PRODUCT-PRODUCT RELATIONSHIP

Product-product relationship is concerned with the allocation of a fixed resource set between competing enterprises. The farmer has to take great care in selecting the most appropriate product or product mix to maximize his profit from the given resource set. The selection of products is very much influenced by the relationship that exists between the particular products under consideration. The relationship between products can be categorized as competitive, supplementary, complementary, or joint products. To explain these categories we will make use of production possibility curve, which represents various possible combinations of two products that can be produced with fixed level of inputs. This curve is also called the production frontier, since all the combinations on this curve show the maximum attainable output for a given level of input. The slope of the production possibility curve denotes the rate at which one product substitutes for another.

Competitive Products

Two products are competitive in the use of given resources if an increase in the output of one product involves a reduction in the output of the other product. The marginal rate of product substitution, which indicates the quantity of one product that must be given up when the output of the other product is increased by one unit, is negative. Marginal rate of product substitution can be denoted as $\frac{\Delta Y_2}{\Delta Y_1}$. It indicates the number of units of Y_2 which must be given up when an additional unit of

Y_1 is to be produced. If the two products are competitive, the marginal rate of product substitution, $\frac{\Delta Y_2}{\Delta Y_1}$, is negative.

The nature of product relationships depends on the nature of production function for each independent product. These could be 1) the constant rate of substitution; 2) decreasing rate of substitution; or 3) increasing rate of substitution.

1. *Constant Rate*. When the two products substitute for each other at a constant rate, the marginal rate of product substitution remains constant over the range of possible product combinations. Two breeds of lamb or of milk cows substitute at constant rates when competing for a given area of range land. Production possibility curve of this type is represented in Figure 3.11, of which the slope $\Delta Y_2/\Delta Y_1$ is constant throughout the curve. When two products substitute at a constant rate, only one of the products should be produced to maximize net revenue. For example, that breed of lamb or cow should be kept on the farm which gives higher return.
2. *Decreasing Rate*: When the two products substitute at diminishing rate, decreasing quantities of one product must be sacrificed to get an additional unit of the other product. The production possibility curve is convex to the origin. An example of this type of relationship is provided in Figure 3.12. Product combinations showing diminishing rate of substitution are not common in agriculture. These may be found on farms where the farmers are operating in stage I of the production function, since the amount of resource being used is so small that the production of both the products is taking place in the region of increasing

