UNIT 1 GENERAL EQUILIBRIUM WITH PRODUCTION

Structure

1.0 OBJECTIVES

After going through the unit, you will be able to explain:

- the meaning of 'Partial Equilibrium' and 'General Equilibrium';
- the concept of Edgeworth box in production;
- Pareto efficiency in production;
- optimal allocation of factors under perfect competition;
- first welfare theorem in production;
- second welfare theorem in production;
- limitations of welfare theorems in production; and
- derivation of transformation curve from general equilibrium in production.

1.1 INTRODUCTION

In Unit 8 of Intermediate Microeconomics-I course in Semester III, you were introduced to the concept of general equilibrium in a pure exchange economy. There we considered a case of two goods and two consumers endowed with some amounts of both the goods. The assumption of no production was also made, and general equilibrium resulted from mutual exchanges of the two goods between the two consumers till a Pareto efficient allocation was reached as a competitive equilibrium. We also came across the two most fundamental results of general equilibrium analysis—the first and second welfare theorems. Now we add production to this model. In other words, consumers will not just be exchanging goods to reach a Pareto efficient allocation; producers will be producing those goods as well—turning factors of production into final consumption goods. As it turns out, this adds some complexity to the analysis of general equilibrium.

In this unit we will focus on general equilibrium analysis wherein we will study a complex problem of attaining equilibrium simultaneously in all the markets where demand and supply in the markets of related goods interact to determine equilibrium prices and quantities. This is a more realistic view and a comprehensive analysis of the economic system as we always expect inter-relationships and inter-dependence among different markets for commodities and factors and the decision-making agents such as consumers, producers and resource owners.

1.2 MEANING OF 'PARTIAL EQUILIBRIUM ANALYSIS' AND 'GENERAL EQUILIBRIUM ANALYSIS'

Let us first revisit the concepts of partial and general equilibrium. In Economics a distinction is made between *Partial* equilibrium and *General* equilibrium analysis. Partial equilibrium analysis is a study of individuals, that is, it involves studying a single good market, a single factor market, a single consumer or a single producer in isolation. Under partial equilibrium analysis, we explain the determination of equilibrium price and quantity of a product or factor through its demand and supply ignoring the prices of and market conditions for other related goods. This is based on the assumption that the price of other products or factors does not change when there is some change in the price of the commodity under consideration.

Therefore, the analysis in which we do not consider the inter-dependence of product and factor markets and the prices of other related commodities and factors is called *Partial Equilibrium Analysis*. Utility maximisation by an individual, cost minimisation by a producer, equilibrium analysis of tea industry or textile industry are all examples of partial equilibrium analysis. However this is not realistic scenario because markets are generally inter-related and inter-dependent, and change in the price of related goods has repercussions on the demand and supply of commodity under consideration. For instance, equilibrium analysis of automobiles market cannot be studied in isolation of the changes in petrol market.

A more appropriate analysis that takes into account the inter-relationship and inter-dependence between different markets and studies the determination of equilibrium simultaneously in all the markets is called the

General Equilibrium Analysis. General equilibrium analysis is a study of simultaneous equilibrium in all the markets and considers all prices as variable. Under it, an economy is studied as a closed system, with all prices being determined simultaneously. General equilibrium analysis takes into account the effect of change in price and market conditions in other goods' markets on the price of the good under consideration. For instance, it takes into account the effect of change in the price of petrol on the demand of automobiles, as change in price of petrol is expected to have a strong impact on demand for automobile— a link which is ignored under partial equilibrium analysis.

Check Your Progress 1

1) Distinguish between Partial equilibrium and General equilibrium analysis.

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2) General equilibrium takes into account inter-dependence and inter-relationship between different markets. Comment.

