Jorgenson's theory of Investment

Jorgenson developed a neoclassical theory of investment. It is called a neo-classical theory because his model uses a neoclassical production function, with several other standard neoclassical assumptions. We shall present a simple version of his model here, as Jorgenson incorporated several aspects (like the tax treatment of income from capital) in his famous 1963 paper, *"Capital Theory and Investment Behavior,"* which make it a bit complex.

The basic assumptions of the model are:

1. The firm operates under perfect competition.
2. There is no uncertainty.
3. There is full employment in the economy where prices of labour and capital are perfectly flexible.
4. There are diminishing marginal products.
5. Inputs are employed up to a point at which their marginal (physical) products are equal to their **real unit costs**.
6. There is a perfect financial market which means the firm can borrow or lend at a given rate of interest.
7. There is the existence of **"putty-putty"** capital which means that even after investment is made, it is instantly adapted without any costs to a different technology.
8. The firm maximises the present value of its current and future profits (which he calls **net worth**) with perfect foresight in relation to all future values.
9. Output and employment on the one hand and capital stock on the other are determined by a kind of iterative process.

A small digression

In Economics, we make all sorts of weird assumptions, perhaps none more so than what we make in our treatment of capital. **Putty-Putty** capital (as opposed to **putty-clay** capital) is a typical example. We assume, under the **"putty-putty"** model that even after the installation of a machine, it can be reshaped to accommodate any number of workers. That is what we call 'substitutability' between labour and capital: if the (w/r) ratio rises (falls), firms employ more (fewer) labourers per unit of capital. On the other hand, the **"putty-clay"** model says that such adjustments are possible only ***ex-ante***, and thus, once a machine is installed, it has to use a fixed number of labourers, that is, the machine becomes hard clay ex-post.

The Model

As mentioned earlier, Jorgenson's theory of investment assumes that the firm maximises its present value. There is a single homogeneous output (Q), which is produced by labour (L), and capital input (I - rate of investment in durable goods), p, w, and q representing their corresponding prices. Then the flow of net receipts (R) at time t is given by

$R(t) = p(t)\,Q(t) - w(t)\,L(t) - q(t)\,I(t)$...... (1)

The present value (the **net worth** W) is defined as the integral of discounted net receipts which is represented as

$W = \int_0^\infty e^{-rt} R(t)\, dt$ ... (2), where r is the rate of interest.

Here Jorgenson deals with tax complexities involving allowable tax deductions related to capital goods. We are ignoring that part.

We also note that net investment is equal to total investment less replacement investment (basically depreciation) where replacement investment is proportional to capital stock K (δ.K), or,

$\dot{K} = I(t) - \delta.K(t)$.......... (3) (*As we know, a dot above a variable indicates the time derivative*)

Next we maximize net worth (2) subject to

(i) a standard neoclassical production function Q = F (L, K) and
(ii) the constraint that the rate of growth of capital stock is investment less replacement,

We obtain the marginal productivity conditions

$\partial Q/\partial L = w/p$.................. (4), and

$\partial Q/\partial K = c/p$.......... (5)

Where $c = q(\delta + r) - \dot{q}$ .... (6), which Jorgenson calls the **user cost of capital, or** the **"shadow" price** of one unit of capital service per period of time. (Jorgenson's formulation of equation (6) is naturally much more complex, as all his intricate tax-related adjustments are incorporated. However, we need not go into such details to get a basic insight into the model).

Jorgenson also assumes that **"all capital gains are transitory,"** (*so that* $\dot{q} = 0$) and thus, the formula for user cost c, reduces to

c = q(δ + r), as the $\dot{q}$ term represents **change in price of capital goods over time**

Now we consider assumption (9) which means that in each period, production and employment are set at the levels given by the first marginal productivity condition and the production function with capital stock fixed at its current level. The demand for capital is set at the level given by the second marginal productivity condition, given output and employment. With stationary market conditions, such a process will converge to the desired maximum of net worth. Let K* represent the desired amount of capital stock, if the production function is Cobb-Douglas with elasticity of output with respect to capital equal to β, we have
$K^* = \beta (pQ/c)$ .... (7)

Finally, Jorgenson assumes that in each period new projects are initiated until the backlog of uncompleted projects is equal to the difference between desired capital stock, K*, and actual capital stock, K(t). It can be shown that under such conditions, we have:

$I(t) = f(K^*_t - K^*_{t-1})$, where the function f will basically represent the iterative adjustment process mentioned in assumption (9).

Up to this point we have discussed investment generated by an increase in desired capital stock. Total investment, say I(t), is actually the sum of investment for expansion and investment for replacement, say I_R. We have already mentioned that replacement investment is proportional to capital stock, that is $I_R = \delta.K$ (see equation 3). Hence, demand for investment I (t) is :

$$I(t) = f(K^*_t - K^*_{t-1}) + \delta.K_t$$

Jorgenson's model has been criticised on the ground that his assumptions of 'no uncertainty' and 'perfect foresight' do not address the basic problems of business investment – that is, lack of perfect foresight and lack of certainty. In reality, investors often delay their investment decisions as a waiting game, as they do not know how economic conditions would unfold.