Figure 3.11: Constant Rate of Product Substitution

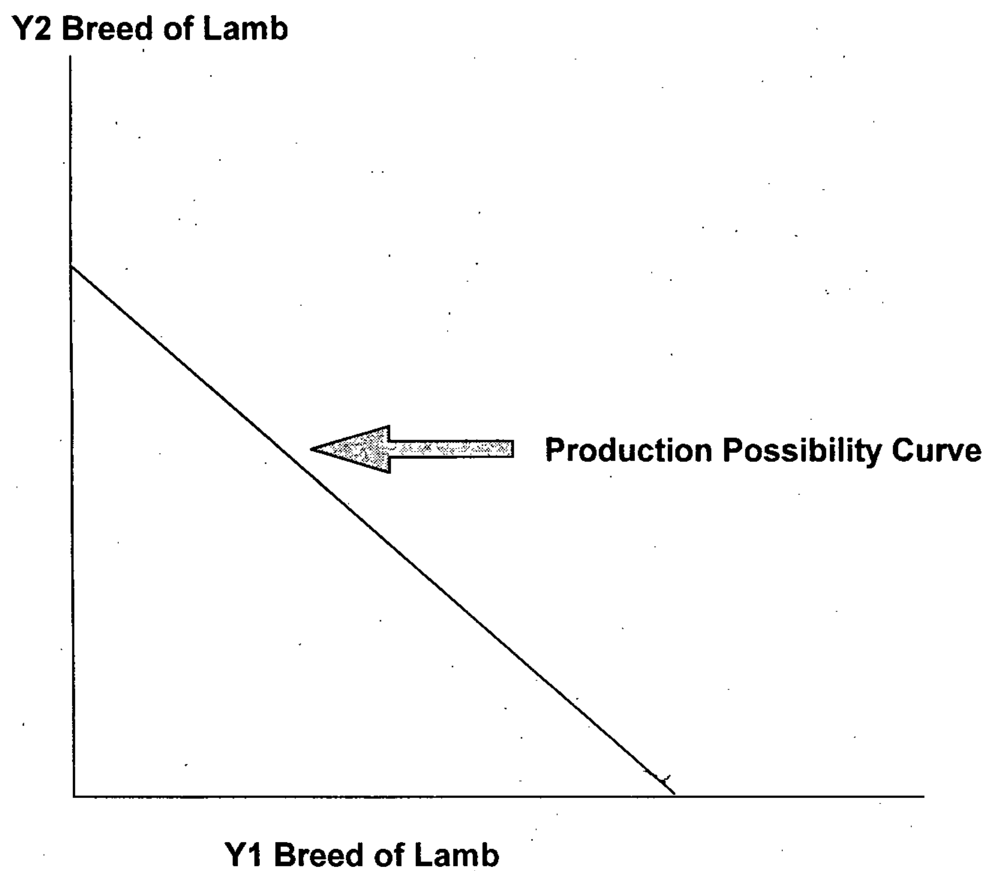
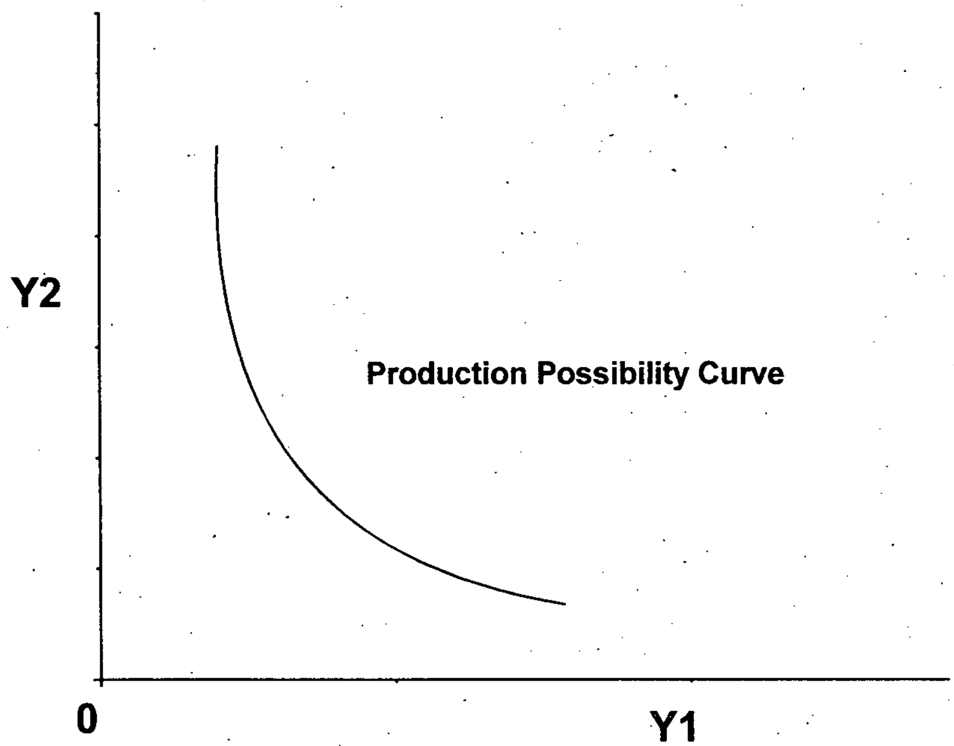


Figure 3.12: Production Possibility Curve Showing Decreasing Rate of Product Substitution



returns. As it has been discussed previously that the rational producer will never produce in this region. A combination of such two products does not yield maximum net revenue. Thus, the producer might have to increase the resource base or to opt for one enterprise.