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1.3 GENERAL EQUILIRBIUM WITH PRODUCTION

General equilibrium is concerned with analysing all the markets, along with considering the mutual dependence between them. In Unit 9 of Intermediate Microeconomics-I course, we discussed the concept of General equilibrium in a pure exchange economy with the assumption of no production taking place. The consumers were actively trading to reach a general equilibrium where we discussed Pareto optimality (Pareto efficiency) and market equilibria and showed the crucial connection between Pareto optimality and market equilibria as captured in the first and second fundamental theorems of welfare economics. Recall that the first theorem broadly says that a market equilibrium is Pareto optimal and the second says that any Pareto optimal allocation can be achieved with the market mechanism. Now in this unit, we discuss the production economy along with market equilibria and identify the Pareto optimal production outcome in that economy. Just like before, the Edgeworth box is employed to capture the essential features of general equilibrium. In the pure exchange case without production, we assumed two consumers A and B, and two commodities X and Y. There general equilibrium entailed Pareto optimal allocation of commodities X and Y among consumers A and B (who were assumed to be endowed with some quantities of both the commodities X and Y). Now from the perspective of attaining general equilibrium with production, we consider two factors of production Labour (L) and Capital (K) that firms employ for the production of the commodities X and Y. To keep the analysis simple and to concentrate on the basic characteristics of general equilibrium with production, it is assumed that—

i) There prevails perfect competition in all the markets.

ii) Both Labour and Capital are available in fixed quantities in the economy.

iii) The technology is given.

Considering the above mentioned assumptions, in the context of General Equilibrium with production, we intend to solve the problem of *Production Efficiency*, that is to determine how much of the capital and labour factors to be used for production of each commodity. Thus, the task under general equilibrium here is to determine equilibrium relative prices and quantities of both the factors employed, labour (L) and capital (K), corresponding to the point at which all markets reach equilibrium simultaneously.

1.4 PRODUCTION EFFICIENCY

1.4.1 Edgeworth Box for Production

Similar to the Edgeworth box we drew for commodity exchange, we construct an Edgeworth box for production in order to visualise production efficiency diagrammatically. A rectangular Edgeworth box with fixed dimensions (given by total endowment of capital and labour) depicts all possible allocations of capital and labour employed for the production of commodities X and Y. Commodity X is represented by origin O_X at the lower-left corner, while commodity Y by O_Y at the upper-right corner. From origin O_X, height of the box (O_XK_0) represents total endowment of capital available in the economy, while its width (O_XL_0)represents total endowment amount of labour available. Similarly, the respective opposite sides from origin O_Y represents the total capital and labour available in the economy. Isoquants with respect to origin O_X (*i.e.*, X_0, X_1, X_2 such that $X_0 < X_1 < X_2$) represent different combinations of capital and labour required for producing a given level of output of commodity X, while those with respect to origin O_Y gives capital-labour production combinations producing a given level of output of commodity Y (*i.e.*, Y_0, Y_1, Y_2 such that $Y_0 < Y_1 < Y_2$). Reaching a final general equilibrium involves allocation of the two factors of production K and L among the production of two commodities X and Y.

