# THE LAW OF EVENTUALLY DIMINISHING RETURNS
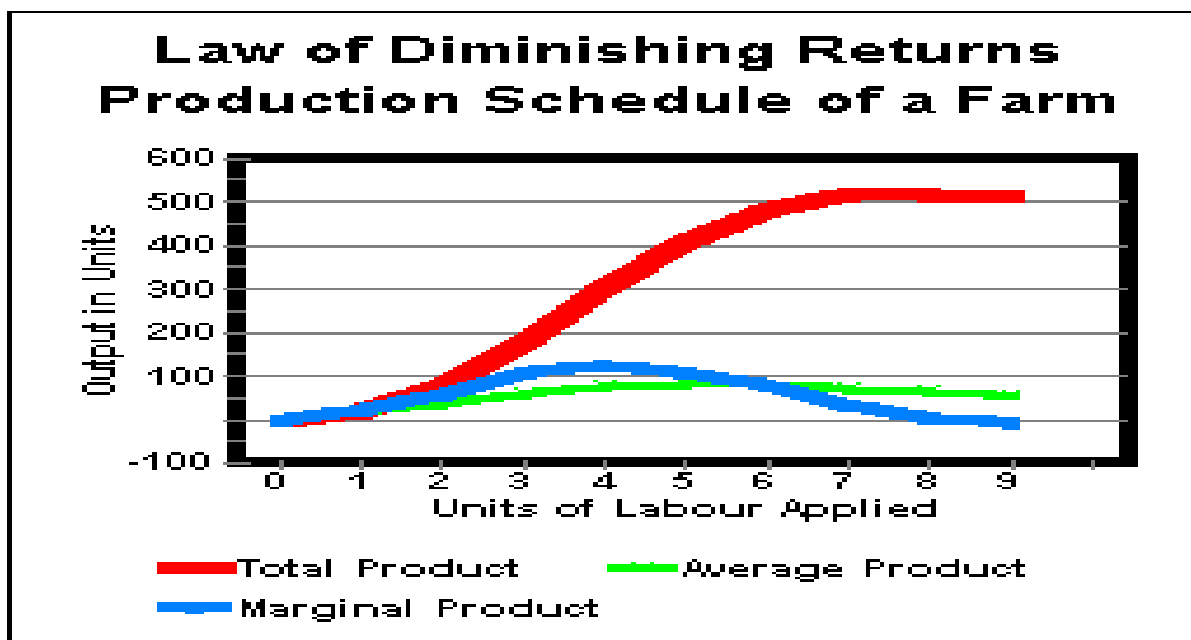
**The Fixed Factor(s):**           a fixed stock of land (10 hectares) and a fixed stock of capital (**K**).

**The Variable Factor:**           units of labour (**L**) added per year to the fixed stock of land and capital

**K/L**                            the ratio of land + capital (**K**) to labour (**L**)

**Total Product**                  Total output produced by the variable units of labour working this land in the course of a year (bushels of wheat, or eggs, or apples, etc.)

**Average Product**                Total output divided by the total quantity of labour working the land that year

**Marginal Product**               The extra (marginal) output produced by adding one *extra* unit of labour per year: the extra contribution to output provided by an additional unit of labour per year

