



**TRAINING
MANUAL**

ANALYSIS OF FOOD MARKETS

10-13th May 2010 | IFPRI offices, ILRI campus, Addis Ababa

The “Training on Food Markets Analysis” is a joint initiative organized by the Ministry of Agriculture and Rural Development (MoARD) of the Government of Ethiopia, the ESSPII program of the International Food Policy Research Institute (IFPRI) and the World Food Program (WFP).

The present training manual is meant to be a learning aid: it expands and provides a written reference to the material taught in the training. Hence it is best used in conjunction with the related Power Point presentations, the Exercises and Solutions. Due to its detailed explanations, it can also be used on its own, as a brief and introductory textbook on the topic of Food Market Analysis.

Reproduction of the material contained in this document has to happen only after explicit consent has been accorded from the three institutions mentioned above.

Table of Contents

Module 1: Basic Concepts in Market Analyses	4
I Basic Concepts in Market Analyses: Markets, prices, demand, supply and market equilibrium	6
II The concept of Social Welfare, Trade and Public policy	22
III Imperfectly Competitive Markets: Monopoly, Oligopoly and Monopolistic Competition	35
Module 2: Price Data Manipulation	38
I Price Data- Types and Their Uses	40
II How to Summarize Data Using Price Indices.....	55
Module 3: Temporal and Spatial Aspects of Markets	65
I Price Changes and Arbitrage	67
II Price Trends, Price Seasonality and Storage	73
III Market Integration	81
IV Integration to the International Market: an Import Parity Pricing Tool.....	86
Module 4: Further Topics.....	90
I Analyze Domestic Food Supply	92
II Terms of Trade Analysis	99

Module 1

Basic Concepts in Market Analyses

Objective of this module

To enable participants understand or refresh the basic concepts and tools of analyzing (agricultural) markets and visualize their policy implications.

Expected Outputs

- Participants will understand or refresh their knowledge of the most commonly used concepts of analyzing the demand side of markets: demand, preferences, indifference curves, budget line, elasticity, income and substitution effects
- Participants will understand or refresh their knowledge of the most commonly used concepts of analyzing the supply side of markets: supply, cost curves, profit maximization, (short and long run) production decisions.
- Participants will be able to analyze and interpret cross price elasticity, income elasticity of consumers goods in Ethiopia; draw conclusions and policy recommendations from such elasticity results

Summary

Part I: Basic Concepts in market analyses: Markets, prices, demand, supply, market equilibrium

- 1.1 Introduction
- 1.2 The Concepts of Demand, Preferences and Elasticity
 - 1.2.1 The budget line and indifference curves
 - 1.2.2 Utility maximization
 - 1.2.3 The demand curve and the law of demand
 - 1.2.4 Price Elasticity of Demand
 - 1.2.5 Market demand curve
 - 1.2.6 Factors affecting demand
- 1.3 The concept of supply: production, cost, and profit maximization
 - 1.3.1 Costs of production and profits
 - 1.3.2 Production decisions
 - 1.3.3 Short Run versus Long Run
 - 1.3.4 Factors affecting supply
- 1.4 Market equilibrium: market prices and change in demand and supply

Part II: The concept of social welfare, Trade and public policy

- 2.1 Consumer and producer surpluses
- 2.2 International Trade: Excess supply and demand
- 2.3 The role of public policy in changing demand and supply: input subsidy & export ban

Part III: Imperfectly Competitive Markets: Monopoly, Oligopoly, and Monopolistic competition

- 3.1 Introduction: market structures
- 3.2 Monopoly
- 3.3 Oligopoly
- 3.4 Monopolistic competition

Part I: Basic Concepts in market analyses: Markets, prices, demand, supply, elasticity, etc

1.1 Introduction

This module summarizes the basic concepts and tools useful to analyze (agricultural) markets and how they relate to policy. This is done by way of answering the following basic questions.

- What do we mean by some commonly used terms: markets, prices, demand, supply, and economic growth (refresher)?
- What are the basic economic tools to analyze markets?
- How can policies improve / distort market performance?
- How do we analyze data / situation to make informed policy decisions?

What is a market?

A market is an institution or mechanism that brings buyers and sellers of particular goods, services, or resources together. The process involves voluntary or mutual exchange between buyers and sellers the final outcome of which is *price*; and the outcome is only as good as the process is able to deliver. Thus, price of a commodity can be *right* only if the process of exchange is right. Thus, a well-functioning market depends on an efficient process of exchange, which depends on a large number of factors. The number of producers and consumers, the level of technology in a given country, infrastructure, institutions, flow of information, and the rule of law—all can contribute to the functioning of a market. Three critical determinants of an efficient process of exchange (*market*) are infrastructure, institutions, and flow of information.

TWO EXAMPLES

Two examples can help explain the significance of understanding the process of exchange. First, the experiences of “*getting prices right*” campaign, which involved dismantling *parastatals* (government market institutions, such as the grain marketing boards in Ethiopia) and allowing market forces to determine prices, suggest that the results of the campaign varied widely across countries. While dismantling of *parastatals* led to higher price variability and reversing of policies in some African countries, it was remarkably successful in China and Vietnam—arguably because they had better infrastructure and institutions.

Second, famines of acute food insecurity have historically been localized phenomenon and many of them are named after a specific region of a country. There are many classic examples of this nature. The 1973 and 1984/85 famines in Wollo and Tigray, and the 2001 acute food shortages (following the

collapse of maize prices) tragically demonstrated how a small decline in food production can trigger massive market failure in the absence of infrastructure, information, and risk mitigating institutions.

1.2 The Concepts of Demand, Preferences and Elasticity

Imagine that there are only two types of people, consumers and producers, in the world. The consumers' interest is to maximize the satisfaction from what they buy and consume, and producers' interest is to maximize the profit from what they produce and sell. When the two interests coincide, an exchange takes place and a "price" is formed (revealed). Pretty simple, isn't it? But, these very simple concepts get really complicated in the real world and sometimes fly beyond the understanding of the smartest of the smarts. Just imagine if we understood the process of exchange with perfect certainty, the world would not have experienced human tragedies from famines and mass starvations! Our endeavors in this module will be to discuss the basic framework for understanding this complex reality. This will no way be comprehensive, but will hopefully help us better understand and analyze the markets and various policy decisions.

Let's begin with some very basic concepts, which some of you might already be familiar with in your previous studies, but refreshing them will be helpful in understanding some of the analytics we will deal with later.

In order to understand the concept of demand, we have to refresh our memories on the following concepts: *budget constraints, preferences, and marginal utility.*

1.2.1 The budget line and indifference curves

The budget line (constraint) simply refers to the income you have at a given time to buy goods and services. Consider the following example. Suppose you have 100 Birrs to spend on two goods, called *Food* and *Nonfood*. Food costs 5 Birr /Kg and nonfood costs 10 Birr / unit. You can spend this 100 Birr in many different ways. Two extreme cases are; (i) buying only food (20kgs) or (ii) buying only nonfood (10 units). But there can be many other combinations in between, which we demonstrate in the graph, as demonstrated in figure 1. The area below the budget line or budget constraint gives what is called consumer's *choice set or budget set*. This budget set contains all the bundles of goods and services that are feasible for the household, given his/her budget limit and prices of goods and services in the market.

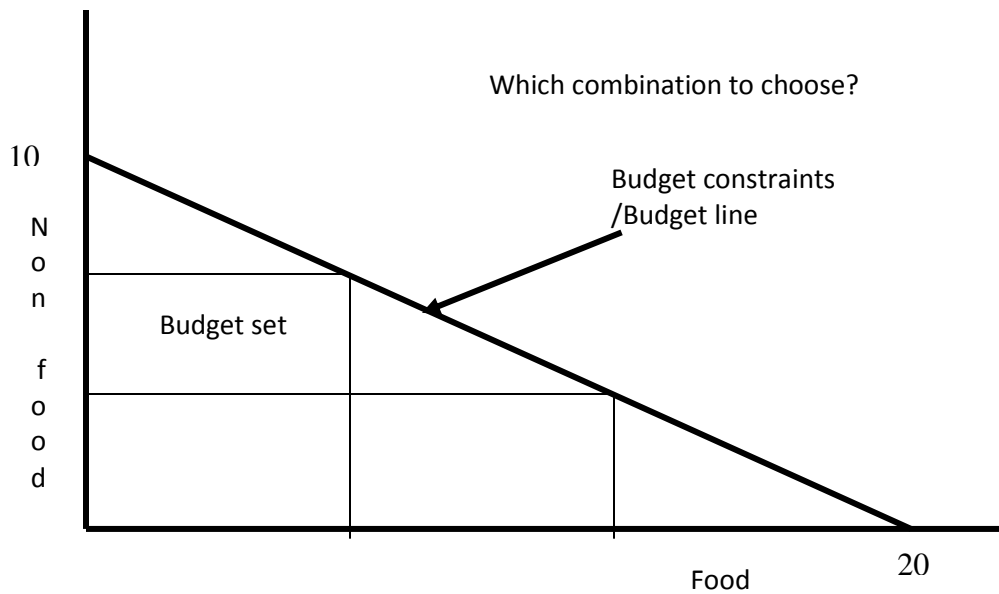


Figure 1: The choice set and budget line

For our understanding, the main question is: which combination to choose?

It is not easy to answer this question because the answer depends on a large number of factors, including our *preferences* for commodities, wealth, services, demography, etc. For example, for a poor household, consuming food is top of its preference list. So, we need some structure to answer this question for which we introduce the *indifference curves* (or simply, *preference curves*), which is introduced in figure 2. The curves convex to the origin are called *indifference curves*. Indifference curves represent the preferences of a consumer between two commodities or bundles of commodities. Indifference curves are useful to visualize consumer preferences among two commodities or bundles of commodities. Again, this is way too simple to be closer to the reality, but it gives us a structure to think.

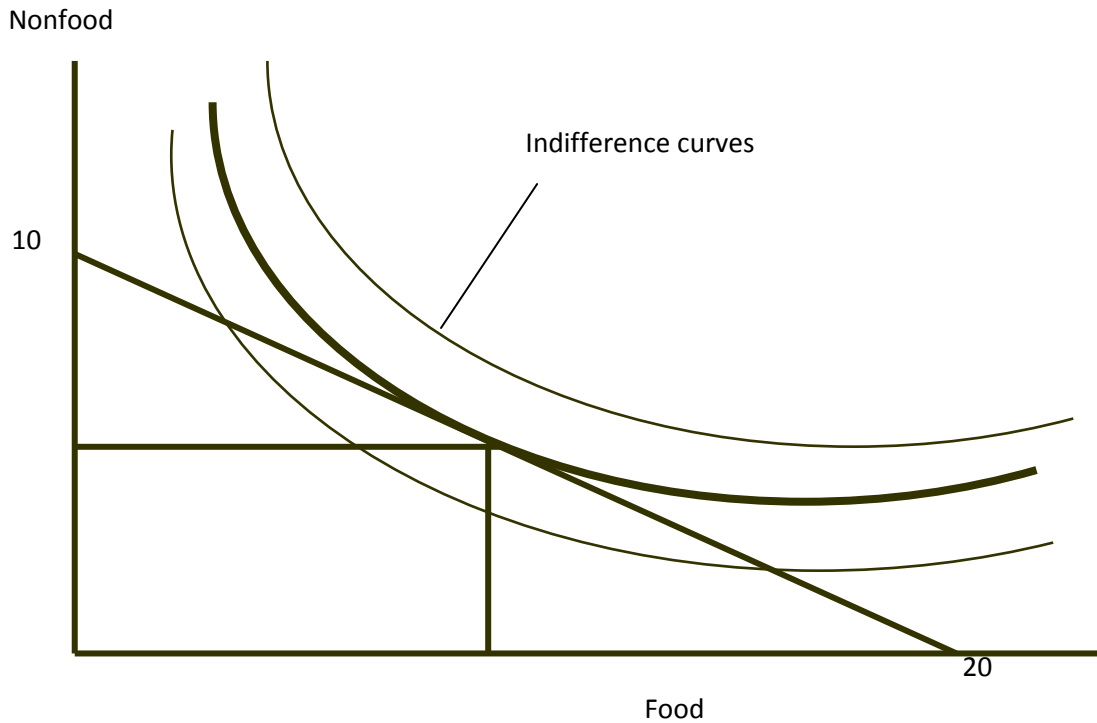


Figure 2: Indifference Curves

Why are *indifference curves* convex to the origin?

This is simple reflection of our choices. It implies that if you have a lot of a given commodity (say A) and very little of another commodity (say B), then you'd be willing to give up more of A to get an additional unit of B. Very realistic, isn't it? This also relates to an important concept of demand theory, called the *law of diminishing marginal utility*, which states that the more you consume a commodity the less satisfaction you get from an additional unit of it.

Indifference curves have the following properties: (i) All combinations of goods on the same indifference curve give the same level of satisfaction (ii) higher indifference curves represent higher level of satisfaction (and you need higher income to reach there) and vice versa, (iii) they do not intersect, and (iv) as stated before, they are convex to the origin.

1.2.2 Utility maximization

We have now discussed the two important concepts in demand theory: the *indifference curves* and the *budget constraint*. We can now answer the basic question, "How do consumers decide which combination to choose?" The answer lies behind the idea that consumers always want to maximize their utility, i.e., strive to obtain the highest level of satisfaction out of what they have. This happens when consumers choose a consumption bundle on the boundary of the choice set, not inside it. This is given by any combination where the indifference

curve is tangent (touches) to their budget constraint. (Why?) Because consumers *cannot* consume at the curves that are above this point (don't have the income) and *wouldn't* consume at any point on the curve that are below this point because that would give lower satisfaction.

What will happen if income increases / decreases? Show it using graph.

Remember our objective is to derive the *demand curve* and we are almost there! We just need to introduce one more concept. How will a price change affect our diagram assuming income does not change? Suppose price of food now increases from 5 birr /kg to 10 birr/kg. How will this price increase change the budget constraint? The budget line will rotate to the left (See Fig. 3a). Why? This is because, with the same 100 Birr income, the consumer will now be able to buy only 10 kg of food, instead of 20 kg. This means, the consumer will now be able to buy less of food, or less of both food and non-food, depending on the relative preference of both at the new market situation (due to the new price). We will come back to this point in subsequent sections.

1.2.3 The demand curve and the law of demand

We now note that the changes in the price of a good or service affects the quantity demanded at the utility maximizing point. Note the move of the equilibrium (tangency point) from point A to Point B on Fig. 3a. On another x-y plane (see fig. 3b.), this results to a move from point A to point B, which defines the relationship between price and quantity demanded of food. This relationship defines the demand function or curve. Thus, the demand curve is derived from the consumer behavior's utility maximization: the law of demand states that, other things (including income) remaining the same, quantity demanded decreases as price increases, and vice-versa. This inverse relationship between demand and supply defines the demand function.

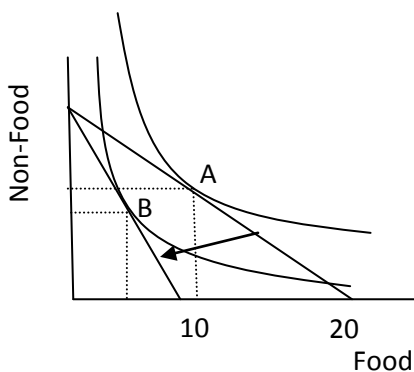


Figure 3a: Budget line rotates to the left

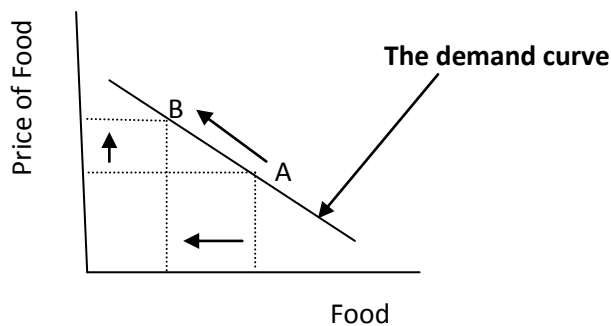


Figure 3b: Derivation of demand curve

1.2.4 Price Elasticity of Demand

Does the shape and location of the demand curve matter? Yes, greatly! To examine, we need to introduce the concept of *price elasticity of demand*. Simply put, price elasticity of demand is the percentage change in quantity demanded due to percentage change in price. Formally,

$$E_d = \frac{\% \text{ Change quantity demanded}}{\% \text{ change in price}}$$

The law of demand suggests that price elasticity of demand is *almost always* negative (Why?). Furthermore, unlike slope of a curve, the estimate of price elasticity of demand is always free from the units of measurement. To illustrate, consider the figure below, which shows two identical demand curves. The only difference between the two is that quantity demanded is measured in kgs on the graph on the left and in ounces (simply said, other unit of measurement) on the graph on the right. Suppose that a typical Ethiopian household consumes five kg of *teff* when price 6 Birr/lb and 10 lb when price is 3 Birr/lb. Price of teff in December was 3 Birr, but increased to 6 Birrs in January. Now if we calculate the numerical value of the slope and elasticity, we shall see that the numbers are very different.

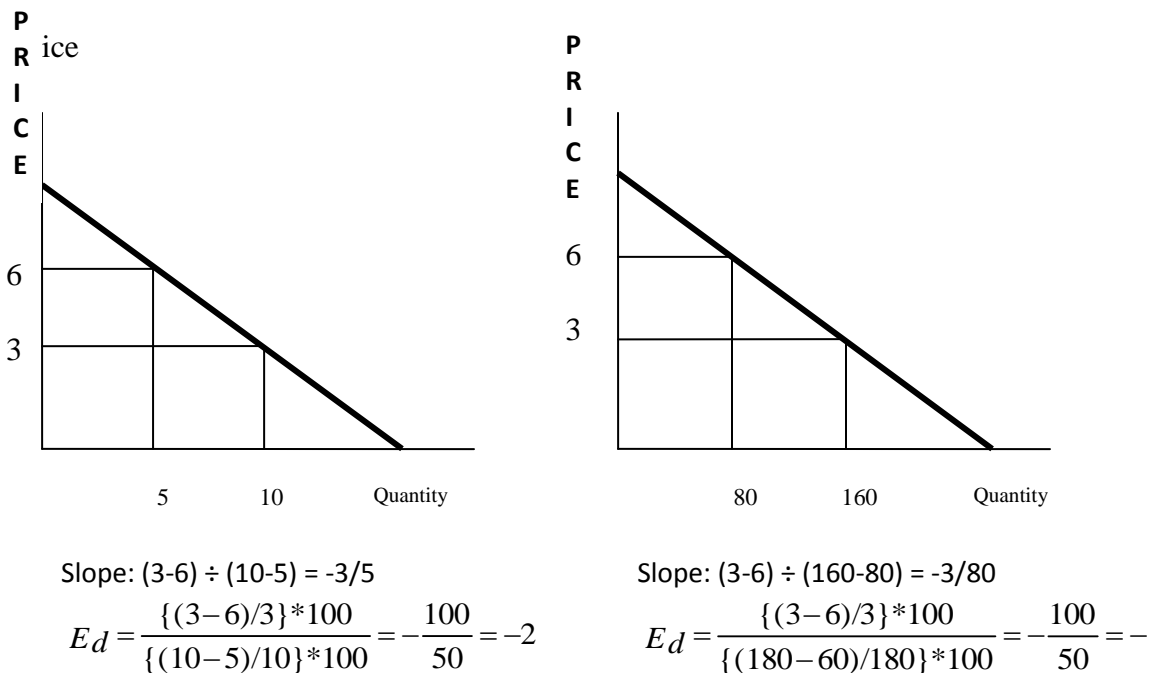


Figure 4: Price elasticity of demand vs. the slope of demand curve

What if, instead of increasing, price of Teff decreased from 6 Birr /Lb to 3 Birr /Lb? Would you still have the same elasticity? Work it out. What do you find?