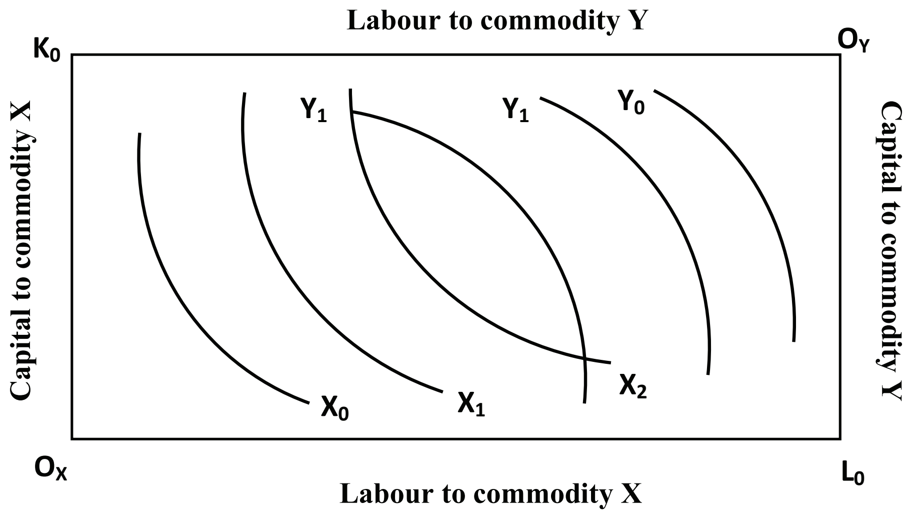

Fig. 1.1: Edgeworth Box with Production

1.4.2 Contract Curve or Efficiency Production Set

Now, consider Fig. 1.2 where point T represent the initial factor allocation among production of commodities X and Y. Here X_1 amount of commodity X is produced using $O_X L_1^X$amount of labour and $O_X K_1^X$amount of capital and Y_1 amount of commodity Y is produced with remaining amounts (*i.e.*$O_Y L_1^Y$amount of labour and $O_Y K_1^Y$amount of capital)of two factors of production. All other points also represent the similar allocation of total amount of both the factors of production. Isoquants representing input allocation for the production of commodities X and Y passing through the initial factor allocation point T form a lens-shaped area (shaded-region). The significance of this lens-shaped area is that every allocation of inputs identified by a point inside this area involves larger outputs of both commodities (called Pareto improvement) than at point T. For instance, point Q can be reached as improvement from point T by increasing production of both commodities. Movement from point T to Q involves shifting some labour from good X to Y industry and some capital from good Y to X industry, increasing outputs of both the commodities at no additional cost. Possibility for such an improvement exists in case of all the points where isoquants for both the commodities intersect.

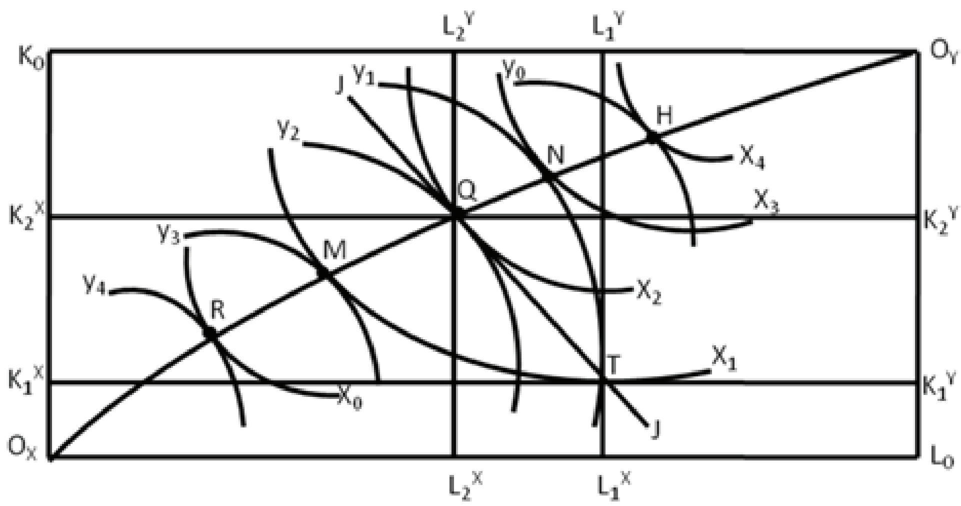

Fig. 1.2: General Equilibrium under Production

As you may notice, at point Q, possibility for further increasing the output of both or any of the commodity X or Y without incurring additional cost in terms of lower output of the other commodity ceases. Such a resource allocation is *efficient* in the sense that output of one commodity cannot be increased without decreasing the output of the other. Indeed, an efficient resource allocation occurs at the point of tangency of the isoquants representing respective commodities, else there exist scope for increasing the production of either or both the commodities through resource reallocation. If we take the locus of all the tangency points of the isoquants from the origins, we get a *contract curve* or an *Efficient Production Set*. In the figure the curve from O_x joining all the tangency points of the isoquants till O_y is the *contract curve*. The general equilibrium, that is, when all markets are simultaneously in equilibrium will lie somewhere on this contract curve. Any point other than the one on the contract curve cannot be a point of general equilibrium as there will always be a scope for improvement in terms of increased total output. Let us understand this by considering point T in Fig. 1.2. As one may notice in Figure 1.2, movement from point T to any point like N, M or Q will lead to increased production of commodity X, Y or both, respectively. Thus T cannot represent an efficient resource allocation.

