital stock, and real value of marine landings, for the province of Newfoundland and Labrador over the period 1961-1994, which is the span of the net capital stock series that we used. GDP is obtained from Statistics Canada (catalogue number 13-213; CANSIM series D31544), and is deflated by the GDP deflator for Newfoundland (CANSIM series D21855) from 1981, when it first became available. For previous years the deflator was chained to the GDP deflator for Canada (catalogue number 13-001; CANSIM series D23203).

Employment is taken from the Statistics Canada Labour Force Survey, as reported in catalogue number 71-201. The 1976 definition is used; unfortunately, a series based on this definition is not available before 1966. We obtained data for the period 1961-1975 based on the previous definition from the Historical Statistics of Canada, and found a consistent discrepancy in the range 3-4% in the two series over the overlap period. Therefore we extended the newer series back to 1961 by regressing the newer series on the older for the overlap period (obtaining $R^2 = 0.9988$), and using the regression to project estimates of the newer series for the period 1961-65. We are confident that any error so induced is well within the precision of the original survey instrument.

Net capital stock is obtained from Statistics Canada catalogue number 13-568, using the geometric depreciation assumption.

Production of the fisheries sector is based on value of marine landings as reported in Statistics Canada catalogue number 24-202 up to 1976, and in Canadian Fisheries Annual Statistical Review thereafter. The series is deflated by a custom Divisia index (Tornqvist approximation) based on the implicit price for each species derived from the landings data.

ANALYSIS

Testing the Order of Integration of the Variables

The first step is to determine the degree of integration of each variable; that is, to determine whether each variable possesses a unit root, and if so, how many. We base this determination on both augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. We apply the tests to specifications with and without an intercept term and a deterministic time trend. The results can be summarized as follows. We can accept the null hypothesis of a unit root in all four variables. For fish landings, we can accept the hypothesis that there is neither a drift term nor a deterministic trend; for capital, we can do so with the ADF test but not the PP test. For the other variables, a deterministic trend appears to be present under both tests. We can reject the hypothesis of a unit root in all the first differences, although the ADF tests are somewhat ambiguous in the case of capital and marine landings.

We can conclude from this analysis then that all four variables have a unit root, but only one unit root, and so are I(1).
**Formulation of the Dynamic Model**

Given that our unit root tests indicate the presence of a deterministic trend in GDP and employment, and perhaps capital stock as well, it would seem reasonable to test for the presence of such a trend in the VECM as well. In addition, an appropriate lag length for $\Delta z_{t-k}$ that captures all the dynamics of the system must be determined. Normal practice is to estimate a VAR using the undifferenced data (as in equation 4.1), using a lag length long enough that it is likely to capture all reasonable dynamic effects (Enders [13 p. 358] suggests starting with $N^{1/3}$, which in our case is about 3), and then test whether this lag length can be shortened. For example, estimating (Eq. 1) with $k = 3$ gives us a covariance matrix of residuals $\Sigma$, while estimating it with $k = 2$ gives a covariance matrix of residuals $\Sigma_t$. Even though we are working with non-stationary variables, we can perform lag length tests using the likelihood ratio test statistic recommended by Sims [12]:

$$(N - c)(\log |\Sigma| - \log |\Sigma_t|)$$

where $N$ is the sample size and $c$ is the number of parameters in an equation in the unrestricted ($k = 3$) system. This statistic is asymptotically distributed as $\chi^2$, with degrees of freedom equal to the number of coefficient restrictions (i.e., the number of parameters in $A_k$). Alternatively, lag length can be selected using a multivariate generalization of an information criterion such as the Akaike (AIC). We can test for the presence of a deterministic trend in the VAR using the same methodology.

The results can be summarized as follows:

- The hypothesis that time trends are absent from the VAR is strongly rejected ($p$-value= 0.010). As well, the Akaike, Schwartz, and Hanna-Quinn information criteria are all lower in a VAR with time trends than in one without any, indicating that the information content of the former model is greater than that in the latter.