So, we need to change the formula a little. To overcome this inconsistency, the formula is revised as follows: Change in quantity demanded = $(Q_1 - Q_2) / \{(Q_1 + Q_2)\}/2$; and change in price = $(P_1 - P_2) / \{(P_1 + P_2)\}/2$. Thus,

$$E_d = \frac{\Delta Q}{\Delta P} \cdot \frac{P_1 + P_2}{Q_1 + Q_2}$$

All we have done here is basically changing the base in calculating the percentage change (from original value to averages).

Some facts about price elasticity of demand:

- Price elasticity of demand is different at different points on the demand curve. If you divide the curve into two equal parts, it is elastic in the top portion and inelastic in the bottom portion.
- The steeper the demand curve the more inelastic the demand for that commodity.
- Note also that $E_d < 0$, except in few exceptional cases where there is no inverse relationship between price and quantity demanded (called, Giffen goods). If $|E_d| > 1$, then demand is **elastic**; if $|E_d| < 1$, then demand is **inelastic**; and if $|E_d| = 1$, then demand is **uni-elastic**.

The bottom line question: Why should price elasticity matter to the policy makers?

Because it tells whole lot about the nature of demand, and hence the scope for policy intervention, such as taxing or subsidizing a commodity.

Consider this example. Suppose that the price of bath room tissue in Ethiopia goes up by 100 percent, but since it is used only by the wealthy people, this is not going to change the demand much. However, price of *teff* or wheat goes up by 100 percent, it can create major food security crisis. What do we learn from this? Should governments in developing countries tax their agriculture?

1.2.5 Market demand curve

So far, we have discussed what an individual consumer's demand curve looks like and how it is derived. However, the market is composed of many consumers in a market or markets and not just one consumer. The next question is therefore to derive the market (or, aggregate) demand curve. In brief, the market demand curve is the sum of all individual demand curves at a given price. That is, the overall quantity demand of the market is the sum of all individual quantities demanded at each going price. For example, the Addis Ababa market demand for teff is the sum of the teff demands of all individuals and households in Addis Ababa plus the demands for teff going outside of Addis Ababa. The derivation of such market demand curve is illustrated in figure 5.

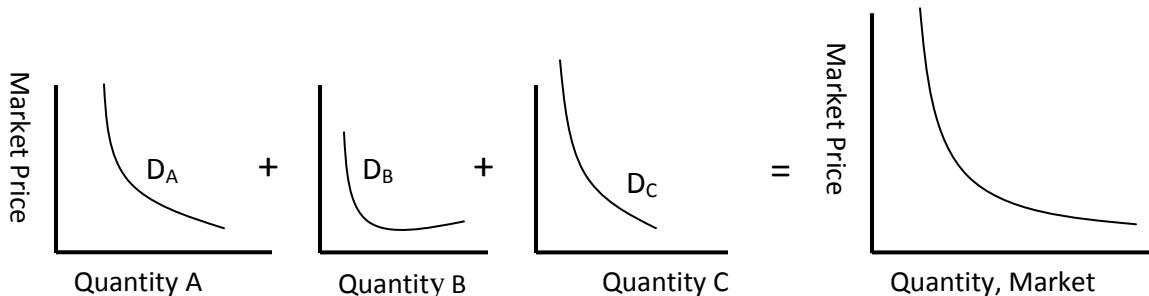


Figure 5: The market demand is the sum of individual demands

It is this market demand that matters in the market price determination. In other words, the interaction of all the factors that determine individual demands (see section 1.6) determine what happens in the market price.

1.2.6 Factors affecting demand

When discussing about 'change in demand', it is important to distinguish between a 'change in quantity demanded' and a 'change in demand' (i.e. between movement along a demand curve and a shift in the level of the curve). It is also important to distinguish between the idea of shift in demand and structural change in demand.

Change in quantity demanded, or simply movement along the same demand curve arises only due to changes in the price of the product itself. In figure 6, an increase of price of the product from P_0 to P_1 results in reduction in the quantity demanded of the product from Q_0 to Q_1 . This means a movement from point A_0 to A_1 on the same demand curve A .

Change in demand, or simply 'shift in demand' arises due to several factors that determine the position (or level) of the demand curve. This can be designated as a movement from A to B or A to C in Figure 6.

In order to illustrate the concepts and the effect of demand determinants, let us assume a simple demand equation in which quantity (Q) is a straight-line function of its price (P) and of consumer income (Y):

$$Q = \alpha - \beta P + \gamma Y$$

Where: α , β and γ are parameters that indicate how the variables are related.

Therefore, at a given income level, one can relate the relationship between price and quantity demanded as follows:

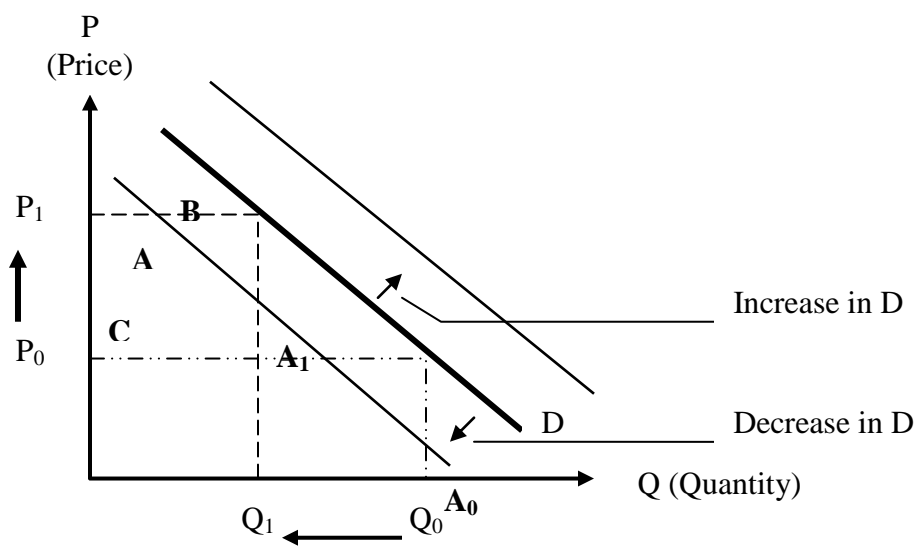


Figure 6: Change in demand vs. change in quantity demanded of a product

In general the major factors influencing the level of demand are grouped into four:

- Consumer income and its distribution
- Consumer tastes and preferences
- Population size and its distribution by age, sex, geographic area etc
- Prices and availability of other commodities and services

These factors are commonly called determinants of demand. For a given level of a demand function, these factors are assumed to be constant but with the passage of time, changes in demand are important aspects of price changes. Let's discuss these factors one by one.

Effect of income change

A demand curve relating quantity (Q) and price (P) can be drawn for a fixed level of income Y (Figure 6). If the level of income changes the demand curve shifts to a new level, which is a parallel shift to the right if the income increases or to the left if income decreases. However, it is possible that one or more of the parameters (α , β and γ) may change. A change in one or more of the parameters is a **structural change**. Structural change may also result in a change in the algebraic form of the demand equation.

Effect of change in consumer taste and preferences

A demand curve assumes a given set of taste and preferences. As long as tastes and preferences remain unchanged, relationships between price and income and quantity also remain unchanged. In general, a change in individual's tastes and preferences is the major source of structural change for a consumer demand curve. Tastes and preferences of individual consumers may change for a variety of reasons such as age, education, experience, and advertising.

Effect of changes in population size and patterns

Increased rate of population growth is linked with increased demand for a product. Population growth is one of the most important factors determining aggregate prices in a country. For example, among other things, population growth is deemed as one factor for the recent food price rises in Ethiopia. A study by Dorosh and Ahmed (2009) indicates that per capita availability of wheat in Ethiopia increased by only 14 per cent between 2000/01 and 2007/08 despite an increase in wheat production by 52 per cent in the same period. This is partly because population has increased by 21 per cent in the same period. Given the limited wheat imports in this period, the high population growth increased real prices of wheat by 30 per cent in the same period. Government imports and sales of wheat in 2008-09 has however effectively increased domestic supply and lowered market wheat prices from extremely high June 2008 levels.

In general, the price of a commodity is influenced by the number of people consuming it. Livelihood patterns and age distribution of the population therefore matter in determining the demand for a product. Change in regional population distribution or the proportion living in urban areas may influence the demand for certain types of commodities. In Ethiopia, for example, Teff is consumed mostly in urban areas. Studies show Ethiopia's urban population has grown by four folds from 3.7 per cent in 1984 to 14 per cent in 2007 (Schmidt and Kedir, 2009). Ethiopia's urbanization is much faster in recent years mainly due to infrastructure development and market access. This will definitely increase the demand for teff and other urban goods for that matter. Regarding age distribution, for example, baby food manufacturers face

increased demand in places with population boom as compared to places with aging population. A change in ethnic composition of a population can also bring a shift in demand for certain commodities taking into consideration traditional habits.

Effect of change in prices of other products

The demand for each commodity is a function of not only its price but also the prices of every other commodity and service. Therefore, a change in the price of one commodity can bring a shift in the demand of other commodities. The direction of change in demand depends on the direction of change in the price of the related commodity and on whether the related commodity is a *substitute* or *complement*. For substitutes, the change in the price of the substitute and the change in the demand are usually positively related, whereas, for complements the change in the price of the related commodity and the change in demand are usually inversely related. An important shifter of demand for some of the agricultural products has been the development and introduction of new products. Artificial fibers have substituted for natural fibers such as cotton and wool. In rural areas of Ethiopia, Enjera is made by combining teff and sorghum or teff and wheat. In such cases, teff and sorghum or teff and wheat are complements of each other.

Length of runs in demand theory

Static demand theory assumes instantaneous adjustment to price changes. However, there are a number of reasons why we do not expect instantaneous adjustment as the quantity demanded at a given price is likely to change gradually over time. The impediments to quick adjustment in the quantity demanded in response to a price change include such factors as imperfect knowledge, consumer uncertainty, technological and institutional barriers, and rigidities in consumer habits.

The distinction in demand theory between *short and long-run* is then related to the period required to adjust in the quantity demanded due to a change in price. The long-run is usually defined as the time required for a complete quantity adjustment to occur in response to a once for all price change.

1.3 The concept of supply: production, cost, and profit maximization

So far, we have discussed the demand (consumer) side of the market. Let's now turn to the other side of the market, namely, the supply (producer) side.

Again, our focus here will be the derivation of the individual and market supply curves. As mentioned earlier, our demonstration will be based on the assumption that markets are competitive (e.g., small farmers in Ethiopia). Note that the primary nature of competitive markets is that *no single producer influences the market*. This will require understanding the following basic concepts:

1.3.1 Costs of production and profits

Fixed Costs: Costs that do not change with output

Variable costs: Those costs that change, or vary, with the level of output.

Total costs: Sum of fixed and variable costs

Average and marginal costs

Average costs is the total costs divided by the output produced and *marginal costs* is the increase in total costs that results from producing one additional units of output.

Profits

$$\begin{aligned}\text{Total profit} &= \text{Total revenue} - \text{Total costs} = \text{TR} - \text{TC} \\ &= \text{Price} \times \text{Quantity} - \text{AC} \times \text{Quantity}\end{aligned}$$

Average and marginal revenue

Average revenue is the total revenue divided by output sold (PQ/Q); and *marginal revenue* is the increase in revenue that results from selling one additional unit of output.

1.3.2 Production decisions

Remember producers produce to maximize profits; and profit is maximized when the following condition is fulfilled:

$$\text{MR} = \text{MC}$$

Related decisions: (i) If $\text{MR} > \text{MC} \rightarrow$ keep producing until $\text{MR} = \text{MC}$;

(ii) If $\text{MR} < \text{MC} \rightarrow$ keep reducing production until $\text{MR} = \text{MC}$

In a competitive market, a producer has to accept the price that is available in the market. Therefore, both marginal revenue and average revenue for a producer in such market is equal to the price. The figure below represents production decision of a typical competitive firm.

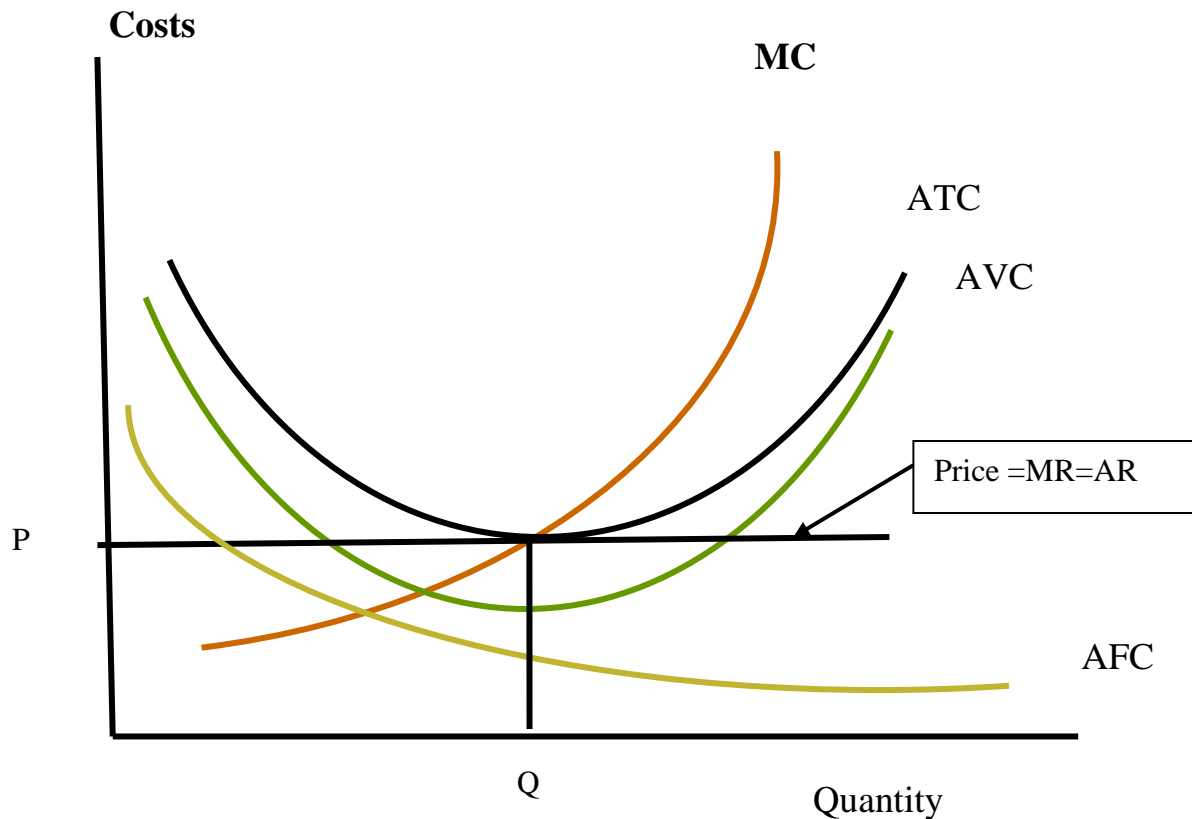


Figure 7: Production decisions in the short run (perfect competitive)

A few questions:

- (a) Should the producer produce more than Q? If not, why not?
- (b) Should the produce less than Q?
- (c) What if market price falls below P?
- (d) When will the producer shut down his / her business?

When the firm is producing at Q, total profit = $TR - TC = PQ - AC \times Q = 0$.

If profit is zero, why is the producer continuing to operate?

To explain this, we need to introduce the concept of two types of profit, namely *economic profit* (also called super normal profit) and *normal profit*. In our diagram, it is the economic profit that is zero, not the normal profit. Why? This is because in constructing the costs, we include value of firm owners' time and capital. That is, at price P and quantity Q, the owner recovers all the costs plus a salary for himself. This means, all production inputs and capital are getting their marginal contribution (opportunity cost), which they would have earned had they been employed elsewhere. As a result it's worthwhile to stay in business.

1.3.3 Short Run versus Long Run

Production decision of a typical firm depends on time, which economists define as *short run* and *long run*. The difference between the two is that in the short run a firm cannot change its technology or fixed costs, but it can do so in the long run.

Production decisions in the short run and long run

There are three important production decisions in the short run.

- If market price is above the minimum of average total costs, firm will make economic profit and will definitely be in business.
- If market price falls below average costs, but above variable costs, a firm can minimize losses by staying in business
- If market price falls below average variable costs, a firm has to shut down its business.

These critical production decisions determine the supply curve in a market. Since a firm stays in business until prices fall to average variable costs, the marginal costs curve above the average variable cost curve is the supply curve of a commodity.

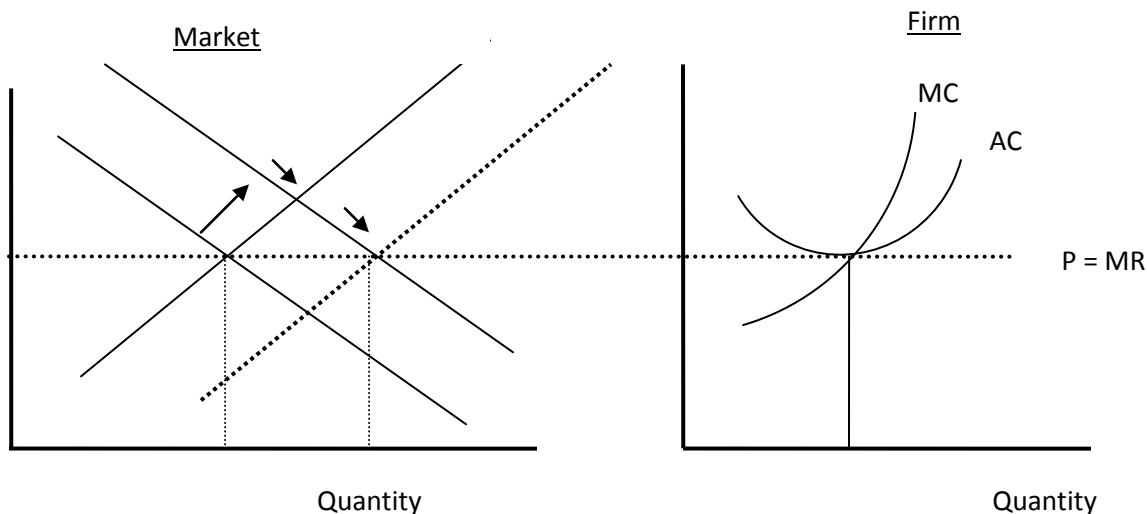


Figure 7: Dynamic market adjustments in the long run

Suppose that, for some unknown reasons, the demand for Ethiopian cheese has gone up, resulting in a rightward shift in the market demand curve. How will it affect a typical cheese firm? Show the effects using Figure 7.

In the short run, the firm will make profits. The neighbors will notice the profits and, understandably, more people will be interested in producing cheese. When that happens, the market supply will increase → a

rightward shift in the supply curve → price will fall → economic profits will diminish—new market equilibrium will be established in the long run with more output of cheese.

What has happened to the economy? Explain?

1.3.4 Factors affecting supply

In general, changes in supply of agricultural products are not significantly explained by the change in product prices. Short-run changes in output are often influenced by the weather condition (e.g. the Ethiopian bumper harvests following good weather conditions) and prevalence of pests, while long-run changes in supply are attributable to factors like improvement in production technology, which result in higher yields. In a similar manner to the demand, it is important to differentiate whether changes in output occur as a result of movement along a supply schedule (change in quantity supplied) or because of change in the supply curve (change in supply). An increase in supply means that a larger quantity will be offered at a given price and a decrease holds the opposite. The principal causes that increase the supply of a product are:

- Changes in input prices
- Change in the returns from commodities that compete for the same resources
- Change in technology that influence both yields and costs of production or efficiency,
- Changes in the prices of joint products (i.e. commodities that are produced together such as wool and mutton)
- Changes in the level of price and/or yield risks faced by the producer
- Institutional constraints such as government ban of production

As with demand relationships, it is useful to distinguish between a parallel shift in the supply curve and a structural change. In order to illustrate, a hypothetical supply function with linear relationships among variables and constant parameters can be written as follow:

$$Q = \alpha + \beta P - \gamma X$$

Where: Q = quantity

P = price of product

X = price of input as a measure of cost and

α β and γ are parameters that indicate how the variables are related.