1.4.3 Pareto Efficiency in Production

Pareto efficiency in production implies factors of production should be so allocated that through any reallocation it will not be possible to increase the output of any one commodity without decreasing the output of the other commodity or to increase the production of both the commodities together. Such an allocations lies on the contract curve where slopes of the isoquants representing resource allocation possibilities of commodities X and Y are equal, that is where the isoquants are tangent to each other. Slope of an isoquant is given by the Marginal rate of technical substitution between capital and labour for production of a good ($MRTS_{LK}$), hence at an efficient resource allocation point

$$MRTS^X_{LK} = MRTS^Y_{LK}$$

The above condition reads— *marginal rate of technical substitution between capital and labour for production of good X is equal to marginal rate of technical substitution between capital and labour for production of good Y.* Given an initial resource allocation between commodity X and Y (here point T), a reallocation of factors for the production of both the goods to reach a tangency condition of isoquants (like point Q) exhausts all Pareto improvements possible over the initial allocation condition. Allocation like Q represents *Pareto efficiency* in production.

However, on the contract curve you cannot tell which point is best as all are Pareto efficient. Which point would be the final equilibrium will depend directly on the initial allocation of resources and other factors like demand and preferences for the final goods, as well as indirectly on the ownership of factors of productions and their relative prices. Also if the initial production occurs somewhere on the contract curve then there is no scope for Pareto improvement. Hence, depending upon the initial allocation, the final equilibrium allocation would vary and is not unique.

Check Your Progress 2

1) Explain the construction of Edgeworth box and show how General equilibrium is attained in production.

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2) What is a Contract curve? How is it the locus of efficient outcomes?

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3) What does determine the final general equilibrium outcome on the contract curve?

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4) Can there be a Pareto efficient allocation where someone is worse off than the initial endowment which was Pareto inefficient?

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5) True or False

   a) Someone can be made better off by moving from one Pareto efficient point to another Pareto efficient point.

b) Someone can be made better off by moving from one Pareto efficient point to another Pareto efficient point without making anybody else worse off.

c) We know the final trading outcome if we know the initial endowment and the contract curve.

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1.5 GENERAL EQUILIBRIUM WITH COMPETITIVE INPUT MARKETS

When there exists perfect competition in factor markets, a point on the production contract curve, that is, the efficient production set will be attained as general equilibrium. This results from the fact that firms in a perfect competitive industry face the same input prices. Here, this tendency means that the wage rate earned by labourers will be the same in the production of commodity X and Y, and similarly for the rental price of capital. Furthermore, every firm will minimise cost by employing inputs in quantities so that $MRTS_{LK}$ equals the ratio of input prices (cost minimising condition requiring equality between slope of isoquants and isocosts). For a wage rate of *w* and a rental price of capital of *r*, the condition for cost minimisation will be:

$$\frac{w}{r} = MRTS_{LK}$$

Geometrically, this equality is shown by the tangency between an isocost line (with a slope of $\frac{w}{r}$) and an isoquant (with the slope $MRTS_{LK}$).In a competitive equilibrium, each producer of commodity X operates at a point where the slope of its isoquant equals the ratio of input prices. Also, each producer of commodity Y operates at a point where the slope of its isoquant also equals the *same* input price ratio. Hence, slopes of the isoquants representing commodities X and Y must equal one another since both are equal to the same input price ratio. That is, in a competitive equilibrium

$$\frac{w}{r} = MRTS^{X}_{LK} = MRTS^{Y}_{LK}$$

Consequently, the competitive equilibrium must lie on the contract curve, which identifies resource allocations where the slopes of isoquants of the two commodities are equal to the factor price ratio. In Fig. 1.2, line JJ passing through the tangency point Q of the two isoquants and the initial allocation point T has slope equal to the factor price ratio ($\frac{w}{r}$).Mathematically, the condition can be established as follows:

Under perfect competition, price of labor (w) and capital (r) is assumed as given and same for all the producers. Producers tend to minimise the cost given by $wL + rK$ (where L and K stands for the units of labour and capital employed to produce output level $\bar{Y}$ respectively) for producing a given level of output $\bar{Y} = f(L, K)$ (output as a function of factor inputs L and K). The constrained optimisation exercise is given by:

$$\text{Min} \qquad wL + rK$$

$$\text{Such that} \qquad f(L,K) = \bar{Y}$$

To solve this, we write down a Lagrangean function ($\mathcal{L}$)

$$\mathcal{L} = wL + rK - \lambda(f(L,K) - \bar{Y})$$

The first-order condition is to differentiate $\mathcal{L}$ with respect to L, K and λ and put the resultant equal to zero.