- The hypothesis that there are no variables with lag length 3 is easily accepted ($p$-value=0.36), but the hypothesis that there are no variables with lag length greater than one is rejected ($p$-value=0.019). The information criteria are all minimized when the lag length is 2.

The VAR was reestimated with a lag length of 2. These results were confirmed in the context of the new model.

On the basis of these results, we will test for cointegration in the context of the VECM

$$\Delta z_t = \Gamma\Delta z_{t-k} + \Pi z_{t-k} + \delta t + \mu + \varepsilon_t$$

(Eq. 3)

which is equation (Eq. 2) with $k = 2$ and including a constant and time trend.

**Testing for Reduced Rank**

An essential step in the VECM methodology is the identification of any linear combination of the model variables which is stationary. Any linear combination of non-stationary variables that is not itself non-stationary must reflect an equilibrium relationship between these forces in which deviations (or ‘errors’) are self-correcting. Identifying these cointegration relationships amounts to estimating the long-run relationships $\Pi z_{t-k}$ in the error-correction model. Since the term $\Pi z_{t-k}$ in equation (Eq. 2) can be decomposed into $\alpha\beta z_{t-k}$, the rank of $\Pi$ must equal the number of cointegration relationships in the $\beta$ matrix, and so a test of the rank of $\Pi$ is a test of the number of cointegration relations that exist in the model.

Johansen [14] developed a procedure to test the rank of $\Pi$ through a test of the rank of a related matrix which is equivalent to a test on the number of eigenvalues $\lambda_i$ in the matrix that are greater than zero. As a bonus, the eigenvectors that correspond to these non-zero eigenvalues define the cointegration space within which the cointegration vectors $\beta$ must lie.

A test of the null hypothesis that there are at most $r$ cointegration vectors in an $n$-variable system is therefore equivalent to the test of the null hypothesis

$$H_0: \lambda_i = 0 \quad i = r + 1, \ldots, n$$

where the $\lambda_i$ are sorted in size order. Johansen’s trace statistic is a likelihood ratio test of this hypothesis (with a non-standard distribution); if the last $n - r + 1$ eigenvalues are close to 0, this test statistic will also be close to zero,
and the null hypothesis can be accepted. An alternative likelihood-ratio test developed by Johnsen is the λ-max statistic, which is equivalent to a test of the null hypothesis

\[ H_0 : \lambda_i = 0 \quad i = r + 1 \]

Thus, the trace statistic tests the null that there are at most \( r \) cointegration vectors, against the alternative that there are more than \( r \), while the alternative for the max test is that there are exactly \( r + 1 \) cointegration vectors.

The results of the two tests are presented in Table II. The trace test strongly rejects the hypothesis that there are no cointegration vectors in the system \( r = 0 \). The max test is less decisive, but this is surely because the two largest eigenvalues are almost the same size. It would be difficult to conclude that one is significant while the other is not, and this is what the max test (which tests against the alternative of \( r = 1 \)) is telling us. When we test that there is only one cointegration vector, both tests reject, the max test strongly and the trace test more tepidly. Neither test provides any support for the for the hypothesis that there are more than 2 cointegration vectors. Thus the Johansen tests provide the strongest support for the hypothesis that there are two cointegration vectors \((r = 2)\), and we shall estimate the VECM on that basis.

<table>
<thead>
<tr>
<th>Table II: Johansen Tests of Cointegration Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>( H_0 : \lambda_i )</td>
</tr>
<tr>
<td>( r = 0 )</td>
</tr>
<tr>
<td>( r = 1 )</td>
</tr>
<tr>
<td>( r = 2 )</td>
</tr>
<tr>
<td>( r = 3 )</td>
</tr>
</tbody>
</table>

***, **, and * represent rejection of the null at 5%, 10%, and 20% levels of significance respectively.

Model Identification

The results of the cointegration tests suggest that among the four variables in the model, there are two long-run relationships (incorporated in the matrix \( \beta \) in the VECM) that are persistent enough that deviations from this relationship are stationary. However, disentangling these relationships is not always easy.