If the functional form of the supply equation changes (the slope), then it is referred as structural change. Changes in technology, such as the development of a new crop variety and production practices, can result in a structural change.

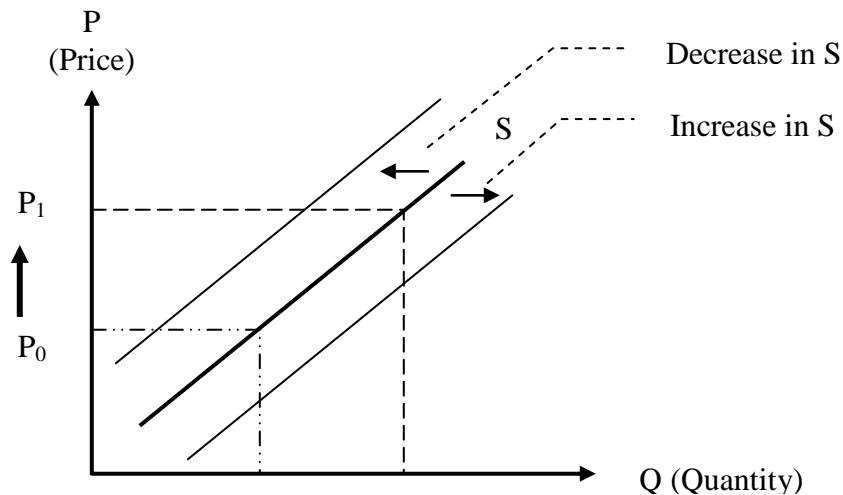


Figure 8: Change in supply and quantity supplied

Effect of input prices

The effect on supply of a change in the product price can be reinforced or neutralized by a change in input prices. Conceptually, as change in own price is treated as a movement along a supply curve, while a change in input prices is treated as a supply shifter. In this regard the product-input price ratios (the relationship between the price of the output and the price of inputs) are important in determining the output of agricultural commodities. In general, as the product-input price ratio increases the supply of the product also increases.

Profitability of competing commodities

The supply of a given commodity decreases if the competing or alternative commodities become more profitable i.e. the supply curve for the commodity shifts to the left. However, it should be stated that in this case the competing commodities are those that can be produced with the same resources (inputs)

Technology

Improvements in the production technology have been the principal cause of long-term shifts in agricultural supply functions. Among the more important technical changes that have increased agricultural supply are the development of high-yielding varieties of crops and improved breeds of livestock; better methods of insects, disease, and weed control; mechanization that makes it possible to plant and harvest more promptly; and better tillage techniques.

Price and yield risks

Risk is an inherent characteristic of life, particularly in smallholder agriculture. There are many sources of risk in agricultural production, e.g., production risk, price (fluctuation) risk. The position of a supply curve is also influenced by these perceived price or yield risks. The greater the risk, the less farmers are likely to produce at a given price. In fact, there is abundant evidence revealing the presence of widespread risk in smallholder (rain fed) agriculture in Ethiopia limits productivity and production and hence supply of agricultural produce. The evidence shows small farmers choose low-risk, low-return production activities so as to avoid large fluctuations in income and consumption. For example, households prefer short duration but low yield crops to long duration but high yield crops to avoid the risk of rain failure; or they tend not to

use chemical fertilizers for fear of low precipitation. There are a number of efforts going on to reduce this risk before and after production decisions take place. The introduction of the Productive Safety Net Program (PSNP) in rural areas of Ethiopia is one effort to protect household asset depletion and consumption shortfalls after shocks occur. The recent efforts to expand small and micro irrigation schemes similarly contribute to the reduction of risk *ex ante*. Such reduction in risk is expected to shift the supply curve to the right by encouraging households to take the right decisions.

Institutional factors

The supply schedule for an agricultural commodity is often influenced by government interventions that directly or indirectly influence the production incentive of the commodity like input subsidy, provision of irrigation facilities and other. After all, the aim of any government policy is to positively influence production and hence supply of (agricultural) produce.

1.4 Market equilibrium: market prices and change in demand and supply

Market prices are set following the interaction between demand and supply in the market under competitive market setup. Any change in either of the demand and supply or both then creates a change in the market price.

Figure 3 depicts the market price and the quantity transacted, which are commonly called equilibrium price and quantity under *competitive market structure* (many buyers and many sellers). Therefore, the equilibrium price is P_0 , at which quantity of Q_0 is transacted. If the demand and supply schedules increase equally, we see no change as to the equilibrium price but the quantity transacted increases (from Q_0 to Q_1).

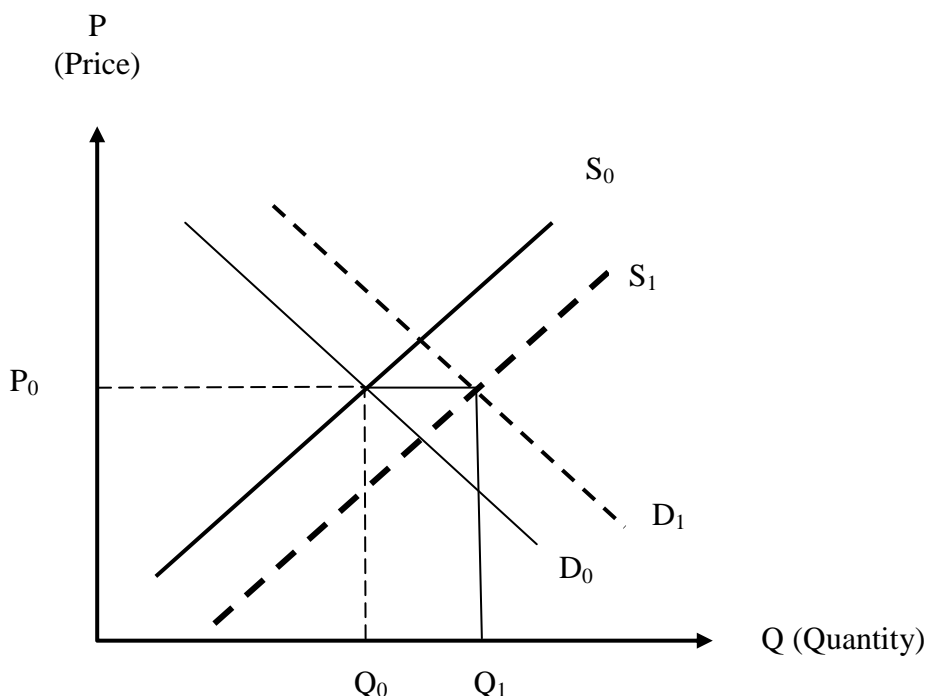


Figure 9: Interaction between demand and supply and market price

Part II: The concept of social welfare, Trade and public policy

2.1 Consumer and producer surpluses

The demand and supply schedules reflect the relationship between prices and quantities at a given income level. However, through market interaction of suppliers and demanders, a single price is determined in a market (which we call equilibrium price), generating benefit for those consumers who are willing to buy at higher price than the equilibrium price and for those producers who are willing to sell at lower price than the equilibrium price. These gains are associated with the concept of consumer and producer surplus, which is depicted below:

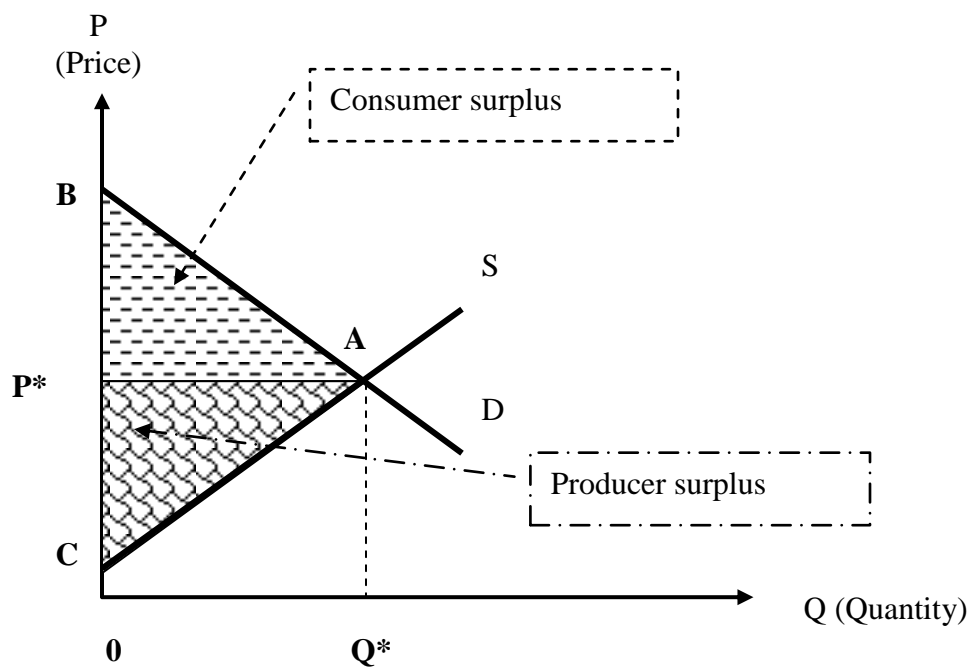


Figure 10: Consumer and producer surplus

The shaded parts of the graph shows both consumers' and producers' surplus. The market equilibrium price is P^* at which producers are willing to sell Q^* amount of produce and similarly consumers are willing to buy the amount. The area BAP^* is the consumer surplus, whereas P^*AC is the producer surplus. Consumers are willing to pay the area BAQ^*0 , however, the actually payment is only P^*AQ^*0 leaving a benefit for the consumers the size of area BAP^* . Similarly, producers are willing to accept CAQ^*0 but they actually receive a size of an area P^*AQ^*0 , leaving a benefit of area size of P^*AC . The stated gains usually vary as the demand and/or supply changes. Mostly the gains to consumers and producers are related with the elasticity of demand and supply.

Table 1: Consumer and producer surplus from domestic trade

Consumers		Producers	
Willing to pay (WTP)	= BAQ^*O	Willing to accept (WTA)	= CAQ^*O
Actually pay	= P^*AQ^*O	Actually received	= P^*AQ^*O
Consumer surplus	= BAP^*	Producer surplus	= P^*AC

2.2 International Trade: Excess supply and demand

The discussion about consumer and producer surplus above assumes a closed economy where there is no trade with other countries or the product is non-tradable. What happens if the product is tradable and the country has trade policy with which it undertakes trade with other countries?

Together with the concept of producer and consumer surplus, excess supply and excess demand concepts are important to understand the effect of policies affecting import and export markets. Excess demand or supply is the difference between domestic demand and domestic supply.

To better understand these concepts, consider two trading countries: A (exporter) and B (importer) of a given commodity, say, food grains. As the two countries get engaged in trade, the domestic equilibrium price increases in country A (Exporter) from P_A to P^* and decreases in country B (Importer) from P_B to P^* , creating welfare gains in both countries. Similarly, the volume of production changes in both countries. In country A, the volume of production increases from Q_{A0} to Q_{AS} , where as in country B, the production decreases from Q_{B0} to Q_{BS} . The level of domestic consumption also changes in both countries, where in country A, the domestic consumption decreases from Q_{A0} to Q_{AD} and in country B, it increases from Q_{B0} to Q_{BD} . The volume of trade is given as follows: Country A exports Q_{AD} to Q_{AS} ; and country B imports Q_{BS} to Q_{BD} (Figure 11).

The global welfare gains due to the price change in both countries due to trade is the area **(a + b) + (d + e)**, where area **(a + b)** is for the exporting country A and area **(d + e)** is for the importing country B (table 2). It can be observed that there is a shift in welfare from consumers to producers in country A and from producers to consumers in country A.

Table 2 Welfare gains from import-export trade

Indicators	Exporter (Country A)	Importer (Country B)
Price change	↑ from P_A to P^*	↓ from P_B to P^*
Production	↑ from Q_{A0} to Q_{AS}	↓ from Q_{B0} to Q_{BS}
Consumption	↓ from Q_{A0} to Q_{AD}	↑ from Q_{B0} to Q_{BD}
Volume of trade	Q_{AD} to Q_{AS}	Q_{BS} to Q_{BD}
Gain for consumers	- (c)	+ (d + e + f)
Gain for producers	+ (a + b + c)	- (f)
Total gain	+ (a + b)	+ (d + e)
Global gain	+ (a + b) + (d + e)	

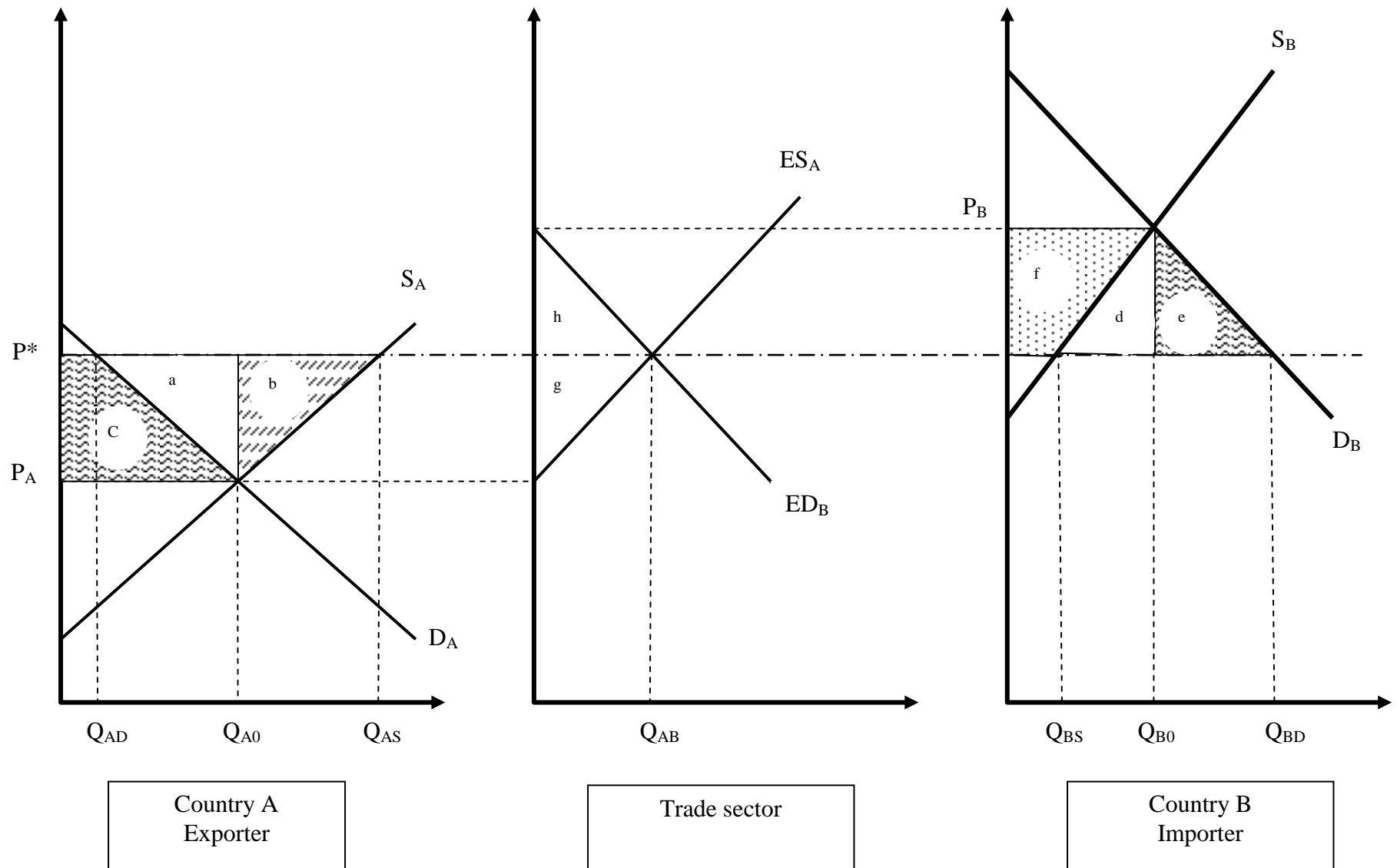


Figure 11: Effect of trade on prices and quantity produced and consumed

2.3 The role of public policy in changing demand and supply

The role of the state in influencing the demand and supply has been considerable due to the specific nature of the agricultural sector. Moreover, it has been justified as means to solve the so-called “farm problem” in developed countries and “food problem” in developing countries. Farm problem arises due to the difficulty in reallocating resources from agricultural sector to non-agricultural sector as means to equalize the inter-sectoral income disparities. The disparity arises due to the slow growth in demand for food relative to the capacity to generate technological progress in food production. The slow growth in demand is in turn the result of low population growth rate, low income elasticity for food, high supply growth. On the other hand, the food problem arises due to excess demand and limited capacity of supply of food resulting from increased population growth, low income (high income elasticity), and inelastic supply.

Thus, the role of the public policy in influencing demand and supply is through direct or indirect influence on the determinants of demand and supply. The influences of the public policy in general and the agricultural policies in particular in relation to agricultural products had two major patterns: developmental pattern, where as the income level of the country increases, there is a tendency to subsidize the agricultural sector and the anti-trade pattern where, for a given level of income, exportables are less protected than importables. In general, there are two major roles of a state. The first role is related to the correction of market failures through productive policies that can be regulatory (like health, land use etc) or supportive like support for research, extension and education. The second role is related to redistribution of income, which is commonly called predatory policy, which is mainly implemented through subsidy and/or taxation.

Policy tools can be grouped into different categories taking into consideration parameters like tools for agricultural input verses output, tools for importers verses exporters, tools that are regulatory verses predatory etc. Taking into consideration the type of policy tool implementing country, the tools that influence supply and demand can generally be categorized into those imposed by importers and exporters either to regulate the domestic market and/or the external trade. Some of the policy tools that can be imposed by importing country are import tariffs, quota, direct production subsidies, import subsidy, and direct consumption subsidy. On the other hand, exporting country can impose export subsidy, production subsidy, noncommercial export, export taxation, export control and embargo. All these policy tools affect either the demand or the supply schedules resulting in change in prices, quantity domestically produced and consumed.

Under partial equilibrium setup and using the consumer and producer surplus concepts, the effect of each policy tool can statically be analyzed. For illustrative purpose simplified examples that are related to the policy tools implemented in the country are here presented.

Input subsidy

In Ethiopia, one of the major tools used to promote improved production and productivity has been provision of modern inputs through subsidy. Among the inputs, improved seed and fertilizer have been the most important ones along with required training and advisory service through the extension program. However, the subsidy of inputs especially for fertilizer and seed has been recently removed

apparently in order to promote the participation of the private sector and also to reduce the financial burden to the government.

In order to illustrate the role of input subsidy and its removal let us consider the Ethiopian maize market. One of the successes of the joint efforts of research and extension demonstrated in Ethiopia is in the maize sector. Following the development of improved maize varieties from the National Research System and effective transfer of these technologies to the producers by the Ministry of Agriculture at different levels and exemplar involvement of SG 2000, the boost in production and productivity of maize in those areas where the technologies reached the farmers have been considerable. This joint effort has resulted in increased production and drastic reduction of maize prices. The extent to which the supply increased normally depends on the achieved level of productivity i.e. the extent to which the parameters of the supply function have changed. This situation is depicted in figure 12.

