A DYNAMIC THEORY OF FISHERIES INVESTMENT

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Contents

Summary

The aim of this chapter is to analyze in a simple way the issue of fish stock investment. The mathematical prerequisites are a basic knowledge of calculus. Both discrete and continuous time frameworks are used. To fish down or to build up a fish stock takes time, and time is money for enterprises and consumers. The concept of discounting is introduced and we analyze how a positive discount rate affects the optimal long run stock level and harvest, as well as the fishery in transition. At any point in time the resource manager has a choice between depleting, rebuilding and equilibrium harvesting of the fish stock. These options imply that harvest has to be either above, below or equal to the natural growth of the stock. To assure profitability of an investment in a fish stock the present value of postponing harvest has to be greater than the value of immediate harvest. The Clark-Munro (1975) rule is derived without use of control theory and the long-run solution of the stock level is presented and discussed graphically. In addition to the bang-bang transition, adjusted transition paths are discussed by use of material from FAO (1995) and OECD (2000).

1. Fish Stock Investment

To fish down or to build up a fish stock takes time, and time is money for enterprises and consumers. In this chapter we introduce the concept of discounting and analyze how a positive discount rate affects the optimal long run harvest and stock level, as well as the fishery in transition. Both discrete and continuous time frameworks are used.

1.1. Discounting

Other chapters discuss resource rent in an open access and in a maximum economic yield fishery, and demonstrate that open access implies dissipation of the potential resource rent due to excessive effort and too low stock level. To change from open access to maximum economic yield fishing necessitates reduced effort and increased stock level. However, rebuilding a fish stock takes time since the resource itself has a limited reproductive and growth capacity. Rebuilding can only take place if harvesting is reduced or stopped for some time since harvest has to be less than natural growth to generate growth in the stock. At any point in time the resource manager has the choice between depletion, rebuilding and equilibrium harvesting of the fish stock. Depletion means that harvest is greater than natural growth, and revenue is high in the short run. However, this harvest strategy is not viable in the long run and will have to be changed after some while to avoid economic losses.

Rebuilding a fish stock means investing the foregone harvest, thus, revenue is reduced in the short run with the aim of getting more in return at a later stage. In this case a part of the potential net revenue is invested in the fish stock, the natural resource capital, to save for future purposes. For the resource owner, usually society, the question at any point in time is whether to consume or invest. For an investment in the stock to be profitable, the return on this investment should be just as good or better than for other investment projects. A sum of money to be received in the future is not of the same value as the same sum of money received today, since money could be deposited in the bank at a positive interest rate. Thus, the interest rate plays an important role in the evaluation of investment projects as well as in comparison of the value of money at different points in time.

Before we proceed to studying capital management of the resource stock, let us recapitulate the main connections between present value and interest rate in a discrete and a continuous time context.

When investing A_0 dollars, for example as a bank deposit, at an annual interest of i per cent, your capital will after one year have grown to $A_0(1+i)$ and after two years the value will be $A_0(1+i)^2$. In general, an investment of A_0 dollars on these conditions will after t years have the following value

$$A_t = A_0(1+i)^t. \qquad (1)$$

Solving Eq. (1) for A_0 gives

$$A_0 = \frac{A_t}{(1+i)^t}. \qquad (2)$$

This shows the connection between the future and the present value of money. A_t dollars in t years is worth A_0 at the present, therefore, A_0 is called the present value of A_t. It is easy to see from Eq. (2) that the present value of a given amount of future money is lower the farther in the future it will be received and the higher the interest is. For businesses and people investing their money, i is usually called the interest rate or market rate of interest, whereas in economic analysis it is often called the social rate of discount. The factor $1/(1+i)^t = (1+i)^{-t}$ of (2) is the discount factor, which has a value less than one for all positive values of i and t. For $t = 0$ the discount factor equals one and it decreases for increased values of t. This means that money at the investment or loan point in time is not discounted, whereas all future money is. Note that the discount factor approaches zero when t goes to infinity. This means that money values in the very, very far future hardly have any value today if they are discounted. The present value of a stream of future annual profit is the sum of the present value of each of them. For example, with an annual interest rate of 5 per cent the present value of a profit of \$1000 a year for the next five years, starting one year from now, is *0.952 · \$1000 + 0.907 · \$1000 + 0.864 · \$1000 + 0.823 · \$1000 + 0.784 · \$1000 = \$4330*. (Deliberately, the author has made a mistake for one of the discount factors – find this by use of your calculator).

Traditionally, discrete time formulae as discussed above are commonly used in investment and economic analysis. This is due to the fact that usually interest is calculated and firms report economic results to owners and tax authorities on an annual basis. However, in principal the period length for interest and present value calculations may be arbitrarily chosen as long as the interest rate is adjusted accordingly. For use in population dynamics and natural resource economics it is often useful to calculate growth and decay on a continuous time basis using the instantaneous annual rate of discount, δ. The relationship between the discrete time annual interest rate and the instantaneous rate of interest is

$$(1+i)^{-t} = e^{-\delta t}, \tag{3}$$

where $e = 2.71828$ is the base of the natural system of logarithms. Figure 1 shows the connection between discount factors for $i = 0.1$ and $\delta = 0.0953$ using discrete and instantaneous time, respectively, on an annual basis. From (3) we derive, by taking the natural logarithm of both sides,

$$\ln(1+i) = \delta. \tag{4}$$

For $i = 0.1$ we derive $\delta = 0.0953$ by using (4). For bank deposits, using the annual rate of interest *i*, compound interest is usually calculated at the end of each year. However, using the instantaneous rate of interest δ implies that interest on interest is calculated on a continuously basis throughout the year. That is why δ is less than i – the continuous calculated interest on interest compensates for the lower value of the proper interest rate (δ compared to i). Note that this discussion is based on a time step of one year in the case of discrete time. If, however, we use a shorter time step, the difference between i and δ, according to Eq. (4), will be smaller. In the extreme case when the time step approaches zero, the discrete time rate of interest, i, will approach the continuous time rate of interest, δ.