$$\frac{\partial \mathcal{L}}{\partial L} = 0 \Rightarrow w - \lambda \frac{\partial f(L,K)}{\partial L} = 0$$

$$\frac{\partial \mathcal{L}}{\partial K} = 0 \Rightarrow r - \lambda \frac{\partial f(L,K)}{\partial K} = 0$$

$$\frac{\partial \mathcal{L}}{\partial \lambda} = 0 \Rightarrow f(L,K) - \bar{Y} = 0$$

Rearranging the above equations, we get

$$\frac{\frac{\partial f(L,K)}{\partial L}}{\frac{\partial f(L,K)}{\partial K}} = \frac{w}{r}$$

$$MRTS_{LK}^{Y} = \frac{w}{r}$$

Similarly for output X $\qquad MRTS_{LK}^{X} = \frac{w}{r}$

Therefore, we get

$$MRTS_{LK}^{X} = MRTS_{LK}^{Y} = \frac{w}{r}$$

Hence, perfect competition ensures optimum allocation of resources in the production of two commodities X and Y.

We already discussed the first and the second welfare theorems in Unit 8 of the Intermediate Microeconomics-I course of Semester III. Let us briefly recall them here from the perspective of the general equilibrium with production.

1.5.1 Production and the First Welfare Theorem

The first welfare theorem ensures that any perfectly competitive equilibrium allocation is Pareto efficient. When all producers act rationally to maximise profits under perfect competition, the competitive equilibrium is Pareto efficient. The conditions for the theorem are quite restrictive, as the result holds only if perfect competition prevails. Thus this theorem takes away the possibility of increasing returns to scale. Perfectly competitive equilibrium exists for non-increasing returns to scale. We also assume convex isoquants and concave transformation curves as this assumption is required to fulfill the second order condition of equilibrium. Thus the existence of perfect competition does not confirm the fulfillment of second order condition of equilibrium.

It also assumes that there is no production externalities (that is — one producer's decision does not affect the production possibilities of other firms) as well as, consumption externalities — as this theorem has nothing to do with the impact of production on distribution of income and thus on consumption. It also completely ignores the concept of equity in distribution and ensures only efficiency. In other words, a factor allocation where one producer is allocated with all the factor inputs, could be a Pareto efficient factor allocation (since no other producer can be made better off without harming the producer with all the factor inputs), but definitely not equitable. Further, one important condition for Pareto optimality is the existence of general equilibrium. If all markets are not simultaneously in equilibrium there would always exist a possibility for Pareto improvement. From welfare point of view perfect competition will not result in Pareto optimality if income distribution is not optimal. Also if there exists unemployment or underutilisation of resources, Pareto optimality will not be achieved as any point inside the PPC cannot be Pareto optimal. So Pareto optimality is ensured if and only if there exists full employment of all resources. Therefore, it can be claimed that perfect competition is a necessary but not a sufficient condition for Pareto optimality.

1.5.2 Production and the Second Welfare Theorem

Second welfare theorem states that any Pareto efficient allocation can be rationalised as competitive market equilibrium under certain assumptions. In other words, any socially desirable efficient allocation can be reached by way of the market mechanism (or as a competitive equilibrium) beginning from the endowment modified with the help of lump-sum transfers. This is in response to the distinct issues of efficiency and equity that are not addressed by the First welfare theorem. For instance, a Pareto efficient factor allocation where one producer is allocated with all the factors is inequitable from society's point of view. A redistribution of endowment among different producers will result in a different Pareto optimal allocation which can be relatively more socially desirable depending on the redistributed endowment and can be achieved through the use of competitive markets. However it involves a lot of practical difficulties in redistributing the endowment among different economic agents of the economy.