The policy tools in stabilizing the maize market in the country were an attempt to export the excess production to neighboring countries like Kenya and purchase at a floor minimum price by the public grain enterprise, Ethiopian Grain Trade Enterprise (EGTE). The effect of these policy tools can be demonstrated using the concept of consumer and producer surplus.

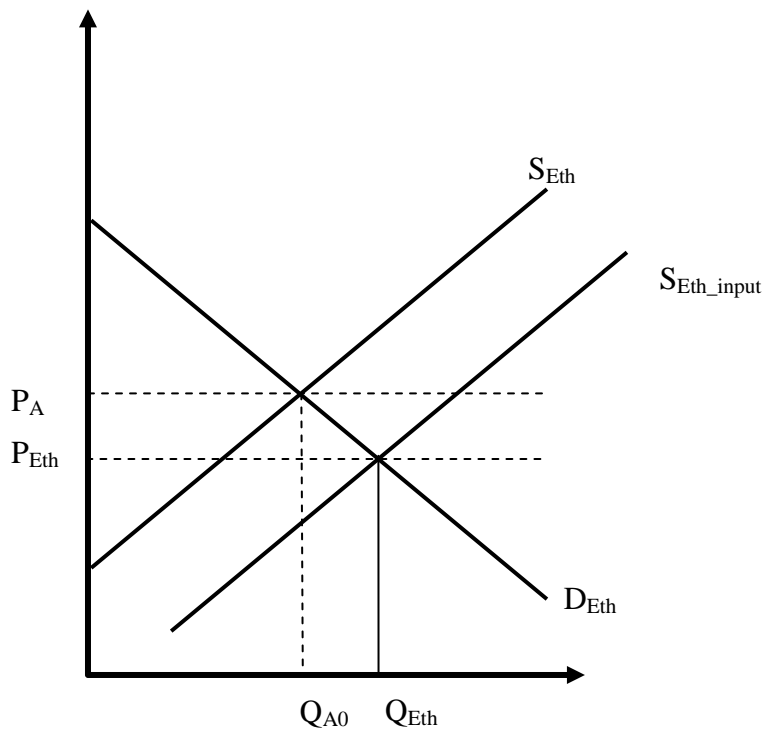


Figure 12: The effect of increase in maize production

First let us see the effect of maize export to neighboring country Kenya without EGTE involvement in market stabilization. As depicted in figure 13, the amount of export from Ethiopia will be Q_{EK} units and the level of domestic consumption Q_{Eth_D} , which is the difference between the total production (Q_{Eth_S}) and the amount exported (Q_{EK}). The price of maize increases from P_{Eth} to P^* , which is the international price for maize (the price in both countries). The stated illustration does not include the most important

component in trade, the transfer costs, which differentiate the price level in both countries. As the transfer costs get smaller the price difference in the two countries also tends to decrease.

The effect of EGTE's participation in the maize market with the objective to stabilize the market is depicted in figure 14. The policy tool used by EGTE is the purchase of maize in the market at a given floor price. Since the floor price (P_{floor}) is greater than the market price, the amount exported will relatively decrease as the excess supply shifts to the left. The international price increases from P^* to P_{floor}^* .

What happens to consumer and producer surpluses in Ethiopia and Kenya? Explain using the graphs.

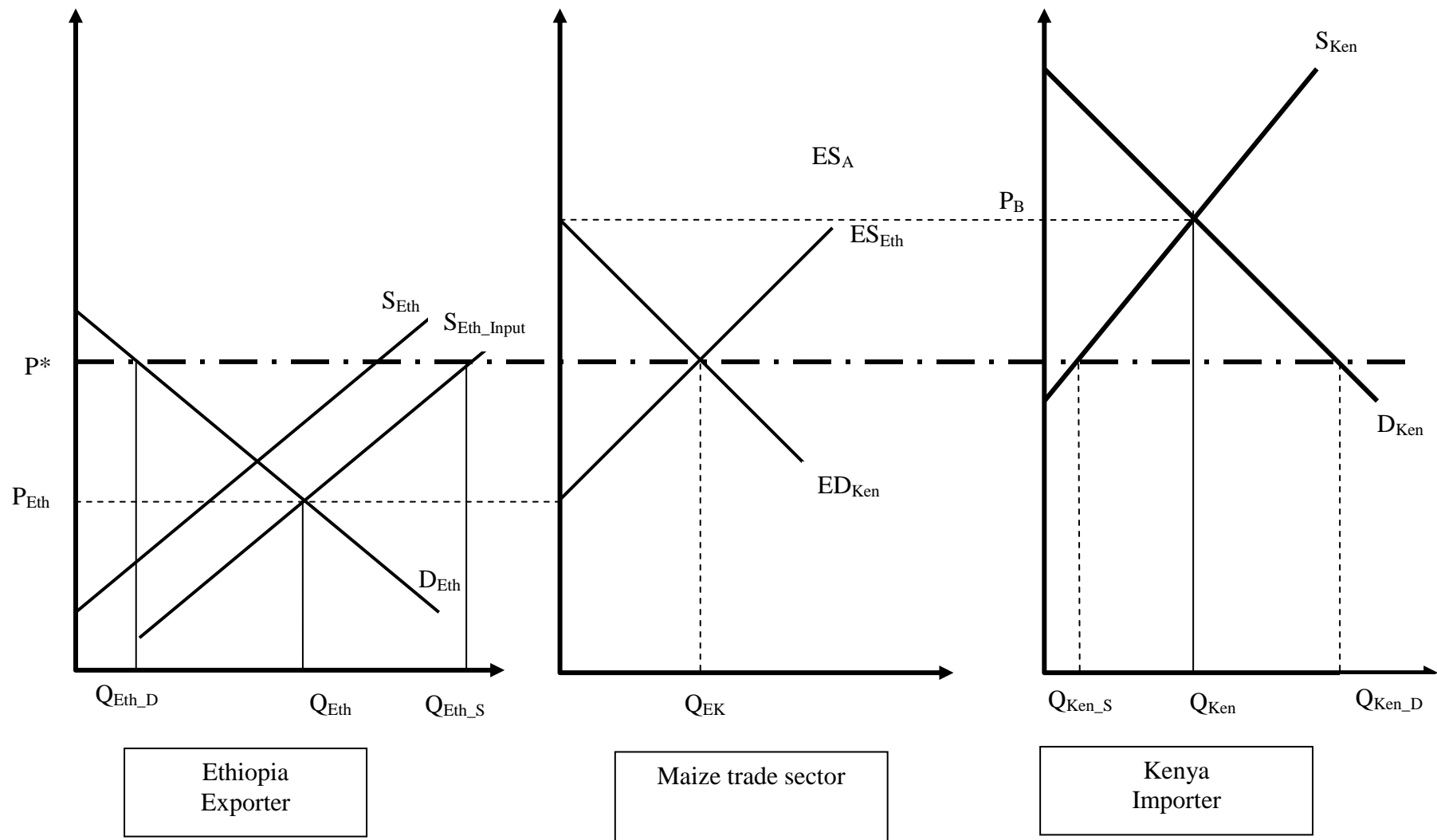


Figure 13: The effect of Ethiopian maize trade with Kenya without EGTE involvement

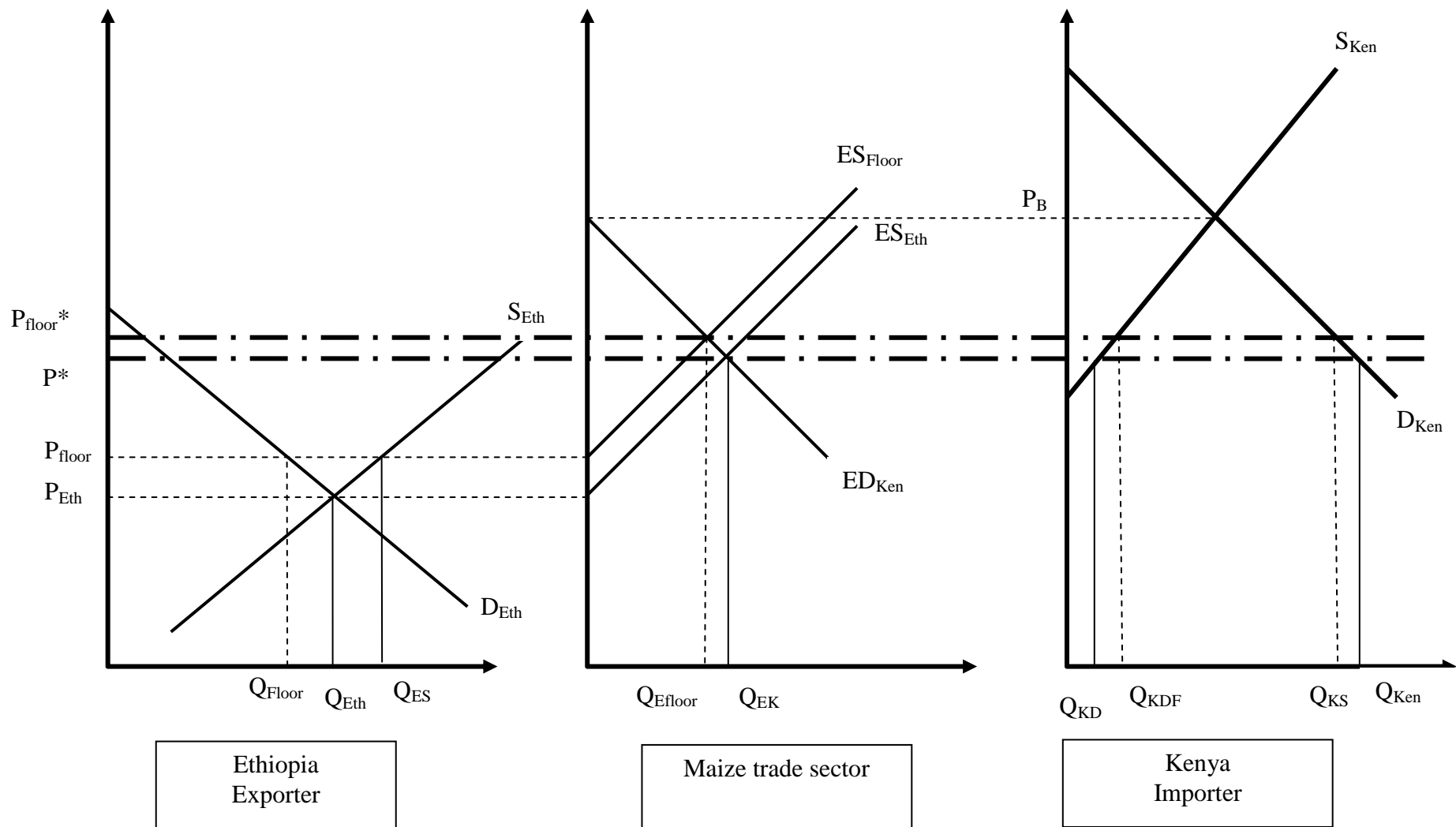


Figure 14: The effect of Ethiopian maize trade with Kenya without EGTE involvement

Export ban of grains

Now let us consider the recent phenomenon in the Ethiopian grain market. Due to the considerable increase in the prices of grains domestically, the government of Ethiopia has recently banned indefinitely the export of grains like teff, maize, sorghum and wheat. EGTE has also intervened to stabilize the grain market by outselling grains at lower price especially in major towns of the country.

We can see the effect of these measures using our simplified maize market example (Figure 15). Let us assume again that the maize export to Kenya is not allowed and EGTE started to sell maize at a price lower than the international price (P_{EGTE}). At the price set by EGTE the quantity demanded in the domestic market would be Q_D and quantity supplied Q_S showing that the difference as excess supply. However, this excess supply can not be exported as there is a ban on exports. Therefore, the total quantity produced (Q_S) will remain in the country. The price, when the total quantity Q_S is supplied to the market will be P_{Eth} , which is lower than even the equilibrium price. One can expect this effect if the factors that determined the price increase are only related to excessive export. However, the price of major grains was still increasing, which shows the driving factors for the price increase seems not related to excessive export.

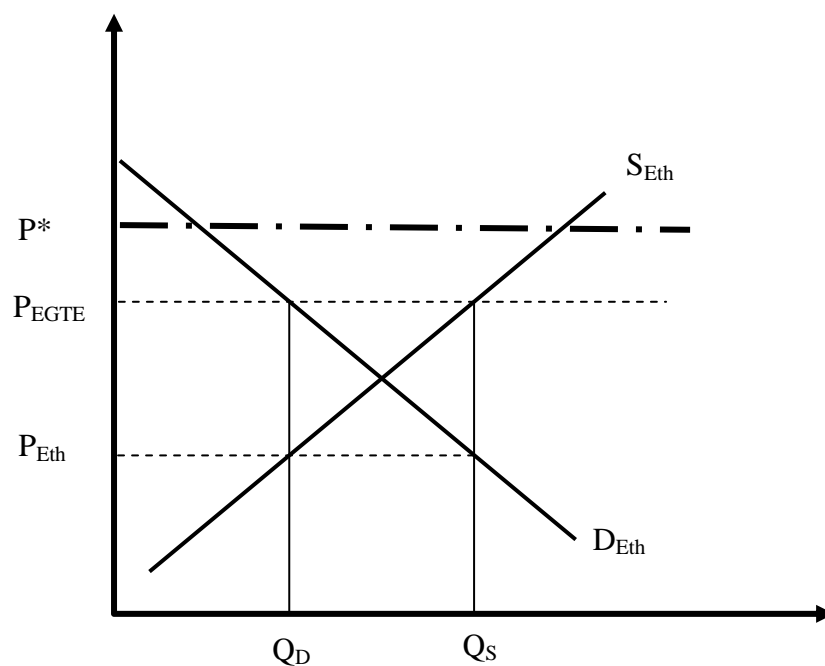


Figure 15: Effect of export ban and EGTE stabilization

Part III: Imperfectly Competitive Markets: Monopoly, Oligopoly, and Monopolistic competition

3.1 Introduction: market structures

The analysis of markets so far was done under one important assumption – that the market is perfectly competitive. In a perfectly competitive market structure, the assumption is that there are many sellers and buyers and no producer or supplier has any influence on the market price. That means, all suppliers are price takers. In other words, price is determined by the interaction between the market demand and market supply. However, under certain circumstances, some suppliers or retailers may have some power over the market. Existence of market power may give them control over the market price determination, and thus prices are not solely the result of market demand and supply but also strategic decisions and interactions among those that control the market power. In such circumstances, we have an imperfect competition, and resulting market price and output supply are very different from the (competitive) one discussed so far.

Coming to the Ethiopian agricultural markets, it can be safely concluded that farmers do not have much control over the price of their produce. They are simply price takers. Nevertheless, it is obvious that there exists substantial market power within the intermediaries of the Ethiopian agricultural produce, mainly the middlemen and the wholesalers. It is thus important to take these differences in market structures when analyzing markets.

Depending on the number and nature of competition among suppliers, economists have identified four types of market structures. These are perfect competition, monopoly, oligopoly, and monopolistic competition. In general, market structures differ in terms of nature of the product (e.g., whether or not there are substitutes for the product), ease of entry into the market, concentration (or number) of suppliers, and nature of competition between suppliers. Perfect competition is an ideal situation where there are large number of small seller (and buyers) of a product, and there are no barriers to entry, and there is no single seller with any form of control in the market. We have discussed this ideal market structure, which is also the basis for analyzing the other market structures. The following sections briefly discuss the three other market structures and compare the resulting market outcomes (mainly, prices, supply and welfare effects) in each situation.

3.2 Monopoly

A monopoly is a market structure in which there is only one producer (or supplier) with full market power for a product. This is an extreme opposite to perfect competition. A typical characteristic of such a market is that other producers or suppliers are unable to enter into the market despite its profit attractiveness. Entry into such a market is restricted due to high costs or other impediments such as economic (e.g., cost of production, resource advantages), legal or social restrictions. A typical characteristic of a monopolist is that it faces the downward sloping market demand curve. Why and what is its significance? The reason is simply the monopolist is the industry and enjoys the market demand curve. Moreover, the monopolist maximizes profits at $MR = MC$, and not $P = MC$ as in perfect competition (see figure 16). Price is then given by the demand curve (P_s in figure 16). The difference between the minimum average cost and this price gives the monopolist an extra (supernormal) profit. This is given by shaded area in figure 16. We can use the concepts of consumer surplus and producer surplus to analyze welfare effects. Note that under perfect competition, sellers get zero profit. The supernormal profit of the profit comes at the expense of lower supply and hence higher price (than perfect competitive) to consumers. This results in loss of consumer surplus (see fig. 17).

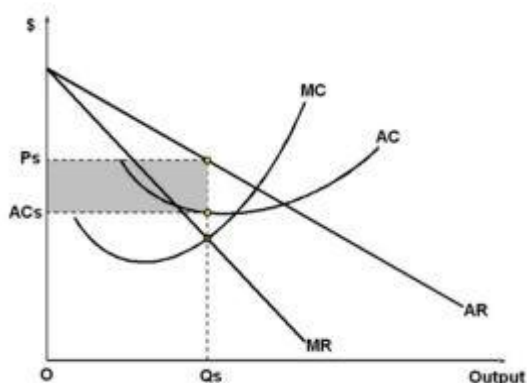


Figure 16: Monopoly profit maximization

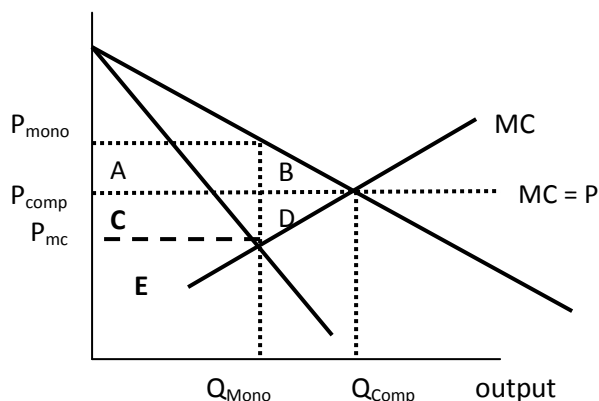


Figure 17: Dead weight loss: Monopoly vs. Perfect competition

Figure 17 gives the comparative price, supply and dead weight losses under monopoly and perfect competition. Note that to simplicity the comparison, the marginal cost curve is now a straight line. The optimal quantity supplied and price for the monopolist is represented by the point where $MR = MC$. In the perfect competition situation, the optimality is given by $P = MC$, and the optimal quantity supplied is Q_{comp} and the price P_{comp} . It is clear from this figure that in a monopoly, less is supplied at a higher price in the perfect competition situation. Profit (producer surplus) for the monopolist is the area under the price line, P_{mono} , above the marginal cost curve, and left of the supply line Q_{mono} . This is the area $A + C + E$. Whereas the producer surplus under perfect competition is equal to the area $C + D + E$. The extra profit for the supplier due to the monopoly power is thus $A - D$. The loss in consumer surplus from the monopoly equals $A + B$. The total welfare loss due to the monopoly equals therefore $B + D$. In simple language, due to the supply restriction capacity of the monopolist in a monopolistic market, prices are often kept higher than the socially desired levels. This leads to social welfare loss (inefficiency). This power, together with other market phenomenon, can lead to undesirable price hikes. However, controlling such market power is not straight forward, and often leads to other sources of inefficiencies. Despite government owned, there are a couple of examples in the Ethiopian situation: the telecommunication industry (which is owned by one state firm), the electricity industry (again, owned by one state firm), the internet industry, etc.

Should monopoly power be checked? Can you think of any government regulation to control monopoly power? What possible unintended outcomes do you expect from such policy?