Note that the Marginal Product curve, while descending, intersects the Average Product curve at the latter's peak. The Marginal Product curve determines the slope of the Total Product curve; and when Marginal Product becomes negative, Total Product begins to decline.
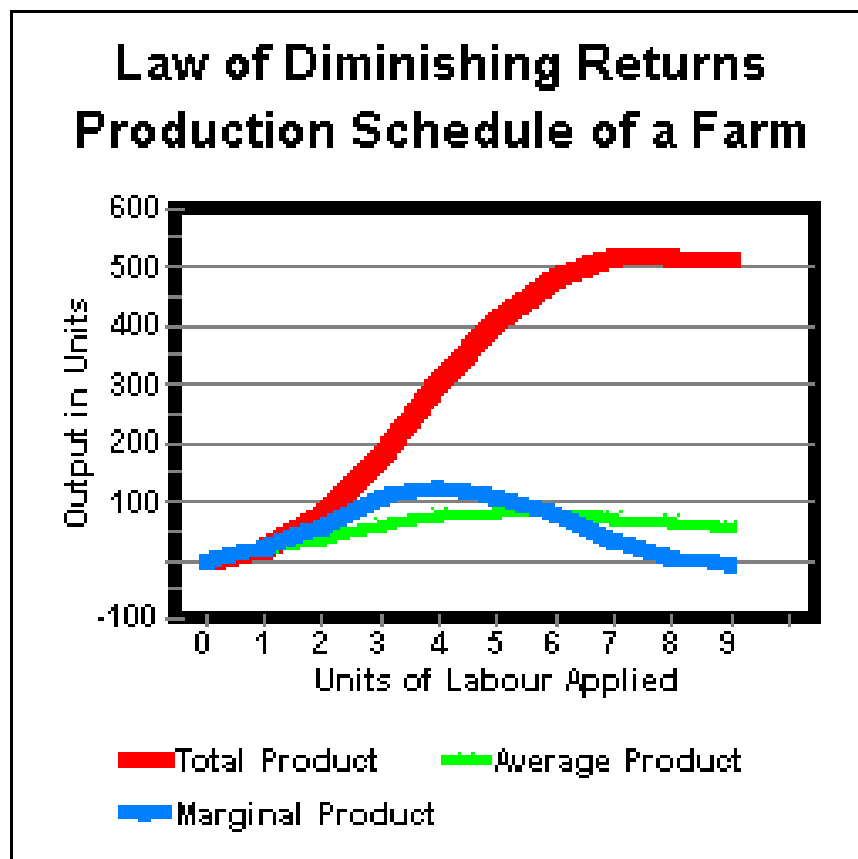
## Production Schedule for an Imaginary Farm

| Variable Factor: Labour | Total Product per year | Average Product per year | Marginal Product per year |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 1 | 20 | 20 | 20 |
| 2 | 76 | 38 | 56 |
| 3 | 183 | 61 | 107 |
| 4 | 304 | 76 | 121 |
| 5 | 410 | 82 | 106 |
| 6 | 486 | 81 | 76 |
| 7 | 518 | 74 | 32 |
| 8 | 520 | 65 | 2 |
| 9 | 513 | 57 | -7 |



Law of Diminishing Returns
Production Schedule of a Farm

Output in Units — Units of Labour Applied

Total Product — Average Product — Marginal Product

## The Law of Diminishing Returns

a) **The Land to Labour Ratio: K/L**

i) **Let us begin with the four factors of production,** and the incomes that each factor earns; and their sum constitutes the total incomes earned in society:

| | |
|---|---|
| **LAND** | **RENT** |
| **LABOUR** | **WAGES** |
| **CAPITAL** | **INTEREST** |
| **ENTERPRISE** | **PROFIT** |

ii) **Land and Labour** were certainly the two key factors in the late-medieval and early modern economy, which was fundamentally agrarian.

iii) **Capital**, however, need not and should not be ignored: we can follow many economists in conveniently lumping land and capital together and calling that result 'K', while calling labour 'L'. Hence we are concerned with the ratio between K and L.

b) **Land**: **Labour Ratio and the Laws of Increasing/ Diminishing Returns**:

i) **Refresh your memory from the "Principles of Economics" course,** and consider these relationships together on the graph on the screen.

(1) The bottom horizontal line (the X-axis) indicates the extra units of labour that are added to a fixed stock of land and capital (with constant technology).

(2) The vertical axis (the Y-axis) indicates the extra units of output that are produced by adding those extra units of labour to that fixed stock of land and capital. Also shown are the total outputs, and the average outputs (total output divided by number of workers).

(3) On one side of the handout, you will find columns and rows with numerical data, indicating for each amount of labour employed the quantities of total output, average output (total divided by

number of workers), and marginal output (extra output added by each additional unit of labour). On the other side, these quantities are plotted on the graph: units of labour plotted by the X-axis, and output for each quantity of labour plotted on the Y axis.]

ii) **Increasing Returns**:

(1) We can see first that when land is initially under-utilized, when population is small and sparse, production is inefficient because of inadequate labour to work that land.

(2) With a sparse population, specialization is difficult or impossible;  and fixed overheads (including protection costs) have to be divided amongst and borne by few people.

(3) Some forms of physical capital cannot be used effectively until more people are available (both in terms of labour and markets).

(4) Thus efficiency is in fact improved by adding more labour to that land.

(5) As more units of labour are added to that land/capital, the result is not only rising total output, but also rising output per extra unit of labour: that is, the extra or marginal product of labour is rising; the extra output produced by that last unit of labour is greater than that added by his immediate predecessor.