In an economy any Pareto optimal combination which is considered fair on distributional grounds can be achieved through perfectly competitive markets. So the endowment can be redistributed first and then relative prices can be used to reflect the scarcity. This leads to a policy intervention on equity grounds and is easily done through taxation which involves transfer of purchasing power from one hand to another without physically altering the initial endowment. However if taxation alter the decision of the agents (as happens when labour income is taxed and there is resulting fall in labour supply) then taxes are distortionary in nature. A lump-sum tax is non-distortionary in nature and any Pareto optimal allocation that is considered just by the society can be achieved by imposing such lump-sum tax. Therefore, the important implication of second welfare theorem is that prices must be used to reflect relative scarcity and a lump-sum tax could be in place to achieve just distribution in the society.

1.6 TRANSFORMATION CURVE

A Transformation curve (also called the Production Possibility Frontier) shows the maximum amount of different combinations of the two goods that an economy can produce by fully utilising all its resources. It basically shows the transformation of one good into another by transferring resources between the productions of two goods. The Edgeworth box depicts isoquant map of two commodities in the factor-space. To depict a clear picture in the output-space we need to derive the production possibility curve from the Edgeworth box.

We derive the transformation curve from the contract curve by bringing down the various combinations of the output of two goods produced from fixed endowments of factors of production from the input-space to the output-space. To derive the Transformation curve, consider the contract curve RH in Fig. 1.2. Now refer Fig. 1.3 where we plot point Q' in the output space (Transformation curve) corresponding to point Q on the contract curve that depicts X_2 amount of good X and Y_2 amount of good Y. Next consider point N on the contact curve and the corresponding to that the point N' on the transformation curve depicts the production combination X_3 and Y_1. Similarly, consider point M' corresponding to point M on the contract curve RH. We can, in this manner, capture each point in output space for the corresponding points in the input space along the contract curve. Joining all such points in the output space we obtain the transformation curve TT in Fig. 1.3.

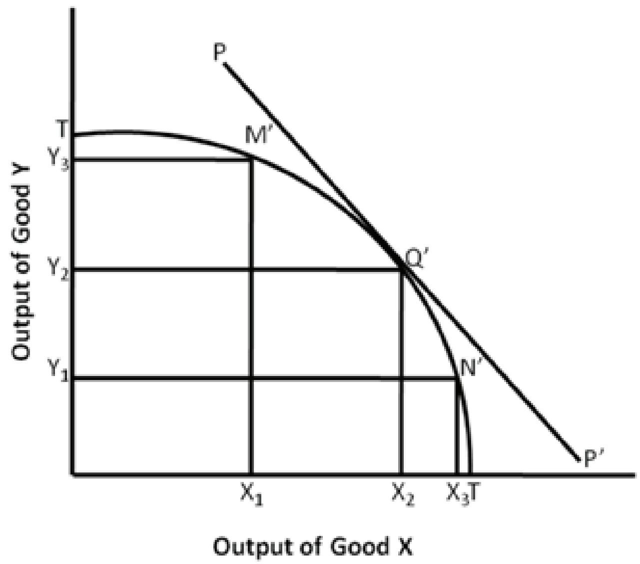

Fig.1.3: Transformation Curve

Important Features of the Transformation Curve

i) The transformation curve represents a set of technically efficient combinations of two final goods that can be produced with fixed endowment of factor inputs. The points inside the curve are feasible but are technically inefficient or in other words, factor inputs are not efficiently employed when such output combinations are produced. Similarly, points outside this curve might be technically efficient and are certainly more desirable than the points on the curve but are not feasible.

ii) Slope of the transformation curve measures the rate of technical transformation from one good to the other (at the margin) known as the marginal rate of product transformation between two goods X and Y ($MRPT_{XY}$). It simply equals the amount of good Y sacrificed by releasing resources from its production to produce additional units of good X. It equals:

$$MRPT_{XY} = \frac{MC_X}{MC_Y}$$

Where

MC_X is marginal cost of production of good X

MC_Y is marginal cost of production of good Y

iii) Transformation curve is concave to the origin because the amount of Y that has to be given up for increasing the production of good X increases as one produces more of good X. This in turn may result from several reasons including:

Diminishing returns, that is, fall in the efficiency with increase in the scale of production. But this might not be true in aggregate.

Differing factor intensities of the products: If we assume, Good X to be capital intensive and good Y to be labour intensive, then marginal productivity of the sector producing good X will decline as more and more labour gets shifted to that sector, and vice versa for the sector producing good Y as more and more capital gets allocated to it. So, even if there is no diminishing returns in each sector, we will get diminishing returns as we force a sector to use a comparatively less technically productive mix of inputs.