3.3 Oligopoly

This is a situation where there are only a few producers or suppliers that control the market. This select group of producers or suppliers has control over the price and, like the monopoly, an oligopoly has high barriers to entry.

Because of the few number of sellers in the market, sellers know each other, which may lead to cooperation or fierce competition. Thus, the type of equilibrium price and quantity supplied depends on the *strategic interactions* that arise between competing sellers. This means, since sellers are big enough to affect the market, each seller prepares to respond to its rivals' choices, and expects strategic reactions against its decisions from each rival seller. Thus, in oligopoly markets, there is a clear tension between cooperation and self-interest. The level of trust, information flow, and future interactions determine the degree of cooperation or competition. In either case, increased profits are achieved at the cost of the other market players and the consumer at large. There are several examples of this type of market

structure in Ethiopia: the sugar industry, the cement industry, the banking industry which is becoming more and more close to monopolistic competition in recent years etc.

3.4 Monopolistic Competition

Monopolistic competition is a market structure that falls between oligopoly and perfect competition. Like perfect competition, there are many small suppliers making zero profits. This distinguishes monopolistic competition from oligopoly. But unlike perfect competition, each supplier has a mild market power (due to slightly differentiated products) and therefore each supplier has some influence over price. As a result, there are slight strategic interactions among suppliers. This distinguishes monopolistic competition from perfect competition.

Module II

Price Data Manipulation

Objective of this module

To enable participants to work with raw price data and adequately manipulate it to suit different types of analysis

Expected Outputs

- To be able to distinguish between different types of price data and to choose the right type of data for a given type of analysis;
- To be able to properly design and monitor the price data collection process;
- To be able to clean a price dataset;
- To be aware of the problem of missing data and to be able to use basic interpolation to solve it;
- To be able to deflate a price time series;
- To be able to aggregate price data in indices for different commodities, geographical areas, points in time.

Summary

Part I: Price Data - Types and Their Uses

1.1 Price Data Collection and cleaning Price Data

1.1.1 Plausibility Checks

1.1.2 Replacing Implausible Values

1.2 What to do about Missing Data?

2.1 RMV functions for Small Holes

2.2 RMV functions for Big Holes

2.3 Testing Data Filling Models

1.3 What to do about Inflation?

1.3.1 Deflation of Price Data

1.3.2 Types of Price Index

1.3.3 Calculating CPIs

Part II: How to summarize Data using Price Indices

2.1 Which Weights?

2.2 Paasche, Laspreye's and Fischer Price Indices

2.3 Data Filling and Price Indices

2.4 More on Price Indices: How to Best Summarize Price Data

2.5 Consumer Price Indices

2.6 Local Preferences

2.7 Farm-gate Price Indices

2.8 Livestock Price Indices

2.9 Aggregation across Markets

2.10 aggregation Across Time

2.11 Seasonal Weights to Price Indices

Part I: Price Data: Types and their uses

Before turning to the technical issues of raw price data analysis, we need to understand the various types of price and market data most commonly used. First, we can distinguish between quantitative price data and qualitative market data. Qualitative market data is a judgment on the local supply and demand conditions, made by local officials. It is in the form of a rating where 1 indicates abundant local supplies and 5 very scarce local supplies in relation to demand.

There are several types of quantitative raw price data. Each type of data has different sources. Different types of data have different uses and are associated with different analytical tools in the context of early warning and food information.

We can distinguish between types of raw price data based on **coverage**, **transaction level** and commodity.

With respect to coverage we can distinguish:

- **Time-series data:** when we have a number of observations for price of the same commodity over time;
- **Cross-section data:** when we observe the price of a number of commodities (or of the same commodity, in different markets), at one point in time;
- **Panel data:** when we observe the price of various commodities (or of the same commodity, in different markets) for a number of points in time.

Depending on whether our interest lies more in studying the behavior of one single commodity over time, or on making comparisons across commodities (or for the same commodity, across different markets), we will need to work with one of the above. For example, if we are doing an analysis of the evolution of the food security situation in an enset-based area of SNNPR, we may need to work with a detailed and complete **time series** of enset prices in the main market of the area. Notice though that, as it will be dealt with in more detail later on in the course, it is very often the cases that a price really makes sense only when seen next to other prices. For instance, we may also be interested in the extent to which enset-producing households can buy meat to enrich their diet with noble proteins: for that purpose a **cross-section** of prices of various commodities (here, enset and livestock) would be needed. We may also be interested in looking at the trend which this relative price has been showing in the past few years, in order to forecast the immediate future or to analyze the dynamic effects of wealth redistribution. If so, a full **panel** of prices would be required.

It is also very important to be aware of the level of market transaction at which a price observation is made. Price values, in fact, tend to vary according to the level of market transaction at which they are observed. If, for instance, a farmer sells maize to a local trader which is eventually sold to an individual in an urban market, we would expect the farmer to get less per unit of maize than the urban customer will pay for the same maize.

The most commonly considered transaction levels at which prices are observed are:

- **Farm-gate level:** The farm-gate price is the price paid to farmers for their produce
- **Wholesale level:** Wholesale prices are paid for transactions between bulk traders or millers
- **Retail level:** The retail price is the price which consumers (households) pay to buy food for their consumption
- **International level:** Border prices are the prices for which commodities are imported from or exported to neighbouring countries

As explained in Module 1, the term **marketing chain** is sometimes used to describe the all links between transaction levels. Each transaction occurs between two **agents**. The agent may be a farmer (producer), a petty trader, a bulk trader, a miller, or a consumer.

Consider, for example, the following marketing system for wheat:

Table 1: Example of a Marketing Chain

AGENTS	TRANSACTION	PRICE OF TRANSACTION
wheat farmer and local petty trader	farmer sells produce to local trader	farm gate price
petty trader and bulk trader	petty trader sells stocks to bulk trader	local wholesale price
bulk trader and commercial miller	bulk trader transports the wheat to Addis Ababa and sells it to a commercial miller	Addis Ababa wholesale price
commercial miller and Addis Ababa shop-keeper	the commercial miller mills the wheat and sells flour to an Addis Ababa shop-keeper	wholesale flour price
shop-keeper and consumer	the shop keeper sells a bag of flour to an Addis Ababa consumer	Addis Ababa retail flour price

Prices are likely to be different at each transactions level. As traders will generally seek to make a profit, they will tend to sell for more than they have purchased. For example, a petty trader buying from a farmer (at the farm-gate price) will sell to the bulk trader at a higher price. The miller in the example above will sell flour at a much higher price (per kilogram) than the purchase price.

According to economic theory, if markets are working well, the difference in price between each transactions level should reflect the costs of each agent. These may be marketing costs (sometimes called transactions costs), milling costs, transportation costs or storage costs. The difference between prices at each transaction level is often called the **price differential** or mark-up.

One of the first steps in price analysis is to define the appropriate **transaction level** for the analysis. Price data from different levels serves different purposes. For instance, if we were analyzing the likely impact of a fall in prices on farm production, it would be appropriate to consider **farm-gate prices**. Table 2 below presents a list of different types of data and their possible uses in early warning. It also indicates the sources of that data in Ethiopia

Table 2: Transaction Levels, Sources and Uses of Price Data

LEVEL	Source	USE
farm-gate	MoARD (?)	predicting the impact of price changes on farm income/production
wholesale	EGTE	explaining private trade behaviour
retail	CSA/MoARD	examining the impact of price changes on demand for food
border	UN/MEDAC	models for examining external trade (imports and exports)

1.1 Price data collection and cleaning price data

This activity is aimed at **cleaning raw data**. Cleaning data means removing obvious data entry errors. Enumerators at the Woreda and sub-Woreda level observe price data and record it. Local officials may make mistakes or their handwriting may be difficult to read. Data is then entered into a computer and the data entry process often involves typographic errors. With large amounts of data being entered into computers, there is a risk that data entry staff will make errors and that prices will be assigned the wrong values.

Sometimes data entry errors will have a very strong influence on the results of price analysis. Consider, for example, that a value of 1000.2 birr for a quintal of sorghum is entered instead of 100.02. It is easy for data entry staff to make this error. It is called a “decimal point error”. Another common typographic error is accidentally swapping numbers. So, instead of 125 birr, 215 birr is entered in the computer. In both cases, the data may suggest a major price rise - but the price rise may not have happened.

While there is no substitute for careful data entry and checking of the entered data, it is also possible and it is always necessary to check data after it has been entered into the computer. The computer can perform data cleaning functions, which identify and remove any errors present in the database or ensure that they are not entered in the first place.

1.1.1 Plausibility Checks

How can we identify data entry errors so that we can clean the database? The first step in data cleaning is to spot implausible values. Implausible values are values that are “most unlikely or outside a plausible range”.

One obvious plausibility check, for example, is that prices are always positive. Negative prices are all implausible values. A negative value would imply that the seller has to pay the buyer for the transaction. For most commodities, we can define a plausible lower and plausible higher value. For example, for all grains (recorded in quintals) a unit value of more than 1000 birr per unit is implausible and probably reflects data entry errors. Similarly values of 0 - 20 birr per quintal are implausible for all the grains. So, we can define an upper plausible value of 1000 birr per unit and a lower limit of 20 birr per quintal for all recorded grain prices. If the observed price is outside this range, we conclude that it is a data error.

The computer can be instructed to recognize implausible values by what is called a Boolean function, a set of logical conditions or a validation rule. We say that if a value in a data is less than the plausible lower limit it is false. Similarly, if it is greater than the upper limit it is false. We only accept values within the plausible range. The set of logical conditions can be presented as follows:

IF: $P \geq P_{max}$ THEN $P = FALSE$ IF: $P \leq P_{min}$ THEN $P = FALSE$

IF: $P_{min} < P < P_{max}$ THEN $P = TRUE$

Where: **P_{max}** = the maximum plausible price or upper limit
 P_{min} = the minimum plausible price or lower limit

Clearly, the range of plausible values will depend on the commodity in question and the unit of measurement. For most price monitoring, the unit of grains and oilseeds is quintals. Animal prices are measured in live head prices.

While it is possible for one chicken to cost 10 birr, this price is implausibly low for a camel. Equally, a price of 1500 birr may be plausible for a camel, but not for a chicken. Thus, for each commodity we can define the maximum and minimum plausible price as table 1 below demonstrates.

Table 1: Plausible Maximum and Minimum Price Values for Commodities				
EXAMPLE	COMMODITY	UNIT	Maximum (in birr)	Minimum (in birr)
	teff	quintal	400	90
	maize	quintal	300	50
	lentils	quintal	600	60
	camel	live animal	3000	500
	chicken	live animal	75	5

Note that the plausible values may change over time. If there is hyper inflation, which means that all prices rise by a large proportion over time, the maximum values may quickly become plausible and the minimum values implausible. This would mean that the computer would start to accept implausibly low values and to reject plausible high values. For this reason, maximum and minimum plausible prices should be reviewed and possibly updated on a regular basis.

1.2.1 Replacing Implausible Values

Suppose now that our computer programme finds that a price value is outside the plausible range. What should we do now? There are several alternatives. The first alternative is to consult the original data source (which might be a hard-copy questionnaire) and see whether the original data has been wrongly entered into the computer. If it has been wrongly entered, we enter the correct value.

If the error appears to be in the questionnaire, the data enumerator may be consulted to find the correct answer (if s/he remembers). This method is used by CSA but for some type of data (including Early Warning Data), it is too time-consuming to be practical.

If, on the other hand, the original data source has not been kept, or the error has occurred in the field level observation, the only alternative is to delete the implausible value from the database, which is then counted as a “missing value”. Missing values are discussed in the next section.

1.2 What to do about Missing Data?

This Unit explains the methods for replacing missing values in price data series. Most price data sets contain missing values. The common causes of missing values are:

- Loss of data through poor communications from the field
- Irregular reporting
- Disruption of the reporting system
- Computer malfunction or corruption of data archives
- Errors in data entry which have to be replaced by missing value entry

Replacing missing values (MVs) is necessary for a number of reasons. Missing data can make it very difficult to interpret trends, average prices, or price variability. Price indices may be inaccurate if values are missing for one or more commodity. Ignoring missing values means running the risk that price changes are identified which are the result of missing data and not of any underlying changes in market conditions.

There is also a practical reason for avoiding missing values. On several common computer applications, it is impossible to perform time-series analysis when there are missing cases (records).

We must therefore find ways to replace missing values. The best way to replace them is to locate the original source and re-enter data. Often, however, the original sources will be lost. In this case, a “function” must be designed to provide “plausible” values for a price observation. There is no perfect method. Indeed, it is difficult to test with accuracy how good a method is. The challenge is to find the best method. The best method in this context is the one that minimizes the error. That is, it keeps the difference between the replaced value and the actual value to a minimum.

The choice of method depends on how much data is missing or how large the “holes” are. We can expect that prices will vary less over short periods than over long periods. From this month to next month price changes, for example, are likely to be less than price changes in the next six months. For this reason, our estimates of the likely prices for a small hole are likely to be less inaccurate than estimates for a large hole.

In some cases, an official may have failed to report for 2 months, which is a relatively small hole. In the 1990-1991, warfare and the collapse of the former government led to a much larger hole, more than half a year in some markets. Hence, we may have to use two different methods.

2.1 RMV Functions for Small Holes

Over a short space of time, there may not be much price variation although this varies between locations. Hence, prices are likely to be reasonably close to those during nearby periods. This means that a method of replacing missing values can be used which reflects recent values.

There are several possible methods. Each method depends on a function expressing the relationship between prices over time. The simplest method is to use a mean function, which suggests that prices in the missing period are approximately the mean of the nearby (before the hole and after the hole) values. The example below uses the mean function.

The original series is:

60 100 **130** **110** mv mv mv **120** **110** 130 140

Where missing values are designated “mv” and the bold values are the “nearby values”.

The mean of the nearby values is $(130 + 110 + 120 + 110) / 4 = 470 / 4 = 117.5$.

An alternative mean based function is the series mean (all values in the series). The series mean method would calculate the mvs at $90/8 = 112.5$.

Perhaps the most common method for “filling” price data is by interpolation. The best known function is called linear interpolation. Interpolation is essentially “joining the points”. In this case it means joining the points where data is available. Consider, for example a price series:

time	t+0	t+1	t+2	t+3	t+4	t+5
price	120	122	124	mv	mv	130

The values in bold are the two nearby points. Interpolation tries to link these points in the most plausible way.

The equation for linear interpolation is:

EQUATION 1: $P_{t+x} = P_{t+a} + (t+x - t+a) \cdot \Delta$

and $\Delta = (P_{t+a} - P_{t+b}) / (t+b - t+a)$

Where: P_{t+x} is the interpolated value for period $t + x$
 P_{t+a} is the last non-missing value before the hole
 P_{t+b} is the first non-missing value after the hole

Consider the following series of maize prices in Addis Zemen:

date	May-89	Jun-89	Jul-89	Aug-89	Sep-89	Oct-89	Nov-89
period	1	2	3	4	5	6	7
raw series	46	47	missing	missing	missing	36	41
interpolated	46	47	44.25	41.5	38.75	36	41

From the table we can see that:

$$t+a = 2 \quad t+b = 6 \quad n = t+b - t+a = 6 - 2 = 4$$

$$\text{so } \Delta = (P_{t+b} - P_{t+a}) / 4 = (36 - 47) / 4 = -11 / 4 = -2.75$$

For July, for example $t+x - t+a = 1$ so the interpolated price is:

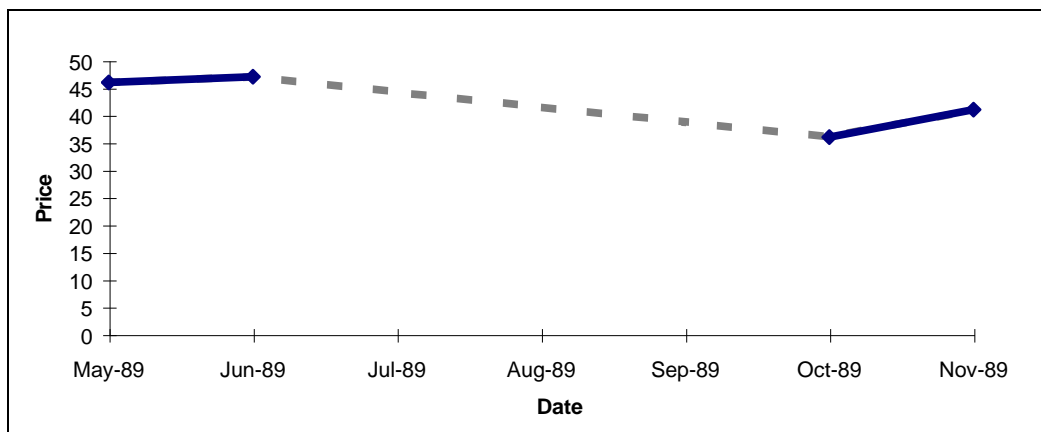
$$47 + 1 \cdot (-2.75) = 44.25$$

or for the third missing month (September), $t+x - t+b = 3$ so the value is:

$$47 + 3 \cdot (-2.75) = 47 - 8.25 = 38.75$$

The same data is presented in the graph below. The dashed line indicates “interpolated values”.

Graph: Example of Price Data Interpolation



Notice that methods for small holes should not be applied when the missing value is at the end of the series. If reliable methods for large holes, which take into account seasonal variations, are available, these should be preferred. Otherwise it is best to leave the data as missing.

2.2 Technical Note: RMV Functions for Large Holes

What happens when, say, one year’s data is missing? The first option is to exclude the missing part of the series from the analysis. This is often the wisest approach for graphing data. Data filling for large holes will rarely be very instructive. However, as has been mentioned, this will limit the analysis, as the

common statistical packages will not be able to perform several statistical procedures, including all time series analysis.

The second option is to try to fill the data using an RMV function. In this case, interpolation could be very misleading. Prices often have a seasonal pattern, which means that they tend to be higher in certain periods of the year (such as the run up to the main harvest). If we use linear interpolation it will not take into account the seasonal dimension to price changes or “seasonality” as it is sometimes called.

With large hole in a price data series we must take into account not only trends in prices over time, but also seasonal patterns when we design a function for data filling. The RMV function should therefore contain two elements: a trend and a seasonal factor:

EQUATION 2: $P_{t+x}^E = f (P_{t+b}, P_{t+a} , T, SW_m)$

- where P_{t+x}^E is the estimated price for the missing value in period t+x
- SW_m is the seasonal weight applied for the month m of the price observation
- P_{t+a} is the last non-miss prior to the “hole”
- P_{t+b} is the first non-miss after the “hole”
- T is the time period (year and month)
- $f ()$ is a function of ()

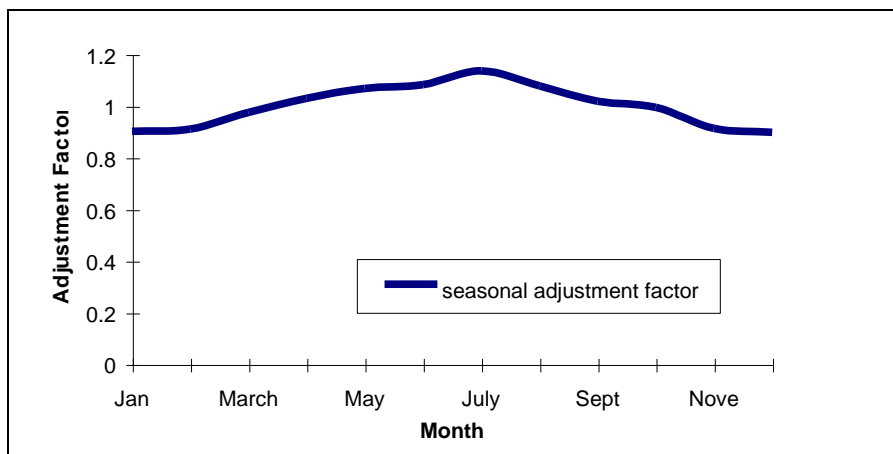
The suggested method follows these steps:

1. interpolate the missing data series (for all parts of the series with more than 5 consecutive misses)
2. calculate the seasonal pattern to price movements from the full interpolated series (the variable S)
3. adjust the interpolated function to reflect the seasonal weight

A computer can be used to calculate the seasonal weight (a multiplicative seasonal adjustment factor). For interested readers, more detailed explanations of these methods can be found in common textbooks on statistical techniques and time-series analysis.

