



The Discounted Net Product

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The Discounted Net Product

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1. Imputing, and Functional Analysis

Management requires imputing net returns to individual inputs, regardless of who owns them. Hence marginal analysis is valuable for managers. Marginal analysis and imputation go together - they are two different (but interrelated) ways of doing the same thing. Each has the purpose of telling you what specific individual inputs do for you, i.e. what they add to your output. That is how you know what they are worth, and what you can bid for them. If you own them, it is how you know what good they are doing you in your business or home (which is a kind of business, too, with assets you can move into or out of your other business).

Such a view of things is called "functional" analysis, as opposed to personal analysis. It deals with the economic functions of resources, regardless of personal ownership. In Latin legalese, it is *in rem* as opposed to *in personam*. In functional analysis we seldom speak of profits, because profits are a personal (or corporate) concept. Instead we speak of revenues, and products, and net products. For example, a parking lot may yield net rents of \$100,000 a year, which are its product, but may yield the owner no personal profit at all if she has hocked it to the max, and turns all that rent over to the lender. She may go bankrupt and "lose everything," but that does not mean the parking lot is lost or destroyed: it just changes ownership while it continues to provide parking space.

A person who inherits millions may regard that money as "free," but that does not normally mean she lends it to the bank without expecting it to earn interest. Likewise, she discounts future values at a rate equal to the interest she can earn - called the "opportunity cost" of her money - even though she doesn't have to borrow the money and pay out interest. This opportunity cost is also called "imputed" interest.

Imputed interest is a real cost, and the concept is good and useful. However, too many economists, once they learn about imputed interest, opportunity cost, and all that, get carried away and lose all perspective and common sense. They forget about personal differences, and carry the idea to absurdity, using premises about the perfection of markets. For examples, they assume that the imputed interest rate used by a wealthy, slothful heir or retiree, for internal accounting purposes, is the same as the cash interest charged to an overextended borrower.

Or, if confronted with facts to the contrary, they instinctively assume the lender's viewpoint, and say that the higher rate charged to the needy borrower is a proper risk premium to cover the higher rate of defaults. From the lender's view that is generally true on the average, but from the individual borrower's view it makes many worthy borrowers pay higher cash interest rates than many unenterprising heirs or retirees use in their internal accounting. This, in turn, biases the allocation of capital, especially durable capital whose holding-cost includes a lot of interest. It biases the allocation of land even more: its holding cost is almost all interest. It is a major market imperfection of which all managers need to be aware. If you don't learn it here, life will soon teach you, and at a high cost to you.

2. Euler's¹ Theorem of Product Exhaustion: its Merits and its Inadequacy

It is good to know that if you pay or impute to each input what it is worth you will not run short of funds. There is a theorem for that. A basic theorem of Intermediate Micro is "Euler's Theorem," which shows that the laws of distribution are integrated: if every input is paid its marginal product, the total product is "exhausted," i.e. all paid out.

A useful corollary of that is that if the return to any input is imputed "residually," i.e. by subtracting the returns to other inputs from the total product, then the residual share equals the marginal product of the input. Indeed, that corollary tells us that we needn't even bother with Euler's Theorem, once having proven it.

We will not make much use of Euler in this course. You will benefit, nonetheless, by reviewing Euler's theorem, using the Cobb-Douglas Function. See Appendix to this section. The usefulness of this Appendix in this course is 1) To link this course to Intermediate Micro; and 2) To see how exponents in production functions are elasticities of production.

A main weakness of Euler's theorem is that it contains a silent premise that everything occurs instantaneously. Like most of ordinary micro theory it seems to be timeless, i.e. it deals only with relations of coexistence, not of sequence. It does not deal

¹Euler is pronounced like "Oiler."

explicitly with the time value of money. This limits its generality and persuasiveness. In this course, therefore, we will not use Euler's Theorem.

3. The Discounted Net Product

Instead, we will use the concept of The Discounted Net Product (DNP). However, to accord with common business usage, we will call it Discounted Cash Flow (DCF). "Cash Flow" is the standard business term for Net Product (Revenues less Expenses); Discounted Cash Flow (DCF) is the standard term for The Discounted Net Product. ("Discounted Marginal Product" is also used.)

These are double net concepts:

Cash Flow, first of all, is net of expenses in the year that revenues are received;

discounting the cash flow then subtracts out intermediate "carrying costs": the costs of travel through time;

what is left is the pure current value, net of all associated costs, of an input you pay up front.

The time cost most discussed by economists is interest, and it will be our main focus here. There are, however, two others that may loom large, and you should know about: storage costs (often consisting mainly of ground rent), and property taxes. Sometimes they are smaller; sometimes larger.

They are often fused with other costs, under other names. Two of them can be confusing, they are so poorly chosen.

"Fixed Costs" is often used to include rent. However, in ordinary micro theory, "fixed" means fixed this year, as output varies. Ordinary micro theory lacks a time-dimension, so it takes no note of the fact that rent is not fixed as time varies. Rent, like interest, is a time-cost. As a process takes more time, it ties up capital longer, and it also ties up space longer. We refer to this preemption of space as a "time-slot."

Land is "fixed" in another sense: it is not usually impaired by use. We handle this by referring to it as a "catalyst": an input that is essential to a chemical reaction, but is not used up by it.

A second confusing term is "overhead" cost. It means about the same as "fixed cost." It is confusing because the main "overhead" cost is actually under foot: the land.