The two eigenvectors corresponding to the significant eigenvalues (normalized on the numerically largest element) are as follows:

\[
\begin{align*}
Y_t & \quad -0.023 \quad 1 \\
L_t & \quad 1 \quad -0.441 \\
K_t & \quad -0.261 \quad -0.249 \\
F_t & \quad -0.039 \quad -0.089
\end{align*}
\]

The first eigenvector appears to be at least part of an expansion-path type growth relationship between labour and capital, whereby additional capital induces a demand for additional labour (and/or vice versa). The other two variables make very little contribution here; in fact, we cannot reject the null hypothesis that a vector with zeroes corresponding to these variables spans the cointegration space (LLR=1.65, d.f.=4, p-value=0.80). Thus the evidence strongly suggests the existence of a cointegration relationship between labour and capital alone, and we can identify this relationship by the imposition of the overidentifying restrictions \( \beta_{11} = \beta_{12} = 0 \) on the first column \( \beta_1 \) of the cointegration matrix \( \beta \).

The second eigenvector appears to reflect a long-run production relationship between GDP, the two primary factors, and fisheries production. All four variables contribute reasonably strongly to the relationship (although the
labour parameter is somewhat smaller than expected). The problem here is that it is impossible to distinguish between the structural relationship in the second column of $\beta$, and one which is a linear combination of the two structural relationships $\beta_2 + \lambda \beta_1$. Therefore, while the second eigenvector may primarily reflect the production relationship $\beta_1$, it may also (and probably does) incorporate elements from $\beta_2$ as well. The suspiciously small value of the element corresponding to labour suggests that this is in fact what is happening.

The good news is that because of the identifying restrictions $\beta_{31} = \beta_{32} = 0$ on the first relationship $\beta_3$, the corresponding elements in $\beta_2$ are not affected, and so the parameter $\beta_{32}$ (which is the one we are mainly interested in, since it reflects the contribution of fisheries production as an economic base to GDP) is identified. However, the same cannot be said for the remaining elements of $\beta_2$, $\beta_{13}$ and $\beta_{23}$, which remain unidentified unless further identifying restrictions can be imposed.  

A fully satisfactory solution to this conundrum would involve introducing into the model a variable that affects the capital-labour relationship but not the production relationship, if such a variable exists. In the meantime, we can force identification by utilizing the close association of the production elasticities of the primary factors with their shares of the product. The share of labour in net national income at factor cost averaged 0.75 (with standard deviation 0.029) over the sample period. If the restriction $\beta_{13} = 3\beta_{12}$ is imposed, all parameters in the model are identified. It must be emphasized that only the otherwise unidentified parameters — $\beta_{12}$, $\beta_{23}$, and the $\alpha_{ij}$ — are affected by this restriction. There is no impact on the estimates of any other parameters.  

### Model Estimation

Upon incorporating the identifying restrictions, we can express the cointegration equations $\beta'x_t$, net of any embedded constant terms and time trends, as follows:

$$L_t = \beta_{13} K_t + \epsilon_{t1},$$
$$Y_t = \beta_{12} L_t + \beta_{23} K_t + \beta_{32} F_t + \epsilon_{t2},$$
$$\beta_{32} = 3\beta_{12}$$

and the dynamic error-correction model as follows:

$$\Delta Y_t = \gamma_{11} \Delta Y_{t-1} + \gamma_{12} \Delta L_{t-1} + \gamma_{13} \Delta K_{t-1} + \gamma_{14} \Delta F_{t-1} + \alpha_{11} \epsilon_{t-1,2} + \alpha_{12} \epsilon_{t-2,2} + \delta_1 t + \mu_{t1},$$
$$\Delta L_t = \gamma_{21} \Delta L_{t-1} + \gamma_{22} \Delta L_{t-1} + \gamma_{23} \Delta K_{t-1} + \gamma_{24} \Delta F_{t-1} + \alpha_{21} \epsilon_{t-1,2} + \alpha_{22} \epsilon_{t-2,2} + \delta_2 t + \mu_{t2},$$
$$\Delta K_t = \gamma_{31} \Delta K_{t-1} + \gamma_{32} \Delta L_{t-1} + \gamma_{33} \Delta K_{t-1} + \gamma_{34} \Delta F_{t-1} + \alpha_{31} \epsilon_{t-1,2} + \alpha_{32} \epsilon_{t-2,2} + \delta_3 t + \mu_{t3},$$
$$\Delta F_t = \gamma_{41} \Delta F_{t-1} + \gamma_{42} \Delta L_{t-1} + \gamma_{43} \Delta K_{t-1} + \gamma_{44} \Delta F_{t-1} + \alpha_{41} \epsilon_{t-1,2} + \alpha_{42} \epsilon_{t-2,2} + \delta_4 t + \mu_{t4}.$$  

We estimate this system by substituting the cointegration equations (Eq. 4) directly into the error-correction model (through the $\epsilon_{t,i,j}$), and estimating the entire system jointly by maximum likelihood. The system does contain non-linear cross-equation restrictions on the $\beta_{ij}$ parameter estimates, but is otherwise linear.

### Cointegration model

The estimates of the cointegration model (Eq. 4) are as follows:

$$L_t = 0.264 K_t + \epsilon_{t1},$$
$$Y_t = 0.612 L_t + 0.204 K_t + 0.088 F_t + \epsilon_{t2},$$

Estimates of the parameters in the error-correction model (Eq. 5) are presented in Table III and discussed below.

(Eq. 7) implies that the fishing industry plays a not insignificant role as an economic base for the Newfoundland economy, quite independent of the returns to the factors of production it employs. While the output elasticity which can be ascribed to this effect is not large, it is nonetheless impressive given that fish landings in Newfoundland account for only 3 percent of Gross Domestic Product, so the leverage these landings provide is considerable, amounting to about 9 percent in indirect effects to supplement the 3 percent of value added.

(Eq. 6) is also of interest. The implication of this result is that capital investment in the Newfoundland economy is not accompanied by a proportionate increase in employment; in fact, a 10 percent increase in capital
stock is associated with only a 2.6 percent increase in employment. The model as presently constituted cannot speak to why this is the case, but the result is consistent with the observed tendency of the Newfoundland economy to import capital and export labour, and sheds some light on why attempts to create employment in Newfoundland by attracting investment have been such spectacular failures.

There are two hypotheses of interest regarding the cointegration parameters. The first is \( H_0 : \beta_{12} = 0 \) — fishing makes no contribution to GDP independent of the primary factors it utilizes. The second is \( H_0 : \beta_{21} = 1 \) — changes in capital stock bring forth proportionate changes in employment. The first hypothesis is decisively rejected in a likelihood ratio test, with a \( p \)-value of 0.0024. We could not actually test the second hypothesis, because we were unable to estimate a model incorporating this restriction that converged — often an indicator that the model is seriously inconsistent with the data. We were able to test the hypothesis that \( \beta_{12} = 0.8 \), and were able to reject this hypothesis with a \( p \)-value of 0.000038.

Table III: Maximum-Likelihood Estimates of Error-Correction Model (Eq. 5),
with Asymptotic Standard Errors