Graph 1 below illustrates a seasonal price adjustment factor for monthly maize prices in Addis Zemen.

Graph 1: Seasonal Maize Price Patterns in Addis Zemen



Using a combination of interpolation and seasonal adjustment, the missing values function for “big holes” can be written as:

EQUATION 3: $P_{t+x}^E = \{ P_i + (t+a \cdot [t+x - t+a] [P_{t+a} - P_{t+b}] / n) \} \cdot SW_m$

Where: m is the month of the missing price value

P_{t+x}^E is the estimated missing price value

SW_m is the seasonal weight for month m

2.3 Technical Note: Testing Data Filling Models

The methods discussed above are not the only ones. Why should one method be selected rather than another?

In fact, it is possible to test “how well” a data filling model works. The method is to take a complete time series (or part of the time series that is complete) and then to remove data, as though it were missing. On the incomplete series we perform different data filling techniques and can then judge how well the filled series compares with the original (complete) series. In other words, we replace actual values for certain periods with “filled” values.

Our objective is to find the filled series which as closely as possible approximates the original series. We can measure the success can by comparing the estimated variable (using a data filling function), with the original series.

The following regression model was used to test various data filling functions:

EQUATION 4: $P_t = \alpha + \beta \cdot P_t^E + u_t$

Where u_t are the unexplained residuals (or errors) of the model.

P_t^E is the price variable including filled data from the replacement process

It could be assumed that the intercept (α) would be zero, suggesting a parameter restriction. In fact the unrestricted and restricted models both gave the same results in terms of the “best performers”.

Monthly DPPC data on maize prices in Addis Zemen (from January 1985 to December 1996) was taken to test the model. The model was run for “small holes”, by removing every second month’s data from the original series to create a variable of expected values. The following data filling methods were then used to create the filled series:

- series mean (the mean of all non-missing variables)
- mean of nearby points
- interpolation
- trend (based on the series trend)
- trend (based on within year trends)

Then the linear regression model (Equation 4 above) was run for each. The coefficient (β) should be close to 1 (unity). The R^2 , overall F test and t-tests are also indicative of the model’s performance. The results of the regression (unrestricted) are presented in Table 1 below:

Table 1: Comparison of Data Filling Techniques

<i>METHOD</i>	R2	SE	F value	F signif.	Beta (t value)	t-test signif.
linear trend (series)	0.861	11.1275	493.9	***	0.93 (22.2)	***
linear interpolation	0.990	4.3566	3922.9	***	0.99 (62.6)	***
mean of nearby points	0.981	5.8772	2064.7	***	0.98 (45.4)	***
series mean	0.802	13.8397	324.1	***	0.89 (18.0)	***
linear trend (by year)	0.931	8.1860	1075.1	***	0.99 (32.8)	***

*** indicates significance at 99 percent or above

From these results it can be seen that, at least for this data series, the interpolation method performed much better than the others. The mean of nearby points performs better than the series mean, and a “within year” trend specification is preferable to using a linear trend based on the full series. For large holes the method was replicated, except that data was removed for eight consecutive cases (leaving the ninth) throughout the series. The following fill variables were used:

- interpolation with no seasonal adjustment
- interpolation with seasonal adjustment
- within year trend specification without seasonal adjustment
- within year trend specification with seasonal adjustment

Table 2: Test Results for Functions with and without Seasonal Adjustment

<i>METHOD</i>	R ²	SE	F value	F signif.	Beta (t value)	t-test signif.
linear trend (by year)	0.849	15.065	207.3	***	0.85 (25.1)	***
SA ¹ linear trend (by year)	0.881	14.691	278.7	***	0.88 (16.7)	***
interpolation	0.924	11.875	468.9	***	0.92 (21.6)	***
SA & interpolation	0.944	10.267	654.2	***	0.94 (25.6)	***

*** indicates significance at 99 percent or above

SA Seasonal adjustments made through multiplicative function

The results show that making seasonal adjustments improves the performance of the model, and that interpolation remains more effective than a “within year” linear trend function.

1.3 What to do about Inflation?

Inflation is defined as increases in all prices in the economy over time. If all prices in the economy rise by 10 percent in a year (this includes prices for goods and prices for labour or wages), then we can say that the annual inflation rate is 10 percent.

Inflation reflects macro-economic changes. Examples of macro-economic changes that lead to inflation are:

- **Increases in aggregate demand:** recall from Module 1 that an outward shift in the demand curve usually results in a price increase. The same is true at the aggregate level. As aggregate demand rises, as it is the case, for example, when there is generalized and sustained economic growth, all prices in the economy will tend to increase. This is often referred to as “demand-push” inflation.
- **Decreases in aggregate output:** this corresponds to an inward shift in the aggregate supply curve. As aggregate supply falls, as would happen, for example, in the case of a natural disaster or of increased price of inputs into production, commodity prices in the economy will tend to rise. This is referred to as “cost-push” inflation.
- **Increases in the money supply:** if the government increases the money supply by printing more birr, each birr is worth less and more birr are needed to pay for the same goods.
- **Devaluation of the currency:** if the birr / dollar exchange rate is devalued, meaning that every dollar is worth fewer birr, this may well lead to some inflation as the cost of imported goods will rise in birr terms. The price of local goods that depend on imported inputs (like goods manufactured using energy from imported oil, or crops produced using imported fertiliser) will also tend to rise.

General price inflation affects wage rates and commodity prices. If all prices in the economy (including wages, which are the prices of labour) rise by ten percent, economic theory tells us that there will be little or no change in how much people consume. The increase in food prices will be offset by an increase in income, and hence in their ability to buy food.

Early warning is mainly interested in local market price conditions and how local price changes might affect people’s income or their ability to buy food. If we monitor prices of food commodities on the market, we have to know whether a price change is a result of changes in local conditions, or whether it is caused by underlying inflation.

Mid-term price analysis is on the other hand more concerned with assessing how price changes determine changes of micro-behavior, and the aggregate consequences that such changes may have. Rational agents will respond only to changes in real prices. If all prices were to rise by ten percent, as in the example above, a worker’s wage still buys the same amount of food. He will not respond to this. But if the worker experiences a nominal wage rise of 10 percent against a rise of the price of all other commodities of 30 percent, he is suffering a reduction in his real budget. As a response to this, he may decide to consume less, work more, or a combination of the two. Because mid-term price analysis wants to study this kind of price incentive effects, it is also mostly concerned with looking at real prices.

Focusing on nominal prices alone can be misleading. We might, for example, spot a major increase in food prices in a Woreda and conclude that a local drop in supply has affected the Woreda, perhaps because of drought. But, if inflation was responsible, we would have come to the wrong conclusion. To allow us to spot local changes in price and market conditions we “remove inflation from the picture”. This is called inflation adjustment or **deflation**.

As will be explained in more details in the two sections below, the usefulness of deflation depends on the price index that is used to represent the aggregate change of prices in the economy. In any of such index, different commodities are given different weights and hence a difference influence on the final index. Given this premise, it is appropriate to warn about possible misuses of deflated prices. If the consumption patterns of the socio-economic group the analyst is concerned with differ from those implied by the weights in the price index, then also deflated prices will give a misleading picture of how purchasing power has been changing for such group.

Because of these potential drawbacks of using real prices, a common rule of thumb is to do analysis of food prices using deflated figures only when inflation is above 10%. For inflation below 10% the cost of

potential distortions introduced by using a non-accurate price index outweigh the benefits of taking into account of a small general price increase.

1.3.1 Deflation of Price Data

Economists usually make the distinction between **nominal prices**, which are the prices observed on the market and **real or deflated prices**, which have been adjusted for inflation. It should be pointed out that sometimes all prices in the economy decrease, this is also called deflation. To avoid confusion we should refer to the economic process of declining prices as general price deflation. The process of adjusting data to reflect general price inflation or deflation is called **deflation of price data**.

The basic method for data deflation begins with a measure of underlying inflation. This is measure of price changes for a large number of commodities in the economy. The basic measure of inflation is called the General Price Index (GPI). The GPI takes a **bundle of commodities** or collection of commodities. Each good in the bundle is “weighted” to reflect its importance in the economy. If people consume more of a good, then it is weighted higher. We create a weighted index, which reflects the prices and weights of the various commodities in the bundle.

The methods for calculating indices (the plural of index) are described in the next unit. The CPI is calculated for each month in the year and for each year. We then measure changes in the price index.

The GPI compares the price of a “bundle” of goods now, with the price of the same bundle in a reference month of a reference year or **base month in the base year**. The base-weighted GPI is the ratio of the GPI in the current month over the GPI in the base month of the base year.

We can calculate the current month base weighted GPI as follows:

EQUATION 1: $BWGPI_{m_y} = GPI_{m_y} / GPI_{base}$

where: **BWGPI_{m_y}** is the current month and year base-weighted GPI

GPI_{m_y} is the current month GPI

GPI_{base} is the GPI in the base month and year

Note that in the base month of the base year the base-weighted GPI is equal to 1 (unity).

Calculation of the Base-Weighted General Price Index in 1995		
Month and Year	General Price Index	Base-Weighted Price Index
January 1995	893	.93
February 1995	935	.97
March 1995 (BASE)	960	1.00
April 1995	998	1.04
May 1995	1006	1.05
June 1995	994	1.04
July 1995	974	1.01
August 1995	992	1.03
September 1995	979	1.02
October 1995	925	.96
November 1995	927	.97
December 1995	935	.97

To calculate the real or deflated price of any one commodity, we simply divide its observed market price (nominal price) by the base-weighted current GPI. If we repeat this for all observations of a particular price on a particular market, we can make a deflated price series. The example below shows how this is done.

White Teff Prices in Habru (North Wollo) in 1995				
EXAMPLE	Month and Year	Nominal Price per Quintal	General Rural CPI	Deflated Price per Quintal
	January 1995	238	0.93	255.7402
	February 1995	241	0.97	247.5311
	March 1995	262	1.00	261.3198
	April 1995	242	1.04	232.7843
	May 1995	235	1.05	224.3255
	June 1995	225	1.04	217.2675
	July 1995	225	1.01	221.7627
	August 1995	230	1.03	222.5252
	September 1995	235	1.02	230.4832
	October 1995	226	0.96	234.5325
	November 1995	235	0.97	243.3675
	December 1995	234	0.97	240.3414

1.3.2 Types of Price Index

So far we have looked at a general price index. As mentioned above, actual price indices differ on the basis of the transaction level that they focus on and the commodity weights they use. The choice of an appropriate price index is crucial if deflation is to give an accurate picture of how the change in the price of one commodity has to be seen in the lights of price changes in all the other commodities that are relevant for the group of interest for the analysis.

Remember that price data can be observed at a number of transaction levels. If we want to explore price changes for the consumer, we are especially interested in changes in retail (or “consumer” prices). It may be that consumer prices are increasing faster or slower than, say, farm-gate prices. So the measure of inflation will, to some extent, depend on the transactions level of the price observations. In Ethiopia, the standard measure is the **consumer price index** (CPI) which, as the name suggests, is an index of retail prices.

The CPI can be used as a general price index for deflating all price data (including farm gate data) if we assume that there are no major changes in the marketing margins over time. We make the reasonable assumption that there are no significant increases in the marketing margins of commodities relative to the total retail price. This means that the percentage changes in the retail price will be the same as the percentage changes in the farm-gate or producer price. This assumption makes it possible to use the CPI for all types of deflation, which is much simpler than calculating a separate producer price index based on prices at the farm or factory gate.

Remember that price indices are based on a system of commodity weights and their prices. But how do we calculate the weights? The weights are calculated based on expenditure shares, that is, on the proportion of total household expenditure spent on a particular commodity.

Now, in urban areas, expenditure patterns tend to be different from those of rural areas. For example, in urban areas households may spend more on cars, petrol and taxis or buses than in a rural area. This means that the weights and therefore the CPI itself may be different for rural areas. For this reason, the CPI can be calculated separately for rural and for urban areas. For early warning purpose, our attention is focused on rural areas. We therefore use the rural CPI, based on average rural expenditure patterns on consumer goods. For mid-term price analysis, it is not clear a priori whether the rural or urban CPI are most suited- it will depend on the specific question at hand.

Although general price inflation tends to affect the prices of all goods and wages, some commodities are affected more than others. Suppose inflation has affected food prices more than prices of non-food commodities.

Now, if we want to assess changes in food prices relative to changes of all prices, we take an index of all prices for deflation purposes. If on the other hand, we wish to assess the changes in the price of one food commodity relative to other food commodity (is teff getting more expensive as a food type?) we should use an index which is based only on food prices.

For most early warning purposes, we are interested in adjusting food prices to reflect general inflation and for this reason we use a consumer price index based on both food and non-food commodities. We are not so interested in changes in one food price in relation to prices of other foods. The types of CPI can be summarized as follows:

Table 1: Types of Consumer Price Index

Types of Commodity	Type of Household		
	Rural	Urban	Both
food	rural food CPI	urban food CPI	general food CPI
non-food	rural non-food CPI	urban non-food CPI	general non-food CPI
both food and non-food	rural general CPI	general urban CPI	general CPI

For early warning, we use the rural general CPI to deflate food price data as it reflects the prices of commodities purchased by rural households and the Ethiopian EWS focuses on rural areas. For mid-term price analysis, which CPI to choose will need to be decided on an ad-hoc basis.

1.3.3 Technical Note: Calculating CPIs

Chapter 2 discusses price indices in more detail. For the purposes of a general understanding of the CPI, it is, however, worth reviewing a few concepts. Firstly, the CPI is based on the prices of “typical bundle of goods” which are commonly consumed by households (or consumers). Each price is given a weight depending on its importance in the household’s budget. The more important the commodity, the higher its weight. For example, a commodity like teff would be given a much higher weight than mineral water, as it accounts for a much large proportion of the average household’s budget.

The commodity price weights are usually calculated based on **expenditure shares**. Expenditure shares are the proportions of the total household expenditure spent on a particular commodity. For example, if, on

average households spend 1200 birr per year of which 20 is spent (on average) on coffee, then the weight for coffee would be calculated as $20 / 1200 = 0.0167$.

In its simplest form, the CPI is the “weighted sum” of all prices which means the sum of all prices times the weight (w) given to each commodity i , or:

$$\text{EQUATION 1: } \quad \text{CPI}_t = \sum_{i=1}^{i=n} (p_{it} \cdot w_i)$$

In fact the CPI is usually expressed in terms in comparison to a “base” year or month which we can designate (b). The CPI is therefore:

$$\text{EQUATION 2: } \quad \text{CPI}_t = \frac{\sum_{i=1}^{i=n} p_{it} \cdot w_i}{\sum_{i=1}^{i=n} p_{ib} \cdot w_i}$$

From equation 2 we can see that, in the base year

$$\text{EQUATION 3: } \quad \text{CPI}_b = \frac{\sum (w_i \cdot P_{ib})}{\sum (w_{ib} \cdot P_{ib})} = 1$$

To deflate a price of a commodity (or “adjust for inflation”) we just divide the nominal price of that commodity (i) in period t by the CPI in period t . In other words, the real price (deflated price = P^R) is the nominal or raw price (P^N) divided by the CPI or:

$$\text{EQUATION 4: } \quad P^R_{it} = P^N_{it} / \text{CPI}_t$$

The simplest measure of the CPI is the index presented in equation 2 above. This is appropriate when only one year’s income and expenditure data is available. When several years of data are available on household expenditure, a more sophisticated index is required. There are several common index methods to address this problem, named after their inventors: the Paasche, Fischer, and Laspeyres’ price indices. These methods are explained in the next unit.

Part II: How to Summarize Data with Price Indices

In this Unit we explain some of the technical questions of creating price indices and then turn to some practical applications. First, we explain what is meant by “weights” and how we should select the appropriate weighting procedures. We then explore three common methods for creating weighted price indices. We show also why it is necessary to use interpolated price data to create the indices.

2.1 Which Weights?

The weight given to any one price in a price index reflects the importance of that price. But how do we assess the “importance” of a particular price? The answer is; it depends on what you are trying to show. For an index of farm-gate output prices, for example, we are generally trying to show whether, in general, farm-gate prices have improved (increased) or deteriorated (declined). We do this because we want to know how farm-gate prices may influence crop production. A high price index would imply strong incentives to increase production whereas a low price index would warn us that farmers may reduce production as a result of lower profitability. In this case, we must ask “how important is crop x in relation to total crop production?”. A price change for a crop that is only produced in small quantities will have a relatively small impact on total incentives, and so it should be given a lower weight.

Similarly, when we make an index of consumer prices we are mainly concerned with the effect of prices on food demand. Commodities that only contribute a small amount to total consumption should therefore take a smaller weight.

If we want to attribute a weight to a given market when creating a zone-level index of prices, we must first measure the importance of that market in terms of total traded quantities in the zone. The bigger the market, the more important its price is for the zone as a whole and therefore the higher its weight should be.

A common feature of all weighted price indices is that the weight is measured as a quantity: a quantity that reflects the importance of the commodity in the particular setting we wish to analyse.

2.2 Technical Note: Paasche, Laspreye’s and Fischer Price Indices

We have suggested that weights are calculated on the basis of quantities. But how are the weights calculated? A common problem with price indices is that higher valued commodities will tend to have more influence on a weighted index than low valued commodities. We adjust for this by calculating all prices in “base weighted prices”. The base weighted price in the current period is calculated as:

$$\text{EQUATION 1: } P^*_{it} = (P_{it} / P_{ib}) \times 100$$

where P_{ib} is the price of commodity i in the base period b

This is called “normalization” of price data. Now with one period of quantity data we can calculate a simple price index as follows:

$$\text{EQUATION 2: } PI_{it} = \sum \{ [P_{it} / P_{ib}] \times 100 \} \cdot [q_i / \sum q]$$

When there are several years of quantity data, we have to decide the appropriate weighting method. One method is to use the base year quantities as a weight. This is called the Paasche index. It is calculated as:

EQUATION 3: $PI^{PAASCHE}_t = \sum ([P_{it} \cdot q_{ib}] / [P_{ib} \cdot \sum q_b])$

An alternative approach is to use the current period quantities to create the weights. This is called the Laspreyes index:

EQUATION 4: $PI^{LASPRESYES}_t = \sum ([P_{it} \cdot q_{it}] / [P_{ib} \cdot \sum q_t])$

The third form of price index calculates a geometric mean weight and is called the Fischer Index. This is the most meaningful index method for price analysis and is calculated:

EQUATION 5: $PI^{FISCHER}_t = \frac{\sum P_{it} \cdot \sqrt{[q_{it} \cdot q_{ib}]}}{P_{ib} \sqrt{[\sum q_t \cdot \sum q_b]}}$

2.3 Technical Note: Data Filling and Price Indices

In Unit 4 above, we saw that most price data series contain missing data. When data is missing this will affect how the price index is calculated. If, for example, the price of one commodity is missing in a commodity index the weights attributed to each commodity price have to be recalculated according to the new list of commodities.

With full data the weight is calculated as:

EQUATION 6: $w_i = x_i / \sum x_i$ for $i=1, 2, 3, \dots, n$ commodities

Now with missing values we have to recalculate the weights just using the reduced set of commodities, and excluding the commodities for which price data is missing. The calculation is laborious and the prices of minor commodities may unduly influence the index.