3. *Increasing Rate*. When two products substitute at increasing rate, increasing quantities of one product must be given up to get an additional unit of the other product. The production possibility curve is concave to the origin. An example of this type of relationship is provided in Table 3.5 and Figure 3.13. This type of relationship is quite common in agriculture. Increasing rate of substitution hold true when both the products are produced in the second region of the production function, i.e., marginal products are positive but diminishing.

Supplementary Products

Two products are supplementary when an increase in output of one product, holding the resources constant in quantity, has no effect on the level of output of the second product. In other words, with the same resources, the output of one product can be increased with neither a gain nor a sacrifice in the other product. Supplementary products use the idle resources. On small farms keeping a few milk animals or poultry birds may be supplementary to the crop enterprises because permanent labour is used to produce these products without reducing the productivity of the crop products. Such a relationship is depicted in Figure 3.14. The portions AB and DC of the curve show that Y_1 and Y_2 are supplementary to each other. However, if the production of Y_2 (or Y_1)is increased further it will compete for

Table 3.5 Possible Product Combinations of Y1 and Y2 under increasing rates of substitution

Beef(Y_1) (Kgs.)	Mutton (Y_2) (Kgs.)	ΔY_1	ΔY_2	MRPS $\Delta Y_2 / \Delta Y_1$
0	1000	-----	------	------
200	985	200	15	0.08
400	965	200	20	0.10
600	930	200	35	0.18
800	885	200	45	0.23
1000	840	200	45	0.23
1200	770	200	70	0.35
1400	690	200	80	0.40
1600	560	200	130	0.65
1800	365	200	195	0.98
2000	0	200	365	1.83

Figure 3.13: Production Possibility Curve Showing Increasing Rate of Substitution.