<table>
<thead>
<tr>
<th>( i )</th>
<th>( Y )</th>
<th>( L )</th>
<th>( K )</th>
<th>( F )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \gamma_{11} )</td>
<td>-0.873***</td>
<td>0.097</td>
<td>0.114</td>
<td>0.521</td>
</tr>
<tr>
<td>(0.159)</td>
<td>(0.158)</td>
<td>(0.185)</td>
<td>(0.694)</td>
<td></td>
</tr>
<tr>
<td>( \gamma_{21} )</td>
<td>-0.238*</td>
<td>-0.094</td>
<td>-0.159</td>
<td>-1.450**</td>
</tr>
<tr>
<td>(0.165)</td>
<td>(0.164)</td>
<td>(0.186)</td>
<td>(0.738)</td>
<td></td>
</tr>
<tr>
<td>( \gamma_{31} )</td>
<td>-0.379***</td>
<td>-0.115</td>
<td>0.466***</td>
<td>-2.283***</td>
</tr>
<tr>
<td>(0.150)</td>
<td>(0.143)</td>
<td>(0.164)</td>
<td>(0.629)</td>
<td></td>
</tr>
<tr>
<td>( \gamma_{41} )</td>
<td>0.102***</td>
<td>-0.010</td>
<td>-0.063</td>
<td>0.062</td>
</tr>
<tr>
<td>(0.045)</td>
<td>(0.045)</td>
<td>(0.051)</td>
<td>(0.203)</td>
<td></td>
</tr>
<tr>
<td>( \alpha_{21} )</td>
<td>-0.380***</td>
<td>-0.432***</td>
<td>0.115</td>
<td>-0.806*</td>
</tr>
<tr>
<td>(0.100)</td>
<td>(0.100)</td>
<td>(0.124)</td>
<td>(0.481)</td>
<td></td>
</tr>
<tr>
<td>( \alpha_{32} )</td>
<td>-0.453**</td>
<td>0.399**</td>
<td>0.293*</td>
<td>2.258***</td>
</tr>
<tr>
<td>(0.174)</td>
<td>(0.184)</td>
<td>(0.216)</td>
<td>(0.795)</td>
<td></td>
</tr>
<tr>
<td>( \delta_{1} )</td>
<td>0.007**</td>
<td>-0.001</td>
<td>-0.007&quot;</td>
<td>-0.033**</td>
</tr>
<tr>
<td>(0.003)</td>
<td>(0.003)</td>
<td>(0.004)</td>
<td>(0.015)</td>
<td></td>
</tr>
<tr>
<td>( \mu_{1} )</td>
<td>2.419***</td>
<td>-0.074</td>
<td>-1.099&quot;</td>
<td>-4.337&quot;</td>
</tr>
<tr>
<td>(0.642)</td>
<td>(0.666)</td>
<td>(0.751)</td>
<td>(3.079)</td>
<td></td>
</tr>
</tbody>
</table>

\( R^2 \) | 0.70 | 0.64 | 0.66 | 0.54

***, **, and * represent rejection of the null at 1%, 5%, and 10% levels of significance (one-tailed) respectively.

Error-correction Model

The parameters in the error-correction model reported in Table III can be categorized into three classes: the short-run multipliers \( \gamma_{it} \), the cointegration adjustment-speed parameters, \( \alpha_{it} \), and the time trends \( \delta_{i} \).
The short-run multipliers measure any one-period (Granger-)causal effects among the variables in the model outside the error-correction process. Most of the estimated parameters are small and statistically insignificant. GDP and capital stock are autoregressive but stable. Fisheries production has a small but highly significant positive impact on GDP, which makes sense. Capital stock, on the other hand, has a statistically significant negative effect on both GDP and fisheries production, an effect that is echoed in a statistically less significant way by employment. The impact of these variables on fisheries production is particularly strong. The latter effect is consistent with the role of the fisheries in the Newfoundland economy as employer of last resort; as employment and capital stock rise in the rest of the economy, resources are absorbed from the fishery, and fisheries production goes down. It is more difficult to understand why a similar (if considerably smaller) effect should apply to GDP, but this may reflect a similar phenomenon in fish processing and perhaps other activities.

The long-term effects act on the model through the error-correction parameters $\alpha_{ij}$, most of which are statistically significant. The main exceptions are the adjustment parameters in the capital equation. This not too surprising, given the lack of malleability of capital and the fact that the capital data used takes no account of capital utilization, which might be expected to play a substantial role in the adjustment process. Notwithstanding this consideration, the joint hypothesis $H_i$: $\alpha_{k1} = \alpha_{k2} = 0$ (both error-correction terms absent) is easily accepted by a Wald test ($W = 2.12$, $p$-value = 0.35), so it cannot be ruled out that capital is exogenous to the error-correction process and plays no role in that process.