All points on the transformation curve are the points of general equilibrium in production as it is a mapping of points from the factor space to the output space. If technology exhibits constant returns to scale then production possibility curve will be a linear function. Suppose Raj can produce 60 chairs in an hour when he produces only chairs. Whereas, when he devotes his time to producing only tables, he produces 30 tables in an hour; though he may produce combinations of both chairs and tables simultaneously as well. On plotting these production possibilities we get the production possibility curve given by the Fig 1.4 (a). The curve is straight-line and downward sloping indicating a linear and a negative relationship between the productions of the two goods. The negative slope indicates the scarcity of the factor resources. Producing more tables require shifting of factor resources out of chair production and thus fewer chairs. Slope of this curve equals $-2\left(=-\frac{60}{30}\right)$, giving the rate at which Raj must give up production of chairs to produce an additional table.The absolute value of the slope measures the opportunity cost of producing an additional unit of table measured in terms of the quantity of chairs that must be forgone.

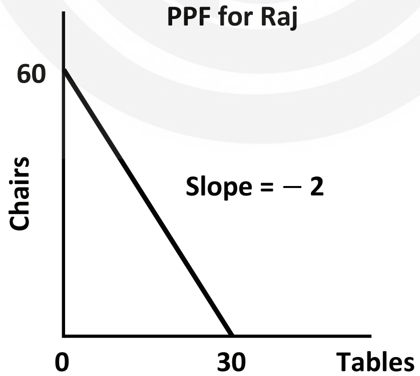

Fig. 1.4 (a): Production Possibility Frontier

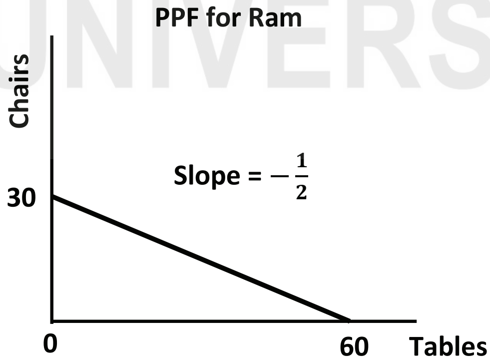

Fig. 1.4 (b): Production Possible Frontier

There is another individual Ram who can produce either 30 chairs or 60 tables in one hour's time. The corresponding PPC is given in Fig. 1.4 (b) with slope −1/2.Clearly Raj has a comparative advantage in producing chairs and Ram has a comparative advantage in producing tables. By comparative advantage it means opportunity cost for producing a chair is lower for Raj (for every extra chair that Raj produces, he has to produce 0.5 units less of table) as compared to Ram (for every extra chair that Raj produces, he has to produce 2 units less of table), and similarly opportunity cost for producing a table is lower for Ram when compared to Raj.

Let us now consider the maximum output of the two individuals combined. If they produce one of the two commodities, then together they can produce either maximum of 90 tables or 90 chairs. In Fig. 1.5 point A represents total chairs produced in one hour when both Ram and Raj produce only chairs and no table. Similarly, point C represents total tables produced when they both produce only tables and no chair. However if they both specialise in producing the good in which they have a comparative advantage (with Raj producing 60 chairs and Ram, 60 tables) a combination represented by point B will be reached. The combined transformation curve will now have a kink with Marginal rate of transformation changing from −1/2 to −2 (see Figure 1.5).We see that in the region above the kink, more than 60 chairs (the maximum amount produced by the expert in producing chair, namely Raj) could be produced. So in this region above the kink Raj spends all day on producing chairs while Ram produces the rest. In the region below the kink, more than 60 tables (the maximum amount produced by the expert in producing table, namely Ram) could be produced. So in the region below the kink Ram spends all day on producing tables while Raj produces the rest. This way of dividing up the work between them is the most efficient possible in the sense that it leads to the highest possible combined production possibility frontier.