(6) These are, in part, the fruits of labour specialization: i.e. the division of labour by specialized tasks.

iii) **Finally, after adding more and more labour to that land we reach a point of maximum or optimum efficiency;** and then, as we add more labour, we encounter one of the most famous and important of all economic laws:

iv) **The Law of Diminishing Returns, which should really be called the Law of Eventually Diminishing Marginal Returns:**

(1) Thus, after that point of maximum efficiency, each additional or marginal unit of labour added to that fixed stock of land and capital (technology still constant) will produce smaller and smaller

additional, or extra, or marginal units of output -- smaller than that produced by the unit of labour previously added.

(2) Note that we are talking about changes in that extra or MARGINAL PRODUCT, and not changes in TOTAL OUTPUT or TOTAL PRODUCT, or even AVERAGE PRODUCT, which will continue to rise for some time after MARGINAL PRODUCT begins to fall.

(3) Note from the graph that the descending Marginal Product curve will intersect the Average Product curve at its maximum or peak (which is also the point where Marginal Cost intersects Average Cost curve; and the optimum production would be at the point that MC = MR).

v) **Overpopulation, however, begins only after AVERAGE PRODUCT begins to decline:**

But not until AVERAGE PRODUCT has reached the **SUBSISTENCE LEVEL** do we have a full-blown demographic crisis. It is very important to recognize this point in any discussion about population and the economy in the pre-industrial era.

c) **Another View of Diminishing Returns in an Agrarian Economy:**

i) **We have already discussed this point, briefly, when we analysed medieval field systems,** and the relationships between the arable fields for grains and other crops, and the pasture lands for livestock, and the changes in land distributions between the two with growing populations.

ii) **Northern European agriculture:** in particular depended upon maintaining a proper balance between grasslands for livestock and arable lands for growing grains and other crops.

iii) **As we saw earlier, in discussing medieval agriculture,** the natural response of the village economy to population growth -- more and larger families -- was to expand the village's arable crop lands at the expense of grass or pasture lands for livestock.

iv) **That soon created a severe problem for livestock husbandry,** because it requires at least twice as much land as does arable farming (grain) to produce the same amount of calories -- sometimes five times as much.

v) **Consider now the table on the screen:** to show what happens to soil fertility and crop production when arable expands too much at the expense of pasture, reducing the relative supply of manure:

vi) **From this table,** you can see that the optimum division (for this particular 100-acre farm) was about three-quarters in pasture and only one-quarter in arable. In fact, in settled and developed parts of western Europe, the arable area was normally greater than that for pasture; and thus if arable expanded at the expense of pasture, then both marginal and total output fell, because of insufficient manure and over-cropping.

### THE EFFECTS OF CHANGING RELATIVE AREAS OF GRASS (LIVESTOCK-PASTURE) AND ARABLE (GRAIN CROPS) ON THE OUTPUT OF A 100-ACRE FARM: IN BUSHELS PER ACRE (WITH LIVESTOCK OUTPUT EQUIVALENTS)

**Assumption:  Farm Operating on a Three-Field System with 2/3 in Crops and 1/3 Fallow (Uncultivated, Land at Rest) each Year**

| Grass Area in Acres | Grain Area in Acres | Fallow Area (at Rest): Acres | Manure Tons per Acre Arable | Grain Yield: Bu. per Acre | Total Grain Output Bu. | Stock Output in Equiv Bu.* | TOTAL OUT-PUT IN BU. |
|---|---|---|---|---|---|---|---|
| 100 | 0.0 | 0.0 | | | | 1,000 | 1,000 |
| 80 | 13.3 | 6.7 | >10.0 | 27.5 | 366 | 800 | 1,166 |
| **77** | **15.3** | **7.7** | **10.0** | **27.5** | **421** | **770** | **1,191** |
| 60 | 26.7 | 13.3 | 4.5 | 16.5 | 441 | 600 | 1,041 |
| 40 | 40.0 | 20.0 | 2.0 | 11.5 | 460 | 400 | 860 |
| 20 | 53.3 | 26.7 | 0.7 | 8.9 | 474 | 200 | 674 |
| 0 | 66.7 | 33.3 | 0.0 | 7.5 | 500 | 0 | 500 |

**\* Assumption:**     That the output of livestock products is equivalent to 10 bushels of grain per acre.

**Source:**     Robert Shiel, 'Improving Soil Fertility in the Pre-Fertiliser Era,' in Bruce M. S. Campbell and Mark Overton, eds., *Land, Labour, and Livestock: Historical Studies in European Agricultural Productivity* (Manchester and New York, 1991), p. 71.