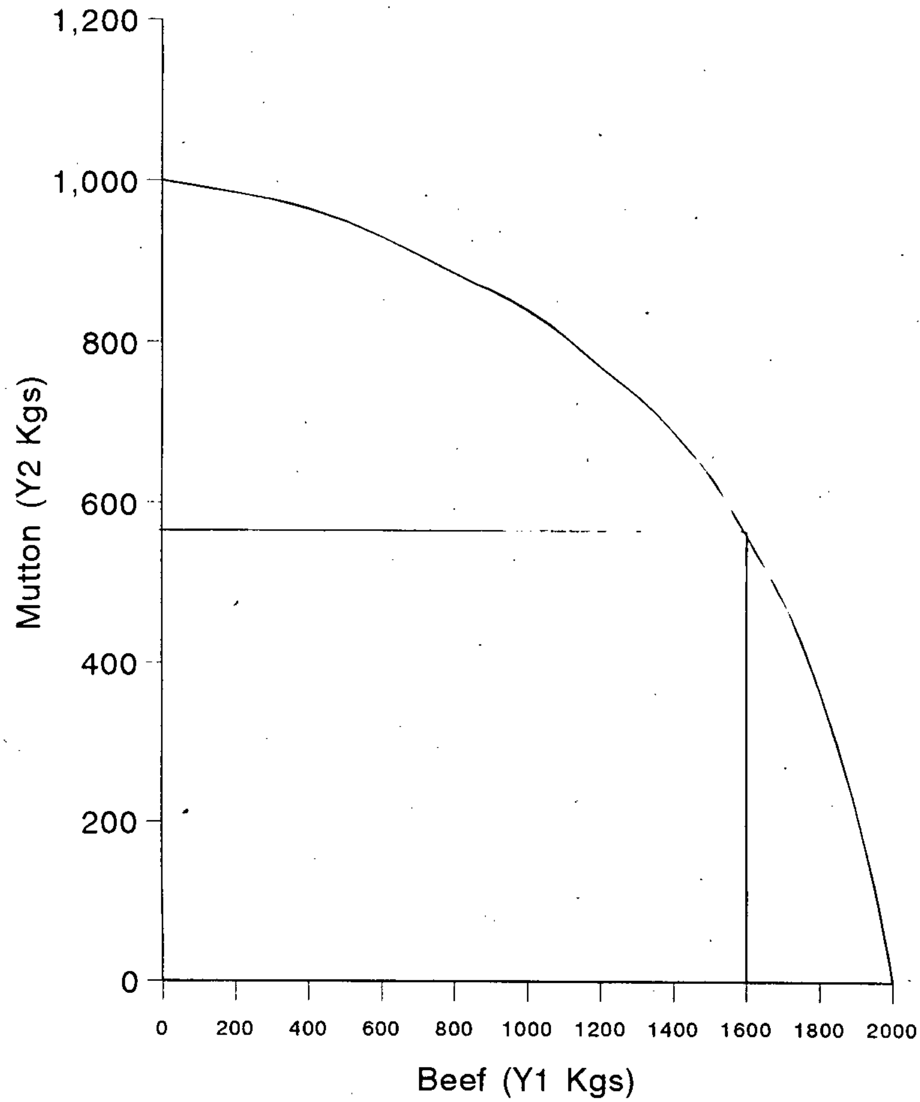
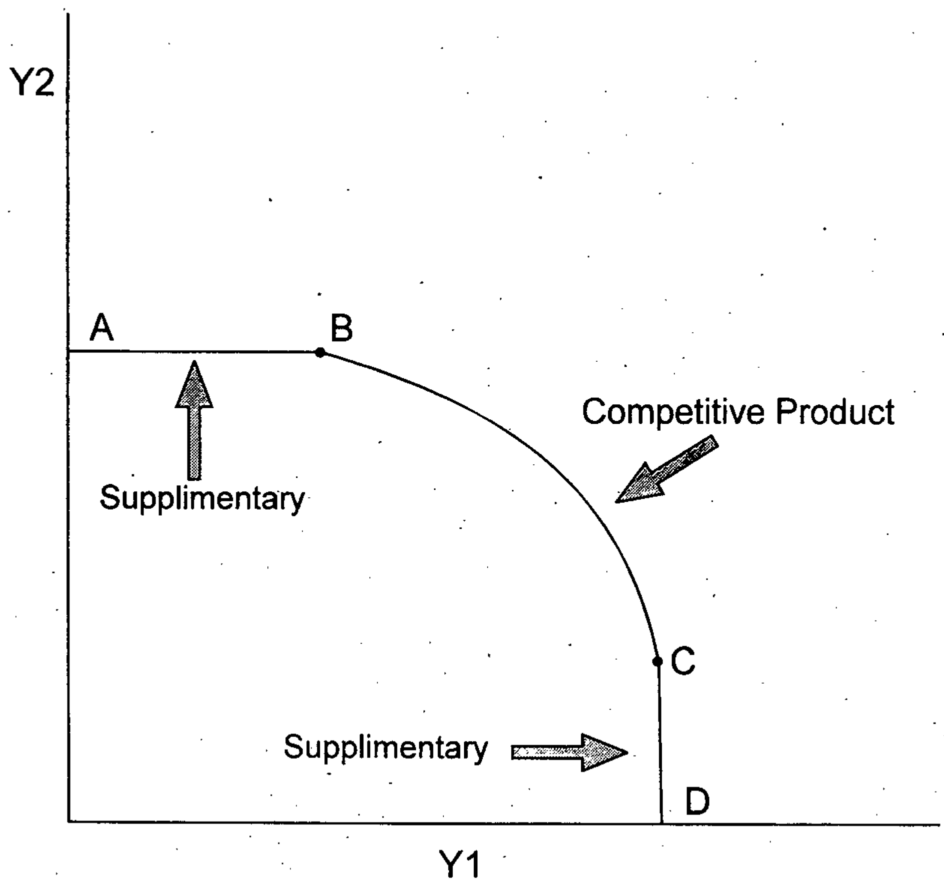


Figure 3.14: Supplimentary Relationship



the fixed labor resource. Thus, it would be necessary to reduce the output of Y_1 (Y_2) to increase the production of Y_2 (Y_1)