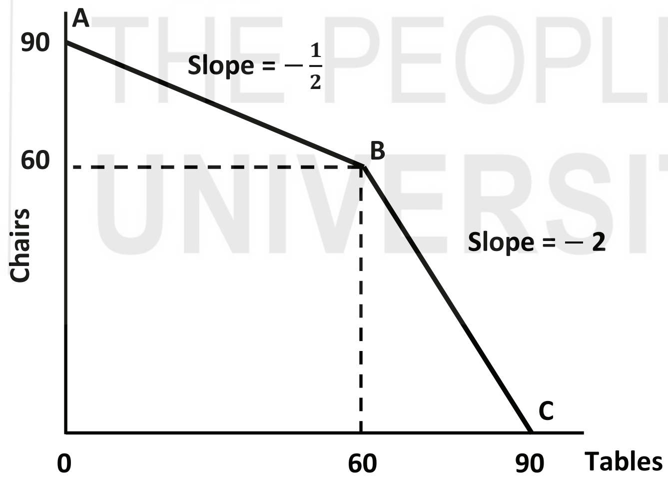

Fig. 1.5: Combined Production Possibility Curve

Check Your Progress 3

1) Define marginal rate of product transformation. Explain why marginal rate of product transformation of one good into another equals the ratio of their marginal costs.

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2) Derive the transformation curve using the concept of general equilibrium in production.

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3) Suppose in an economy there are two individuals, Robinson and Friday who can produce using only one factor of production i.e. labour. Answer the following:

   i) Robinson using all his labour can produce either 5 units of food or 10 units of clothing per day and Friday can produce either 10 units of clothing or 15 units of food a day. Derive the production possibility frontier for such an economy using the information.

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1.7 LET US SUM UP

In this unit we have studied the difference between partial equilibrium analysis and general equilibrium analysis. Partial equilibrium analysis is a study of a single market whereas general equilibrium is concerned with equilibrium in all the markets simultaneously. We learnt how the Edgeworth Box can be used to study general equilibrium in production and reach the condition of Production Efficiency. Such a condition involves efficient allocation of two factors of production (labour and capital here) for the production of two goods (good X and Y here).

The concept of Pareto optimality is an important condition for optimal allocation of factor resources in a general equilibrium. It allows us to reach the condition of general equilibrium where all markets are simultaneously in equilibrium. It eliminates all the possibilities of Pareto improvements. Each party involved exploits maximum possible gain by efficiently allocating factor resources for the production of an efficient output combination given the initial factor allocation among them. A condition is given by the tangency of the isoquants of both the parties involved where the factor price ratio is equal to the slope of the line passing through this tangency point the initial endowment point. We further learnt about the first and the second welfare theorem and its applicability and limitations in general equilibrium with production. We finally derived the transformation curve (or the PPF) using the concept of general equilibrium in production and the concept of comparative advantage.

1.8 SOME USEFUL REFERENCES

- Hal R. Varian (2006), *7th edition Intermediate Microeconomics*, Chapter (31-33), East – West Press.
- C.Synder and W.Nicholson (2010), *Indian edition Fundamental of Microeconomics*, Chapter 13 , Cengage Learning India.
- A.Koutsoyiannis (1985), *2nd edition Modern Microeconomics,* Chapters 21-23, English language book society/Macmillian (ELBS).

1.9 ANSWERS OR HINTS TO CHECK YOUR PROGRESS EXERCISES

Check Your Progress 1

1) Refer Section 1.2 and answer.
2) Refer Section 1.2 and answer

Check Your Progress 2

1) For construction of Edgeworth box in 2x2 model for production refer Section 1.4.
2) Contract curve is the locus of tangency points of the isoquants in the Edgeworth box for production. It depicts all Pareto optimal points reaching which eliminates all the possibilities of Pareto improvements. Any factor allocation point on the contract curve is efficient in the sense that no producer can be made better off with any possible factor reallocation without harming the other producer in terms of lower output production.
3) Initial endowment determines the final general equilibrium on the contract curve.
4) No
5) a and c true, b false

Check Your Progress 3

1) Marginal rate of product transformation is the rate at which resources from one good is taken away to produce additional unit of another good.
2) Check the derivation in Section 1.6
3) a) Production possibility curve is kinked.

   b) Individually: 12 hrs, 6.6 hrs. Combined: 8 hrs and 5.2 hrs

   c) Equilibrium at the kink of the PPC.