Given the large amount of data that are regularly collected and analysed by price analysts, readjusting the weights to reflect missing data is simply not feasible. It adds unnecessary complexity to the calculations. A better approach is to use interpolated data for all calculations of price indices.

Although it is the most practical approach, the problem with using interpolated series is that for months in which fill values are used there is a change that erroneous fill values will lead to errors in the index estimate. This will depend on the number of missing values for each month and on the importance of the commodities for which the data is missing. However, over a large number of commodities and assuming that the interpolation functions are chosen well, the probability of major errors is reduced

2.4 More on Price Indices: How to Best Summarize Price Data

It is generally confusing to present more than three variables in a graph. There are two options for simplifying the interpretation of price graphs and of price analysis in general. The first option is to exclude certain commodity prices from the analysis and focus on the most “important” prices. For retail price analysis, this would be the prices of the most commonly purchased commodities.

The problem with this approach is that data is under-utilized or wasted. What is the point of collecting data on many commodities if it not to be used? Another problem is that selective commodity analysis can be misleading. We could, for instance, imagine a situation where the prices of the two main food

commodities has not risen, but prices of several other food commodities have shot up and influenced consumer demand. Concentrating only on the main commodities could lead us to the conclusion that consumers have not been influenced by price changes, whereas in reality they have.

The second option is to create a commodity price index which reflects the prices of all commodities for which we have data. The aim of this activity is to find a rational and consistent way of grouping commodities and markets to summarize data, so that price information can be presented in a succinct and enlightening fashion.

For the analysis of summary data, which is fundamental for the regular reporting activities of many institutions that monitor prices, we have to produce summary price data, for commodity groups (cereals, prices, livestock). The basic method is similar for all types of commodity index: the weighted sum of the prices. Price indices can be made for any commodity grouping like:

- vehicle spare parts
- food prices
- seed prices
- house prices

2.5 Consumer Price Indices

For the present training, we are mainly concerned with the analysis of consumer prices of food. To summarize data on individual commodity prices for foodstuffs we can create indices based on food categories such as:

- cereals
- pulses
- meat
- fruit and vegetables

Alternatively, we could create a single index that we can call the “food price index” which includes data on prices of all food types.

Consumer price indices are primarily used to assess the impact of price changes on demand/ consumption. For this reason, the appropriate choice of weight will depend on the “importance” of a particular commodity in the total consumption or purchases of the household. In an area where maize is the most important purchased food commodity, for example, maize should take a higher weight than a lesser commodity, like tomatoes.

The usual method is to calculate the weights based on the quantities consumed or the quantity of money spent on a particular commodity. The quantity of money spent is called expenditure. Expenditure shares are the proportions of total average household expenditure spent on particular commodities. So, for example, if average total annual household expenditure in a zone is 250 birr and expenditure on maize is 50 birr per year, then the weight would be calculated as $50 / 250 = 0.2$

A crucial condition for calculating weights is that the sum of all weights adds up to one. If, for example, we wish to calculate a cereal price index, we would take the expenditures on all the cereal commodities and sum them. The weight for individual commodities (i) would then be calculated as:

EQUATION 1:
$$w_i = \frac{EXP_i}{\sum_{i=1}^n EXP_i}$$

Where EXP_i is the expenditure share of commodity i out of m commodities and w_i is the weight assigned to commodity i. It can be seen from equation 1 that:

$$\sum_{i=1}^n w_i = 1$$

EQUATION 2:
$$\sum_1 w_i = \sum_1 EXP_i / \sum_1 EXP_i = 1$$

Or: “the sum of the weights is equal to one”.

When we create a cereal price index, the individual cereals are weighted by expenditure on that commodity divided by total expenditure on cereals not total expenditure on all commodities.

Data is available at the national level on expenditure on specific commodities from the CSA. Data on household expenditure is not available on a regular basis. Thus the appropriate index is a Paasche index which is defined as:

EQUATION 3:
$$PI^{PAASCHE}_t = \sum ([P_{it} \cdot EXP_{ib}] / [P_{ib} \cdot \sum EXP_b])$$

Expenditure data is taken from the most recent income and expenditure survey, which is used as the base year.

2.6 Local Preferences

A major problem with expenditure data in Ethiopia is that it is not sufficiently disaggregated. Expenditure and consumption patterns vary a great deal between zones and, probably, within zones. But zone or Woreda level expenditure data is not available.

If households in a Woreda exhibit very different expenditure patterns from the national norm, the weights (calculated from national averages) will give a misleading impression of the relative importance of different commodities. There are two possible solutions. The first is to collect local secondary data (from CSA Income and Expenditure Surveys). If no such data is available at a local (Woreda level), the second option is to use “subjective” weights, based on the analysts’ perception of the relative importance of a particular commodity in the consumption of a particular area.

The simplest method for calculating subjective weights is to “rank” commodities from 1 (least important) to **n** (most important) in sequential order and to sum up the rank values.

We wish to create a cereal price index for a Woreda in SNNPR, but expenditure data is not available. The commodities under consideration are: maize, sorghum, wheat, teff, barley, millet and oats. Our perception is that this is the rank of importance of the commodities, so we can make a table for prices in June of 1994 as follows:

Table1: Subjective Commodity Weights Method

COMMODITY	RANK	WEIGHT
maize	7	7/28 = 0.25
sorghum	6	6/28 = 0.21
wheat	5	5/28 = 0.18
teff	4	4/28 = 0.14
barley	3	3/28 = 0.11
millet	2	2/28 = 0.07
oats	1	1/28 = 0.04
TOTAL	28	1

NOTE: weights values are rounded to two places after the decimal point

So the cereals price index for the selected area of SNNPR in June 1994 is 104.29.
Now to calculate a base-weighted price index we first

Table 2: Price Index Calculations Using a Base Price

	Jan	Feb	March	April	May	June	weight
maize	80.00	80.00	85.00	75.00	80.00	87.00	
maize b	100.00	100.00	106.25	93.75	100.00	108.75	0.25
sorghum	90.00	88.00	92.00	90.00	85.00	96.00	
sorghum b	100.00	97.78	102.22	100.00	94.44	106.67	0.21
wheat	110.00	120.00	124.00	122.00	115.00	110.00	
wheat b	100.00	109.09	112.73	110.91	104.55	100.00	0.18
teff	150.00	145.00	150.00	155.00	160.00	161.00	
teff b	100.00	96.67	100.00	103.33	106.67	107.33	0.14
barley	101.00	110.00	110.00	110.00	112.00	115.00	
barley b	100.00	108.91	108.91	108.91	110.89	113.86	0.11
millet	85.00	88.00	90.00	95.00	98.00	95.00	
millet b	100.00	103.53	105.88	111.76	115.29	111.76	0.07
oats	112.00	120.00	120.00	120.00	113.00	115.00	
oats b	100.00	107.14	107.14	107.14	100.89	102.68	0.04
INDEX	100.00	102.13	105.94	102.91	102.86	107.08	

So, for example, for prices in March, we can calculate the index (from equation 3) as:

$$\{[(85/80) * 100] * 0.25\} + \{[(92/90) * 100] * 0.21\} + \{[(124/110) * 100] * 0.18\} + \{[(150/150) * 100] * 0.14\} + \{[(110/101) * 100] * 0.11\} + \{[(90/85) * 100] * 0.07\} + \{[(120/112) * 100] * 0.04\} = 105.94$$

EXAMPLE

2.7 Farm-Gate Price Indices

The sections above looked at retail prices and consumer price indices. We now turn to farm-gate prices. As we have mentioned, farm-gate prices have a different function for analysis. We use farm-gate prices to assess production incentives (whether they are favourable) and likely income from production.

For this reason, when we calculate weights we must look at the breakdown of production by commodity. If we have one year's production data we can use the following method for calculating weight for commodity 1 from a number n of commodities i as follows:

$$\text{EQUATION 4: } w_1 = \text{PROD}_1 / \sum_{i=1}^{i=n} \text{PROD}_i$$

Where: PROD_1 is production of commodity one in the area in question and the denominator is total production (of all commodities 1 to m) in the year. If several years of production data are available, one of the three alternative index measures should be used.

The farm-gate price index for output prices (FGPIND) is simply the weighted sum of the base-weighted prices as in equation 4 above, or:

$$\text{EQUATION 5: } \text{FGPIND}_t = \sum_{i=1}^{i=n} w_i \cdot ([P_{it} / P_{ib}] * 100)$$

For current year analysis, production estimates might well be available by commodity. In this case, it is possible to use a Fischer index as follows:

$$\text{EQUATION 6: } \text{FGPIND}^F_t = \sum \{ P_{it+0} \cdot \sqrt{ [q_{it+0} \cdot q_{ib}] } \} / \{ P_{ib} \sqrt{ [\sum q_{t+0} \cdot \sum q_b] } \}$$

When we are analyzing farm-gate prices, we must also consider farm-input prices. A rise in farm-gate prices may have no impact on farm income or production incentives if there has been a corresponding increase in farm input prices. It is possible to make an index that combines both farm gate (output) prices and input prices at the farm-gate. The index is the ratio of the output price index and an input price index.

To calculate the input price index we need data on farm-gate input prices (for example, for labour, draft oxen, fertiliser, improved seeds and pesticide) and on average farm expenditure on these inputs. We can then calculate the expenditure share for one input (say fertiliser) as the average farmer expenditure on fertiliser divided by the total average farm expenditure on all farm inputs. The farm-input price index is then the sum of expenditure-weighted and base-weighted prices of each input.

$$\text{EQUATION 7: } \text{PROFIND}_t = \text{FGPIND}^F_t / \text{XPIND}^F_t$$

Where: XPIND^F_t is a Fischer index of farm-input prices.

The farm-input price index is based on the quantities of farm inputs used to produce a unit of output. The ratio is equal to 1 (unity) in the base year. A ratio of more than one would imply improvements in farm profitability since the base year. A ratio of less than one would imply deterioration in profitability.

2.8 Livestock Price Indices

Meat and livestock head prices are generally considered in the context of the "income" side and not from a consumer perspective. Meat accounts for a small proportion of expenditure among poor rural households, but prices are very important for pastoral (or, more generally, livestock-dependent)

households. For this reason, livestock price indices are generally calculated with weights that reflect the breakdown of production or herd sizes. The method is similar to that of crop output price indices. The weight given should reflect the sales volume of each animal type in the area under consideration.

Unfortunately, data on animal sales volumes by animal type is rarely available. Data on herd composition is therefore used as a proxy for animal sales composition, in areas where one or more year's data is available. The problem is that data is often not available on herd sizes or production, especially in pastoral areas. It may therefore be necessary to use a subjective weight method for making livestock price indices.

The subjective method depends on the analyst's judgment on the breakdown of the herds by animal. It would, for instance be possible to rank animals from 1 to n (where 1 is the least important animal in herds). The calculation of the weights and the indices would be the same as the calculation of the subjective consumer price indices above.

Another important type of price index is the livestock / food "**terms of trade**" (TOT) which compares livestock head prices and market food prices. This is often calculated as:

$$\text{TOT} = \frac{\text{The price of the predominant animal}}{\text{The price of the most consumed cereal}}$$

The ratio is a measure of food **purchasing power** in livestock producing areas, that is, a measure of current food prices with respect to current income. It is inadequate in areas where several animal types are produced and more than one food commodity is purchased.

A more complete measure of terms of trade is the ratio of a consumer food price index to a weighted livestock farm-gate price index. This ratio, by capturing a wider range of price information, is likely to give a more complete picture of the food purchasing power of livestock dependent households.

Calculation and analysis of Terms of Trade are discussed in more detail in Module 4 of this document.

2.9 Aggregation across Markets

In Unit 3, we discussed "commodity aggregation" and how to create commodity indices. While commodity aggregation is necessary, it may not be enough to provide sufficiently summarized data. There are so many markets in Ethiopia that we cannot hope to present data on all of them.

There is therefore a need to create price indices for groups of markets at the zonal level for regular summary reports. In many zones, particularly the more populous ones, several markets report on a regular basis. Using averages can present a rather biased picture as small markets will unduly influence the index. For this reason, we need to create a system of market weights for each market.

How can we measure the importance of one market in a zone or region?

Ideally, the weight would be based on total traded volumes of a specific market in relation to traded volumes at the zonal or regional level. So, for a consumer price index a particular market would be weighted by the volume of retail sales of the commodities in question in that market, divided by the total volume of retail sales in the zone.

Unfortunately, little or no data is likely to be available on the volumes of market transactions. For this reason, we have to find an alternative “indicator” of volumes of transactions. Alternative indicators (when the actual variable cannot be measured directly) are called “proxy measures”.

One proxy for traded volumes is the total population of the area that the market serves. As with commodity grouping it will be necessary to create procedures for calculating market weights and then for applying them to produce the necessary indices. There is a possibility of also using subjective judgments on the relative importance of a particular market in a zone when creating market weights. Using the first approach, the population of the Woreda in which the market is found would be a reasonable indicator - most of the monitored markets are located in the Woreda capitals. The weight given to market j, for j Woredas in a zone where markets are reporting would be calculated as:

$$\text{EQUATION 1: } \quad w_{pop_j} / \sum_1^m w_{pop_j}$$

Where: w_{pop_j} is the population of woreda j in which market j is found and there are a total of m woredas in the zone

The territorial price index for a zone, for commodity i, in period t would therefore be calculated as:

$$\text{EQUATION 2: } \quad PIND_{it} = \sum p_{ijt} \cdot [w_{pop_j} / \sum w_{pop_j}]$$

Using the second approach, markets in a zone can be ranked in order of their perceived importance in the zone or region. If there are six markets and the most important is ranked 6 (r6) down to the least important ranked 1 (r1). The market weight is then calculated as:

$$\text{EQUATION 3: } \quad w_j = r_j / \sum r_j$$

2.10 Aggregation across Time

For the purpose of data summary for many types of analysis, we often need to have a general impression of “prices this year” compared to previous years. In particular, we may wish to use annual price data to draw conclusions about the average food security situation in a specific year. Our data is collected on a monthly basis. So how do we draw conclusions about the whole year?

We could just take the annual average. However, seasonal patterns in consumption and sales mean that for both farm-gate and consumer price indices, the annual average price is not a good indicator of the prices faced by consumers and farmers respectively. It is necessary to create weighted indices that reflect **seasonality**.

In Ethiopia, most food security analysis is focused on rural households that are both producers and consumers of food commodities. Food is harvested once or, in Belg areas, twice a year. Typically, householders consume from on-farm production and sell their produce for the immediate post-harvest period. Then, as the lean season approaches more food is purchased on the market for household consumption. We can say very generally that farm households as producers will benefit from high prices in the post harvest period but during the lean season, if households become net purchasers on the market, they will suffer from higher prices.

The implication of these seasonal patterns in sales and purchases is that we should give a higher weight to a consumer price index in the period when households are purchasing more. Similarly for farm-gate price indices, we should give more importance to months when sales are higher.

This may be an over-simplification. Suppose farmers are good economists, as they often are. They would expect prices to rise towards the lean season and to be depressed in the post-harvest period. So they might decide to “speculate” against prices. By storing their produce and selling it later in the season, they can make more profit.

It is difficult to say how far farmers speculate. On farm storage patterns tend to vary from location to location. Often farmers need cash in the immediate post harvest period to pay off input loans. Towards the end of the peak supply season they may already be purchasing inputs for the next cropping season. Sometimes liquidity problems will mean that households choose not to store.

Although the economic theory tells us that farmers should speculate, the theory is based on the idea that farmers can get as much credit as they wish, at any time. So, if they have to buy farm inputs they are not forced to sell their produce at seasonally low prices, but can hold out for higher prices, and buy the inputs on credit. The reality is that credit, if it is available at all, is rarely sufficient and often not provided on time. In the absence of credit, funds must be raised by sales.

Another reason why farmers may not store is that on-farm storage facilities are not adequate and there is a high risk of losses from storage pests and humidity.

It is difficult to say when households will sell and when they will buy without data on actual monthly sales and purchase volumes. We can only say that it is probable that sales will peak in the post harvest period and purchases will peak in the lean season.

2.11 Seasonal Weights to Price Indices

As there is little or no data on seasonality, it is difficult to assign a set of rational weights to annual farm-gate or consumer price indices. The only practical method is essentially subjective. Each month (or season) in the year is “scored” based on local knowledge, according to the relative volume of purchases or sales of a given commodity. The scores can then be used to create a weight for each month. The annual index is the weighted sum of prices in each month.

Note that the seasonal patterns are likely to be much stronger for annual crop producing households. In these areas, sales may follow a “counter-cyclical” pattern. That is, when market prices are lowest, sales are highest. Purchases also follow a counter-cyclical pattern. In areas where households are more dependent on livestock or off-farm income, food purchases may be much more “spread out” over the year. Equally perennial crop producers will tend to have more regular purchases of food commodities over the year.

So, if the weights for each month are w_k , $k=1,2, \dots,12$, the annual index for a price or index P is:

EQUATION 1:
$$P = \sum_{k=1}^{12} w_k P_k$$

2.12 Three Way Indices

In this Chapter, we have discussed three types of aggregation and index:

- by commodity
- by location
- over time

Suppose we want to get a general picture of “food prices this year in zone x”. This is a three-way aggregation using all the methods, presented above. Mathematically it does not matter whether we first create a commodity index and then a seasonally weighted index of monthly observations or calculate the seasonal index for each commodity and then create a multiple commodity index. The results are the same. In fact, we can say that:

$$\text{EQUATION 2: } \text{ANNUALPI}_{t+0} = \sum_{i=1}^{i=n} \sum_{j=1}^{j=m} \sum_{k=1}^{k=12} (w_i \cdot w_j \cdot w_k \cdot [p_{ijk t+0} / p_{ijk \text{base}}])$$

Where **ANNUALPI_{t+0}** is the annual value of the price index for markets $j=1, j=2, \dots, j=m$ and commodities $i=1, i=2, \dots, i=n$) aggregated over 12 months

Module 3

Temporal and Spatial Aspects of Markets

Objective of this module

To enable participants to understand the relevance of spatial and temporal arbitrage for interpreting price time series; appreciate their relevance for the efficient working of markets and the welfare consequences of market failure in this area; to think of policies to address these failures; to analyze price data distinguishing between seasonality and trends, and being able to test for market integration.

Expected Outputs

By the end of this session, the participants will be able to do the following:

1. Meaningfully analyze Price Changes
2. Analyze components of price time series
3. Discuss trend analysis
4. Practice trend component of a time series using multiplicative model of time series decomposition
5. Understand basic concepts of the market for storage, its relation with seasonal price variability, and the consequences of market failure in this area
6. Understand the notions of spatial and temporal arbitrage
7. Understand the pre-conditions for efficient spatial arbitrage and the causes for market failure in this area
8. Evaluate the welfare losses from market segmentation
9. Analyze time series of prices in spatially distinct markets to test for market integration

Summary

Part I: Price changes and Arbitrage

- 1.1 The Concept of Arbitrage
- 1.2 How to Study Price Changes
 - 1.2.1 Comparing Like with Like
 - 1.2.2 Percentage Changes
 - 1.2.3 Price Variance
 - 1.2.4 Price Ratings
 - 1.2.5 Seasonal Decomposition

Part II: Price trends, price seasonality and storage

- 2.1 Price Trends and Price Seasonality
 - 2.1.1 The Eye-Balling Method
- 2.2 The Market for Storage
 - 2.2.1 How Storage Ought to Work - the Competitive Model
 - 2.2.2 The Causes and Consequences of Market Failure

Part III: Market Integration

- 3.1 How Transport Should Work
- 3.2 The Causes and Consequences of Market Failure
- 3.3 Policy Implications of Market Failure
- 3.4 Testing for Market Integration

Part IV: Integration with International Markets: an Import Parity Pricing Tool

- 4.1 What is Import Parity Pricing
- 4.2 What Insight can This Tool Provide?
- 4.3 How to Analyze, Interpret and Use the Data
- 4.4 How to Calculate the Indicator

Part I: Price changes and Arbitrage

1.1 The concept of arbitrage

So far, we have looked at supply and demand, and how the market determines prices. Our understanding is incomplete, however, until we know how the food market works, that is, the mechanics of trade. In this module we look at how trade should work and why it might not. Private trade has three main roles:

- Transportation of commodities between locations, or **spatial arbitrage**;
- Storage of commodities over time, **temporal arbitrage**;
- Trade in commodities between countries, or **international arbitrage**.