Complementary Products

Two products are complementary when an increase in output of one product, using the fixed resources, also increases the output of the second product. In other words a shift of resources from one product to a second product will increase rather than decrease the output of the first. This type of relationship widely prevails in agriculture. On a mixed farm of poultry and fish, the waste of poultry can be used as feed of fish. Thus, this relationship is complementary between these two products. Such a relationship is depicted in Figure 3.15. The complementary range goes from D to C. In this area, an increase is production of Y_2 is accompanied by an increase in the production of Y_1. However, after this range this relationship will be competitive since both the products will compete for the fixed resource, say labour. However, on a large Fish farm this relationship could be supplementary by keeping few poultry birds, i.e., AB.

Joint Products

These products are obtained in fixed proportions. If a given quantity of one product is produced, the quantity of the other products is fixed by nature. Joint products are produced through a single production function and for the purpose of analysis they may be treated as single product. The combinations of products are represented in Figure 3.16. Examples of joint products are lamb and wool, eggs and chicken manure, milk and calves, and beef and hides. The relevant part of this PPC curve is the point

Figure 3.15: A Graphical Representation of Complementary Products

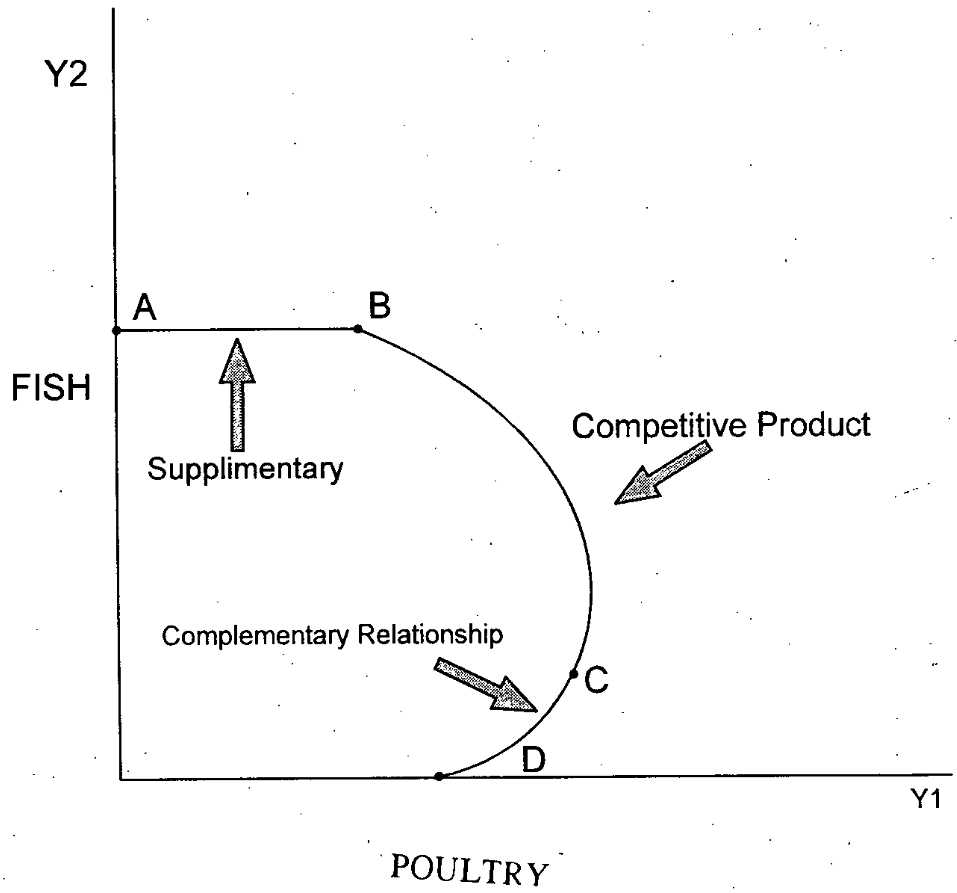
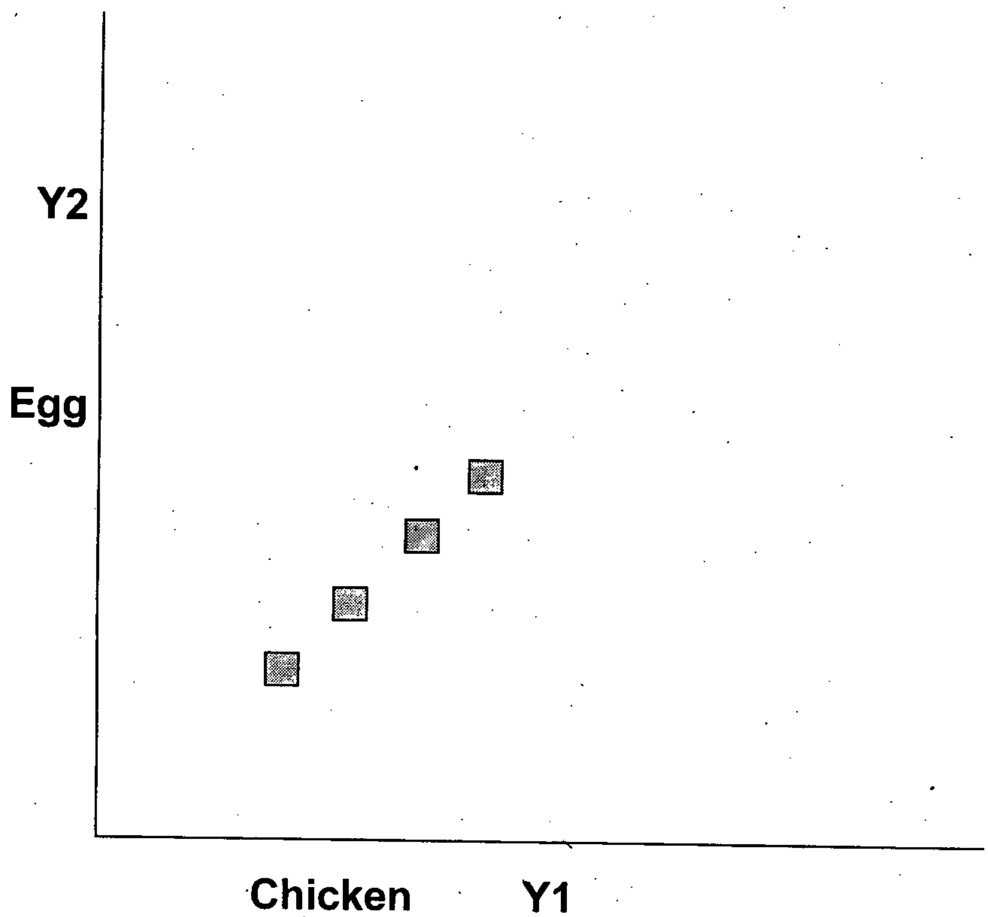


Figure 3.16: Joint products



on the corner; that is, these products are produced in fixed proportion regardless of the price situation.

OPTIMUM PRODUCT COMBINATION

The optimum product combination depends on the marginal rate of product substitution and the price ratio. The marginal rate of product combination shows the rate at which products can be substituted in the production, while the price ratio shows how the product can be exchanged in the market. Maximum net revenue is attained at a point with resources or costs fixed in quantity, where the marginal rate of product substitution is inversely equal to the product price ratio. This can be written as $\frac{\Delta Y_2}{\Delta Y_1} = \frac{P_{Y_1}}{P_{Y_2}}$,

where $\Delta Y_2 / \Delta Y_1$ is marginal rate of product substitution and the P_{Y_1} / P_{Y_2} is price ratio of the two products. This can also be written as $\Delta Y_2 . P_{Y_2} = \Delta Y_1 . P_{Y_1}$, which implies that marginal revenue obtained from product Y_1 is equal to marginal revenue of product Y_2. If $\frac{\Delta Y_2}{\Delta Y_1} > \frac{P_{Y_1}}{P_{Y_2}}$ implying