The error-correction terms pertaining to the first cointegration vector $\alpha_{1i}$ govern the adjustment process to the expansion-path/growth relation between labour and capital. The estimates suggest that when employment becomes higher than the existing capital stock can sustain in the long-run, then employment, GDP, and (at 10% significance) fish production decline, and capital stock (insignificantly) increases. The opposite happens when employment is too low to effectively utilize the existing capital stock.

The second set of error correction terms $\alpha_{2i}$ control the adjustment to the long-run production relationship. These estimates imply that an economy that is producing more than can be sustained in the long-run with existing factor utilization will respond by reducing GDP and increasing both employment and (at 10% significance) capital stock. The opposite happens to an economy with underutilized production factors. All of this is reasonable.

On the other hand, the substantial role played by fisheries production in this error-correction process is a surprise. Economic base theory generally assumes that the base activity is exogenous. The estimates of the error-correction model, by contrast, imply a very substantial (and certainly statistically significant) feedback relation from the long-run production relationship to fisheries production, suggesting that the base activity not only has an important leverage effect on GDP, but also plays an important role in the adjustment process. For example, an economy that is producing more than can be sustained in the long-run with existing factor utilization responds not only by reducing GDP and increasing both employment and capital stock, but also by expanding the base activity — which in turn enhances the production capacity of the economy. Therefore, the relationship between the base and non-base industries is not unidirectional; the two sectors feed on one another.

In summary, once error-correction effects are incorporated into the model, the variables in the model are closely intertwined, all variables Granger-causing one another. Only capital may be an exception; at a 5% (but not 10%) level of significance, none of the other variables Granger-cause capital stock. The time trends are mostly significant but small. The largest is a negative 3 percent trend in fisheries production, and probably reflects the effect of resource depletion over the sample period.

**Model diagnostics**

Diagnostic tests of the model are briefly summarized here. There is no evidence of autocorrelation in the residuals of any of the equations in the error-correction model, suggesting that the model has adequately captured all the dynamic processes. All equations have residuals that are normally distributed. There is some evidence of heteroskedasticity in the equations (except for the fish production equation), but the evidence is spotty and unsystematic; there is no evidence of a consistent pattern of heteroskedasticity in any equation. These results (with some reservations regarding heteroskedasticity) all support the characterization of the model estimates as maximum likelihood. Model specification and stability do not reveal any concerns regarding model misspecification or parameter shifts, with the possible exception of the capital equation, which may have experienced a (possibly transitory) structural shift in the early 1970s.
CONCLUSION

Historically, the fishery has been the mainstay of the Newfoundland economy, but its importance has declined precipitously over the last century. The boom-or-bust character of the Newfoundland is nonetheless mirrored in the chronic instability of the fishery, both on the resource side and the market side, suggesting a relation between the two that goes beyond the direct contribution of the fishery to value added. This direct connection is consistent with the notion that certain industries act as an economic base for the rest of the economy. The idea of an economic base has a long history, but is not particularly well-formed. The leverage effect could be due to backward or forward linkages which could in principle be documented in an input-output table. Alternatively, it could have a direct multiplier effect on consumption, or could be the result of induced transfer payments in a federal state.

We tested the hypothesis that the fishery has an impact on the broader economy in Newfoundland and Labrador over and above its contribution to value added. The hypothesis is tested using modern cointegration analysis, establishing the existence of a long-run cointegrated relationship between gross domestic product, inputs of primary factors of production, and the size of the fishery. The implication of the statistical analysis is that the size of the fisheries sector in Newfoundland and Labrador has an impact on the size of the economy, over and above its contribution to value added (which would be reflected in its employment of the primary factors of production). An effect of this nature is consistent with a role for the fishery as an economic base for the economy of Newfoundland and Labrador.