Another special feature of ground rent as a time-cost is that it usually varies inversely with interest rates. Thus, it offsets in part the effect of changes in interest rates on time-costs. This gives ground rent a special twist that most economists overlook. For example, it makes most economists overstate the effects of "easy money" (lower interest rates) on investment decisions, and also on the distribution of income. As interest rates fall, rents rise.

There are other time-costs, like insurance and security, that need separate treatment. They are not covered in this course, except in a bundle as part of "overhead."

To summarize, find the discounted marginal product of a worker whose work adds \$1,000 to the value of a product to be sold in 8 years, with sales costs of \$200. Storage costs will be \$50/year. Use $i=.06$.

Net future marginal product is \$800. Discounted at 6%, the DCF is $\$800/1.59 = \502 . The DCF of the storage costs is $\$50 \times$ the DCF Factor, which is 6.21. $\$50 \times 6.21 = \310.49 . $\$502$ less $\$310.49 = \191.51 .

To avoid downsizing, or cutting salaries, you can raise the DMP of the workers. Here are 4 ways to do it:

- 1, Raise the net sales value after 8 years;
- 2, Lower the discount rate;
- 3, Lower the storage costs;
- 4, Shorten the wait below 8 years

4. Valuation of Land: first pass

What happens if you discount the expected future net product of your operation and get a value much higher than the cost of the original cost of the inputs to which you are imputing the discounted net product? Chances are you have left something out; chances are that is the value of land, which you have taken as free because it was already there.

The common way of valuing land is to discount future net products, subtract their current capital costs of production

(e.g. construction, planting, breeding, manufacturing, smelting, or whatever), and impute the residual to land, thus: $DNP - K = S$, where S = Site Value.

This will not work if you have already deducted the annual value of the site under the heading of "storage costs." Here, as everywhere, avoid double counting. However, the more common error, as to land, is zero counting. So look out for it. It's real, and it's costly.

Why is this just the "first pass" at valuing land? Because land lasts longer than the first generation of use. To get land value we must add the present net value of future generations, too. This comes later.

APPENDIX on EULER'S THEOREM or Imputing and Exhausting the Total Product

1. Distributive "exhaustion" of the total product

a. In the simple two-factor model all the TP above the wage bill goes as gain to the fixed factor. Thus the TP is exhausted. The fixed factor gets everything that is left over. This is called "residual" imputation.

b. But what if this residual return to land were different from the MP of land? Then land would be getting more or less than its MP, which would defy the logic of the marginal productivity theory. Fortunately the theorists came up with Euler's Theorem, which shows that this residual must equal the MP of land times the quantity of land.²

$$dP/dW \times W + dP/dL \times L = P$$

For formal proof I leave you to any book on micro theory. But an easy proof goes like this. Note what happens if we divide both sides by P. (I'll leave the operation to you). The equation now says that the sum of the left side equals one. The left side now consists of two MP/AP ratios: the first for W (work) and the second for L (land). MP/AP ratios are also "elasticities of production." They are the exponents in the Cobb-Douglas Function, normally denoted as α and β . In fact we could have done it the other way, and derived the theorem from the postulate that $\alpha + \beta$ equal one, then multiplying by P.

Well, that is a comfort, all the pieces fit together. Residual imputation is consistent with marginal productivity imputation, and Euler may be derived from alpha plus beta equal one. We needn't choose one idea over the other, all are consistent.

2. What if returns to scale are other than constant?

Another approach to product imputation is the net product approach, which goes back to the origins of economics with Dr.

²This is only true if there are constant returns to scale. (Pedantic theorists, to intimidate their readers, prefer to express this as "assuming homogeneous production functions of degree one," or some such gobbledygook which adds nothing to the subject but sheer terror, in order to endow the pedant with a gloss of intimacy with deep mathematical mysteries.)

François Quesnay (ca. 1770), and still has merit today. This approach even lets us cope with conditions where the epsilons add up to other than one -- you must have wondered about that.

If the residual rent is lower than the MP of land then the firm can raise the net gain per acre (rent) by adding land. In the urban land market this phenomenon is called "plottage," the increment in unit land value achieved by assembling small parcels into large ones. More common is "negative plottage" where the MP of land is lower than the residual rent, and large parcels want to be subdivided into smaller ones.

Refer to the paper on the Marginal Product as a Systems Concept - paragraph #4, about adding an 11th acre. That explains that $MP = MNP$ at a point. In class I may go over the net product analysis (time allowing), and show that max ANP is the optimal scale, and at this point $ANP = MNP$. It follows that MP of land = ANP of land at optimal scale, which is of course also where there are constant returns to scale. Since these are just notes and not a book I merely allude to these things, and indicate how the parts fit into the whole, in case we do cover these matters.

Some operations or improvements to land get stuck back to the left of optimal scale. A water pipeline typically does, for example. The pipe is characterized by "indivisibility," another term for economies of scale, meaning that pipes of larger diameter carry water at lower cost per unit. In these conditions the sum of marginal products must exceed the total product. How to cope? Can life go on?

What happens here is a big topic which has its own branch of theory and practise - it is called "Marginal-cost Pricing." In a nutshell the water service, if optimally priced, would yield a negative rent, usually called a deficit or loss.

Since it is a monopoly, however, it needn't be optimally priced unless intelligently regulated in the public interest, which sometimes happens. One way to cope is to overprice, which is commonplace. Another and better way is to note that the negative rents in the water system are offset by positive rents created in the lands served by the water. The trick is to tap these customer rents to offset the negative rents in the system. This whole matter is much of what public utility economics is all about, and goes by the name of "marginal-cost pricing under conditions of decreasing cost." ("Decreasing cost" is another way of saying "increasing returns to scale.") We may find time to cover this topic this quarter.