$(\Delta Y_2)\ (P_{Y_2}) > (\Delta Y_1)\ (P_{Y_1})$, then revenue can be increased by substituting Y_2 for Y_1 till the equality holds. On the other hand, if $\frac{\Delta Y_2}{\Delta Y_1} < \frac{P_{Y_1}}{P_{Y_2}}$ implying $(\Delta Y_2)\ (P_{Y_2}) < (\Delta Y_1)\ (P_{Y_1})$

then revenue can be increased by substituting Y_1 for Y_2 till the equality holds.

This profit maximizing procedure can intuitively be explained using the law of diminishing returns. When some units of a fixed resource are diverted from product Y_1 to product Y_2

additional physical output of Y_2 will decline and of Y_1 will increase and vice versa.

The condition mentioned above for the profit maximization or net revenue can also be illustrated graphically (using infomation given in Table 3.6. Any combination of two products Y_1 and Y_2 represented by production possibility curve can be produced with the given available resources. Any point on this curve which gives the maximum revenue will also maximize net revenue. If we assume that Py_1 = 60/kg and Py_2 = Rs 90/kg, we can draw iso-revenue lines showing all possible combinations of Y_1 and Y_2 which will generate an equal revenue.

For example, we can construct an iso-revenue line showing all possible combinations of Y_1 and Y_2 which will generate Rs 146400. This amount can be earned either by 2440 units of Y_1 (i.e., 146400/60) or 1626.67 units of Y_2 (*i.e.*, $\frac{146400}{90}$) or by any other combination of Y_1 and Y_2.

Production at any other combination will yield total revenue less than that associated with combination mentioned above because the gain in revenue from increasing the production of one product is less than the reduction in revenue in the production of the other product (see last column of Table 3.6).

Figure 3.17 also explains the phenomenon of determining optimal combination of two outputs. This diagram has various combinations of two products on horizontal axis; while total revenue from both products, marginal rate of product substitution (MRPS) and the price ratio are on vertical axis. This figure clearly shows that where MRPS is equal to Px_1/Px_2 at 9th combination total revenue from two products is maximum. The 9th combination in Table 3.6 shows 1600 kg of beef and 560 kg of mutton production.

Table 3.6 **Determining the Optimum Combination of Two Products**

Number of Combi-nation	Output (kgs)		Change in Y1 and Y2		MRPS = $\Delta Y_2 / \Delta Y_1$	Price Ratio = $\frac{PY_1}{PY_2}$	Additional Revenue		Total Revenue from Y_1 and Y_2
	Beef (Y_1)	Mutton (Y_2)	ΔY_1	ΔY_2			$\Delta Y_1.PY_1$	$\Delta Y_2.PY_2$	
1	0	1000	---	-----	------	0.67	-------	------	90000
2	200	1000	200	15	0.08	0.67	12000	1350	100650
3	400	965	200	20	0.10	0.67	12000	1800	110850
4	600	930	200	35	0.18	0.67	12000	3150	119700
5	800	885	200	45	0.23	0.67	12000	4050	127650
6	1000	840	200	45	0.23	0.67	12000	4050	135600
7	1200	770	200	70	0.35	0.67	12000	6300	141300
8	1400	690	200	80	0.40	0.67	12000	7200	146100
9	1600	560	200	130	0.65	0.67	12000	11700	146400
10	1800	365	200	195	0.98	0.67	12000	17550	140850
11	2000	0	200	365	1.83	0.67	12000	32850	120000

Note: Price of Y_1 (P_{y1} = Rs.60.00 /kg); Price of Y_2 (P_{y2} = Rs. 90.00 /kg)

A producer should always take advantage of the complementary and supplementary relations and thus, produce at a point where the relationship between the products is competitive. A producer will maximize total revenue at any point in the competitive range where the marginal rate of product substitution is equal to the price ratio.

Figure 3.17: A Graphical Representation of Determining the Optimum Combination of Two Products.