As noted above formula (2) is for the discrete time case. Using continuous time the corresponding formula for computation of the present value A_0 of the future value at time t, $A(t)$, we get

$$A_0 = A(t)\, e^{-\delta t}. \qquad (5)$$

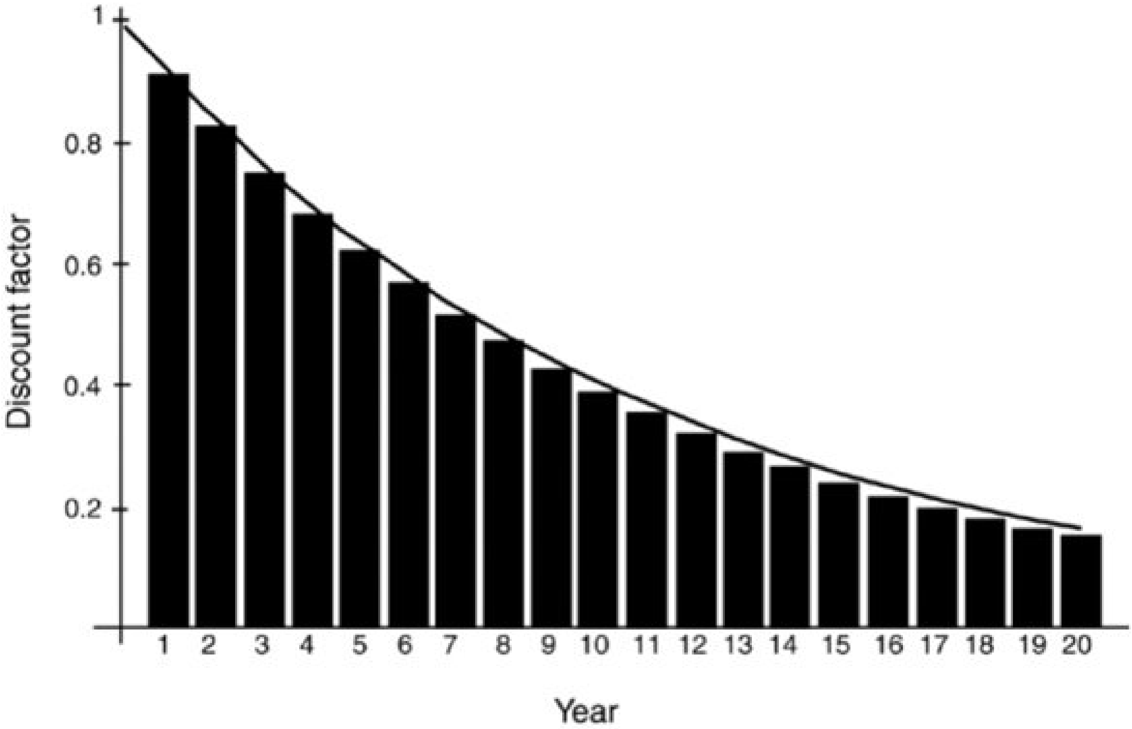

Figure 1: Discount factors for discrete (bars) and continuous (curve) time, with $i = 0.10$ and $\delta = 0.0953$.

Whether one should use discrete or continuous time approach in economic analysis of investment is primarily a question of convenience. The formula (2) and (5) give the same result as long as *i* and δ are in accordance with (4). In theoretical analysis it seems that the continuous time approach is the preferred one, whereas in empirical work discrete time calculations are the most common. The fact that most fish stocks are assessed at regular time intervals is a practical argument for using discrete time models in studies of applied fisheries biology and fisheries economics.

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Biographical Sketch

Dr. Ola Flaaten is a Professor of Resource Economics at the Norwegian College of Fishery Science, University of Tromso, Norway (UiT). As the son of a fisherman and raised in a fishing village above the Arctic Circle he early in life got to know the practical issues of the fishing industry. He earned his MA in economics at the University of Oslo and his Dr. Phil. in resource economics at the University of Tromsø. In 1998-2001 he was Head of the Fisheries Department, the Organisation for Economic Cooperation and Development (OECD), Paris, and has spent sabbatical years at the University of British Columbia, Canada and the University of Portsmouth, UK. Previously he has worked for the Ministry of Fisheries, Oslo and the Regional Labour and Development Agency, Tromso. Currently he is enjoying being an advisor to the economic component of the joint project between Nha Trang University and three Norwegian universities, funded by the Government of Vietnam and the Government of Norway through The Norwegian Agency for Development Cooperation (NORAD). He is also the academic coordinator of the NORAD supported MSc program in Fisheries and aquaculture management and economics, NTU – a joint NTU-UiT English taught program. He has published one book, book chapters, journal articles, conference proceeding papers, and economic and policy reports, in both English and Norwegian, with some translations to Russian and Vietnamese. He has held elected positions nationally and internationally, including serving on the Executive Committee of the International Institute for Fisheries Economics and Trade (IIFET).