The elasticity of this effect, at 0.088 is not large, but is still three times the size of the direct impact of marine production on value added, implying a substantial multiplier effect. The estimate suggests, for example, that the expansion in the crustacean fishery in the period between 1994 and 2004 would have contributed eight percentage points to the 44 percent growth in the economy of Newfoundland and Labrador that occurred during this period as a result of this leverage effect.

The error-correction model provides a number of additional interesting implications:

- the implicit ‘expansion path’ of the economy of Newfoundland and Labrador appears to be strongly biased toward capital and away from labour, making it difficult to resolve the deep-seated unemployment problems that have characterized this economy for generations through capital investment;
- in contrast to standard economic-base theory, in which the direction of causality is unidirectional from the economic base to general economic activity, the relationship between the two in Newfoundland and Labrador is apparently bidirectional and mutually reinforcing (but still convergent), so that an increase in economic activity acts to expand the economic base as well as vice-versa;
- the variables in the model are closely intertwined, and all (with the possible exception of capital, which may be exogenous) Granger-cause one another.

The model can be extended in several directions. First, it would be interesting to establish whether the conclusions of the current paper hold up in other fishery-based economies; for example, Agnarson and Arnason [15] in an unpublished paper have found similar (but even stronger) effects for Iceland. Second, it would also be interesting to apply the methodology to other industries, in Newfoundland or elsewhere, in order to establish to what degree this apparent economic base effect appears in other industries, and whether the industries in which it does appear have common characteristics.

REFERENCES

1. The series is not totally comparable over its entire length because of a data redefinition in 1996.

2. For simplicity, constant terms and deterministic regressors such as dummy variables and time trends have been suppressed in (4.1).

3. Since the decomposition of $\Pi$ into $\alpha$ and $\beta'$ depends on identifying $\beta$, a failure to identify $\beta_2$ means that the first column of the adjustment-speed matrix $\alpha$ is not identified either.

4. The factor-price ratio is an obvious candidate; however, as a relative price, it may not possess a unit root, and so would be asymptotically irrelevant to the cointegration relationship. More generally, the fact that capital and labour appear to be cointegrated by themselves suggests that there are no additional integrated variables in the relationship.

5. This statistic is obtained from the Provincial Economic Accounts, by dividing Wages, Salaries and Supplementary Labour Income (CANSIM series D31557) by Net Domestic Income at factor cost (CANSIM series D31545).

6. The rank condition $\beta_{k1} \beta_{k2} + \beta_{k3} \neq 0$ must also be satisfied. This will be the case if these parameters are all positive, which they should be.

7. The restriction only just-identifies the parameters, and so it cannot be tested.

8. Constant terms and time trends specific to the cointegration equations cannot be identified — and so of course are not estimated. The basic problem is that there is no basis on which a portion of the constant term in an error-correction equation $\mu$, can be allocated to the cointegration errors as (say) $\alpha_{\epsilon_3} \mu_3 + \alpha_{\epsilon_4} \mu_4$, unless it can be established that all of the constant term enters into the cointegration equations (which may not be supported by the data). The same considerations apply to time trends. In fact both possibilities are strongly rejected by the data in the present model. One “solution” would be to regress each $\epsilon_i$ on a time trend, and take the estimated coefficients as the constant and time trend pertaining to that particular cointegration equation. However, nothing in our model turns on the identification of these parameters.

9. The size of the adjustment parameter (2.258) may lead to concerns that this feedback process is not stable. In fact, what is important for stability is not the size of $\alpha_{\epsilon_2}$ but that of $\alpha_{\epsilon_3} \beta_{\epsilon_2}$, which is about 0.2. This reflects the strength of the error-correction which acts directly through $F_i$, and while not trivial, is nowhere near the size needed to create instability.

ENDNOTES

1. The series is not totally comparable over its entire length because of a data redefinition in 1996.

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