Arbitrage refers to the activity of moving commodities across space, time and countries in order to take advantage of the existing **price differential**. If wheat sells for a higher price in Mekelle's market than in Addis Ababa's, and transportation costs are sufficiently low, traders will make a profit by moving wheat from the Addis Ababa's market to Mekelle's. Similarly, if teff sells for a low price in the harvest month of December, while gains a much better price in June, traders have an incentive to store it and take advantage of higher prices later on in the year- provided storage costs are sufficiently low.

So arbitrage will happen whenever price differential are higher than arbitrage costs. For spatial arbitrage such costs typically include:

- Transport costs and freight insurance costs
- Transaction costs (e.g., brokerage fees, customs duty, sales taxes, negotiation and communication costs)
- Losses due to spoilage, mishandling, theft, etc.

For temporal arbitrage the costs include:

- Storage, fumigation, insurance, security fees;
- Transaction costs (e.g. brokerage fees, customs duty, sales taxes, negotiation and communication costs);
- Losses due to perishability mishandling, theft, etc.

If markets are working well and both spatial and temporal arbitrage are taking place un-hindered we expect two consequences on the behavior of prices:

- Less variability;
- Stabilization around mid-range prices.

If the private trade is performing the arbitrage roles well, the result is likely to be more stable and "well behaved" prices. Local shocks to supply will in fact be smoothed by movement of commodities across time and space, so that the resulting price shocks are moderated. Stable prices are an advantage to both producers and consumers. They help people to plan and mean that unexpected and damaging price rises or falls can be avoided.

Furthermore, stabilization will tend to happen around mid-range prices, as local shocks tend to offset each other and hence overall demand and supply tend to be much more stable and balanced. That, when

arbitrage works across space and time the market tends to clear at a mid-range level because supply tends to be smoothed.

The cost of failure in arbitrage is thus more volatile prices and more severe price shocks.

If we know how markets are working, we can draw deeper insights into the reasons for price changes, how long they are likely to last and how they will affect people. Furthermore, an understanding of the workings of the market will also allow us to make better judgments on the appropriate type of relief intervention policy, as explained in Module 6. In many cases, a policy that is appropriate when markets are working well is not appropriate when markets are not working well or vice-versa. Appropriate policy responses are discussed in the Units below.

In this module we explore price time series analysis (units 2 and 3), temporal arbitrage and seasonality (unit 4) and market integration and spatial arbitrage (unit 5).

1.2 How to Study Price Changes?

How can we identify changes in prices? To identify large changes in price (either positive or negative), we need to be able to compare current prices with historic levels

Note that for all such comparisons, we must use inflation-adjusted data (see Module 2, Unit 5). Otherwise, macroeconomic factors, like the devaluation of the birr, rather than local market factors could influence the results. If there have been high levels of general price inflation any current price observation (any commodity, any market) might be higher than the historic mean, but this would not necessarily indicate that local market conditions had changed for all commodities in all locations.

There are several methods for comparing current prices with means. One is to measure the percentage change of the current value from the historic mean (for the same period in the year). The second method, which is somewhat more complicated, uses the concept of variance.

Before we explain these methods, we must explore some of the general issues of comparing like with like.

1.2.1 Comparing Like with Like

As we have discussed, prices are subject to seasonal fluctuations meaning that they are likely to be higher in some periods of the year than in others. Consider, for example, analysis of post harvest prices in January (when they are likely to be at a low point). If we compare them with prices throughout the previous year (including lean) season prices, we may conclude that: "current prices are lower than the average for last year." However, this could simply reflect seasonal lows.

For this reason, when we assess price changes we should always compare prices in the current period with those in the corresponding month of previous years. Thus, if we are looking at prices in January of this year, we might compare them with the average prices in January of the five previous years. This is the simplest way to avoid false conclusions. Technical Note 1.5 describes an alternative method.

Comparing like with like extends to commodity choice and market selection as well as time period. It is not meaningful to say that current maize prices are higher than the average cereal prices for the past ten years, or that prices in one particular market are higher than average historic prices in the zone as a whole.

1.2.2 Percentage Changes

The simplest form of price comparison is of percentage changes from the mean. The mean is defined as the average value of that price (or index) for the previous T years. For example, if we have a series from 1986 to 1995 inclusive, the mean price for June (m+6) is:

$$\text{EQUATION 1: } P_{\text{mean } m+6} = \frac{\sum_{y=1986}^{y=1995} P_{y \text{ } m+6}}{10}$$

If we want to compare June 1996 with the mean we can express this as a percentage

$$\text{EQUATION 2: } P\% \Delta = \left(\left[\frac{P_{1996 \text{ } m+6}}{P_{\text{mean } m+6}} \right] * 100 \right) - 100$$

The mean maize prices for June are calculated from an interpolated series of 10 years (from June 1986 to June 1995) for Addis Zemen market. The mean was calculated using the real price series (inflation adjusted using general CPI data provided by CSA). It was also calculated for the nominal (no inflation adjustment) series. June 1996 prices are compared to the mean (percentage changes from the mean). The results are presented in table 1 below.

Table 1: June 1996 Maize Prices Compared to the Mean

	Price in June 1996	mean June price 1986-1995	1996 % change from mean
nominal maize prices	85	84	1
real (adjusted) maize prices	88	122	-28

It can be seen from this example that when allowance is made for inflation in the 11 year period the results change dramatically. The nominal price series gives the impression that the June 1996 maize were 1 percent higher than the average of the previous ten years, whereas the adjusted series shows a 28 percent fall from the mean. This illustrates the need to use an inflation-adjusted series for all comparison with past values.

1.2.3 Price Variance

Calculating percentage changes from the mean tells us whether prices are higher or lower than the mean. But what does a 28 percent drop in prices really signify? A 28 percent fall from the mean may be a very unusual occurrence in some markets but a regular occurrence in others. In most rural markets in Ethiopia, there is high monthly and yearly variability in food prices.

We need to design a method for assessing whether changes are “exceptional” compared to “normal changes”. In a very unstable market (with high variability) a 28 percent fall in prices would be much less significant than a 28 percent fall in prices in a normally stable market.

In fact there is a measure of normal price variation, the standard deviation. The standard deviation is calculated as the average sum of the squares of deviations from the mean. The formula for calculating the standard deviation of a price series (sdP) of T observations is:

EQUATION 3:
$$sdP = (n\sum P^2 - [\sum P]^2) / (T [T-1])$$

The current period deviation from the mean (ΔP_{t+0}) is simply:

EQUATION 4:
$$\Delta P_{t+0} = P_{t+0} - P_{mean}$$

A method for detecting exceptionally high prices takes into consideration both the mean and the standard deviation or average variation of a series. It measures the current price in terms of number of standard deviations from the mean. The current deviation expressed as “numbers of standard deviations from the mean” or **nsdP** is calculated (from equations 3 and 4 above) as:

EQUATION 5:
$$nsdP = \Delta P_{t+0} / sdP$$

From the same maize prices series for Addis Zemen, we find that there is a high level of year on year variability in maize prices. The standard deviation of the June prices from 1996 to 1995 is 35. The June 1996 deviation from the mean is -34. The current variance measure is therefore:

EQUATION 6:
$$\Delta P_{t+0} / sdP = - 34 / 35 = - 0.98$$

Given high maize price variability in Addis Zemen, a value of -34 birr away from the mean does not amount to an “exceptional” change. It represents a decrease of about 1 standard deviation from the mean. Notice that if price variations follow a normal distribution (this need not be the case necessarily!), then about 70% of variations happens within the interval defined from plus one standard deviation over the mean to minus one standard deviation. Values outside this interval can be considered as less frequent or even “exceptional”.

1.2.4 Volatility

In sections 1.2.2 and 1.2.3 we have looked at how to analyse price changes. Given a particular price, we want to know whether it is an “exceptional” or “normal” variation from the prices typically observed in that market. We now turn to the question of how to measure the magnitude of price changes observed in a given market. We want to be able to investigate whether a given market tends to experience large and frequent price changes, or whether its price changes tend to be moderate in frequency and magnitude. To refer to this concept economist talk about the **volatility** of prices in a market.

Notice that investigating whether a market is volatile is an important step for establishing the most appropriate food security intervention. In particular, cash transfers are not advisable in a highly volatile market. Cash transfer boost demand for food and hence cause price increases. If a market is volatile and hence prone to large price hikes, the effect on food prices of the cash transfer can be particularly emphasised. Following the transfer, prices may hence increase by a large amount, damaging non-recipient households. This problem is particularly acute when transfers are mis-targeted and some eligible households do not receive any cash. If so, not only these households had from the beginning poor mean to ensure access to food, but they now also suffer additionally from the higher food prices.

Volatility can be calculated using what is known as the “coefficient of variation”. The formula to be used is:

$$CV = \frac{sdP}{average}$$

Where CV stands for “coefficient of variation” and sdP is the standard deviation. What do we calculate the standard deviation and the average over? There are two possibilities, one meant to give an overall view of volatility in the market of interest and one meant to analyse short term changes in volatility.

The first possibility is to calculate the standard deviation and volatility over the whole series of available prices, or over some big interval of time. In this fashion we get an overall view volatility in the market. If we use a series that spans over more than one year, the coefficient of variation we calculate reflects both inter-annual and intra-annual price fluctuations. Once we get to such an overall figure, we can compare volatility in different markets. For example we can compare a market which we suspect to be volatile to a market which we know to be supported by good functioning storage and transport markets. If we use a series that cover only the 12 months of one year, we isolate intra-annual price fluctuations. In this case, we can compare volatility in different years for the same market.

The second possibility is to focus short term moving series for every month we are interested in analysing. Short term is usually defined as 5 to 7 months. Hence, for, say, the month of June, we consider a series of 5 to 7 months where June is in the middle. Of this series, we calculate average and standard deviation. With this method, we can calculate a monthly coefficient of variation for a series of months. By plotting such series we can analyse how volatility of a market is changing through short periods of time.

Moving averages are explained with more detail below, in particular, look at equation 6 in section 2.1.2.

1.2.5 Price Ratings

The approach outlined above has an important function in food security analysis. Counting the standard deviations from the norm allows us to classify market prices in a way that is analogous to qualitative ratings of other variables (such as food production). The qualitative variables tend to be classified 1 to 5 with the following meaning:

- | | | |
|---|---|----------------------------------------------------------------------------|
| 1 | = | very good (much better than normal) much higher than normal for production |
| 2 | = | good, better than normal, higher than normal for production |
| 3 | = | about normal |
| 4 | = | worse than normal |
| 5 | = | much worse than normal |

For most inflation adjusted price series, if the current price is more than 1.5 standard deviations from the norm, this implies a major price fall or rise. Hence, we can “convert” the quantitative price analysis into a price rating (**PRAT**) which is analogous to qualitative ratings for other variables, and allows us to make some quick judgements on the food security situation:

EQUATION 7: $PRAT = 3 + (\Delta P_{t+0} / sdP) = 3 + (-34 / 35) = 2.02$

If, for example, an index of consumer prices indicates a “large increase” in prices and the rating is calculated at 4.6 then this, combined with a Woreda level report of “very poor crops” might sound the warning bell.

Part II: Price Trends and Price Seasonality

2.1 Price Trends

Once data has been adjusted to reflect underlying inflation, it will be possible to identify market and commodity specific **price trends** or “movements over time”. We might, for instance, wish to identify those markets where consumer food prices are showing an upward tendency. This will be useful for regular market reporting on market conditions. It will be possible to report, for market x, that “food prices are uncharacteristically high and continuing to rise”. The second purpose of trend analysis is it sometimes useful to be able to make price predictions.

In this analysis we are examining “within year” trends, from month to month. For this reason, we must always use de-seasonalised data. Otherwise, seasonal patterns might be wrongly interpreted as trends. Further, within year inflation can lead to trends, which are accountable to macroeconomic factors, rather than changes in local market conditions. In order to avoid misleading results, we therefore have to use deflated price data. Some of the common computer tools for identifying trends will not work if there are missing values. It is therefore necessary to use a price series that has been filled, deflated, and de-seasonalised.

Computer tools can be used to identify upward or downward price trends. We can characterise trends in a number of ways. The first way is according to direction (up or down). The second is according to the magnitude of the trend (strong or weak). A strong upward trend would imply that each month price rise by a large amount. The third way of characterising is according to the “significance” of the trend. Significance is a statistical concept, which is explained in more detail below. If prices have continuously and consistently risen over a sustained period, this is likely to be a significant upward trend. If, on the other hand, prices have fluctuated but “in general” they have risen, the trend may be statistically insignificant.

We can use these three characterisations to identify eight types of trend, as table 1 below illustrates:

Table 1: Types of Price Trend

	Upwards		Downwards	
	Strong	Weak	Strong	Weak
statistically significant	Significant strong upward	Significant weak upward	Significant strong downward	Significant weak downward
statistically insignificant	Insignificant strong upward	Insignificant weak upward	Insignificant strong downward	Insignificant weak downward

Notice that a trend usual take place during a definite interval of time. We can have an upward trend that lasts for two years, followed by a period of price stability, for example. Notice that in the analysis of time series it is important to bear this aspect in mind. In particular, it is sometimes the case that the series shows **structural shifts**. Due to big changes in the underlying structure of the economy (for example, big policy changes such as trade liberalization) a series can be “divided” into two or more separate periods characterized by very different trends and patterns of seasonal fluctuations. Identifying such structural

shifts is crucial when connecting the analysis of the data to the real world conditions that are behind what we observe in graphs and figures.

2.1.2 The Eye-Balling Method

The simplest way to identify the existence of a trend and to make a general judgement on its direction, strength and significance is to graph a price series (with time on the horizontal axis and the price on the vertical axis). The analyst can then make a judgement on the likely type of trend. It is possible to assess the direction and the rough magnitude of the trend, although the method is not suited to judging the significance of a trend. This method is sometimes called (colloquially) data eye-balling. Four examples are given below.

In the example below we can see at a glance that market 1 shows a strong upward trend in maize prices and market two a weak upward trend.

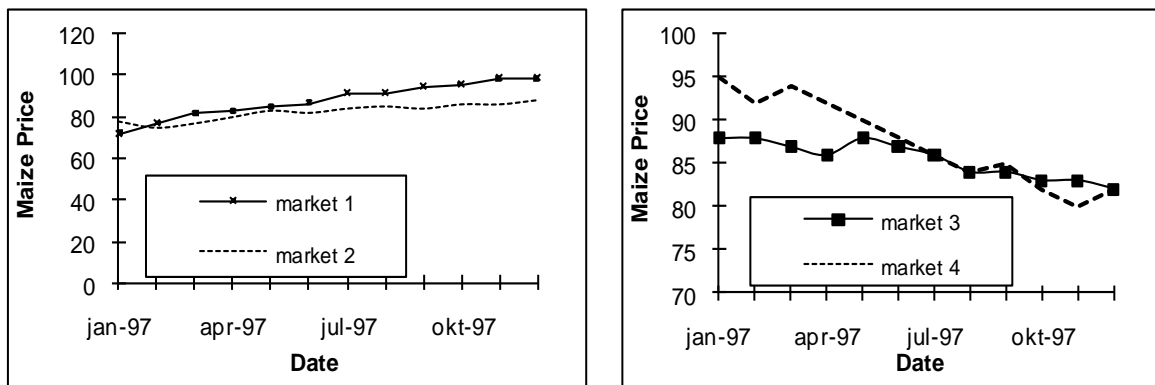


Figure 1: Examples of Upward and Downward Trends

Market 3 demonstrates a weak downward trend, whereas market 4 exhibits a strong downward trend.

2.1.2 Formal Trend Analysis

There are various, more formal, techniques for estimating trends. Let us start by thinking a bit more rigorously about price time series. The following formula is helpful to summarise the main components which are behind the observed time series values:

Equation 1 $P = T * C * S * I$

Where P is the observed price, T is the trend component, C is the cyclical component, S is the seasonal component and I the random component. Equation 1 captures what is known as the **multiplicative model of time series decomposition**. Let us look at each of the four elements on the right hand side of equation 1 separately.

The **trend component** refers to the general tendency of a time series (upward or downward, strong or moderate, significant or not significant). As it was discussed above, it can be detected by visual observation of a scatter plot of the raw data. But visual detection has to be supported by a more rigorous statistical method.

For price series in general there is no one single ideal method as the types of trend may vary between product and market place, depending in part on the seasonal structure of production. The appropriate

trend specification can, however, be identified, by reiterative testing of the data and by selecting the trend specification that achieves the “best fit.”

One such trend specification is the linear one:

EQUATION 2: $P_{it} = a + b T$

In this equation, T is the independent variable. We can judge the direction of the trend by the sign of the parameter b. A negative sign implies a downward trend (prices become lower as time goes by). Conversely, a positive sign implies an upward trend. The size of the parameter b is indicative of the strength of the trend. The method can also be used to assess the significance of the trend. A high R² is indicative of a significant trend and the significance of the F test is a good test.

The graphical examples shown in Figure 1 can be tested more formally using this model. The results are presented in table 2 below:

Table 2: Results of Trend Analysis for Within Year Maize Prices for 4 Markets

	R ²	F test	F signif.	B (t test)	t-signif.
market 1	0.96	286	***	+2.37 (+16.9)	***
market 2	0.81	74	***	+1.05 (+08.6)	***
market 3	0.86	64	***	-0.57 (-08.0)	***
market 4	0.94	156	***	-1.36 (-12.5)	***

*** Significant at a 1 percent confidence interval or below

From the results, we can see that Market 1 has a strong and highly significant upward trend. Market 2 also has an upward trend although weaker and, although the regression passes the one percent significance test, it is less statistically significant than market 1. Market 4 has a strong and highly significant downward trend. Market 3 has a weaker and less significant downward trend.

The statistics and mathematics of trend analysis are quite complex and if analysts are interested they may refer to standard textbooks on the subject.

The **cyclical component** refers to cyclical fluctuations of the price variable above or below the trend component. These are mid-range price movements, of contraction or expansion, which span too little to count as proper trends, and too long to be considered as seasonal variation.

The best way to identify them is through the use of moving averages. A 12 month moving average is defined as:

Equation 3 $MA^{12} = \frac{[\sum_{i=t-6}^{i=t+5} P_i + \sum_{i=t-5}^{i=t+6} P_i]}{24}$

Notice that the moving average gets rid of the seasonal and random variation, and hence is a combination of the trend and cyclical components:

$$\text{Equation 4 } MA^{12} = T * C$$

We can get the estimated trend value once we have estimated equation 1 above. Once that is done, we simply divide the moving average by the trend component and are left with the cyclical component:

$$\text{Equation 5 } \frac{MA^{12}}{T} = \frac{T * C}{T} = C$$

The **seasonal component** refers to short term fluctuations in the time series within the general trend. These are often calendar-related and predictable fluctuations which recur seasonally. Seasonal variation is very common in agricultural price time series because of the biological nature of production and supply.

Seasonality gives the wrong impressions about the general movement of a time series. For example, if we observe low prices for wheat in the harvest month of December 2009 and do not take seasonality into account, we may erroneously conclude that wheat prices are generally decreasing. In fact, because during harvest time supply of wheat is very large, wheat prices experience a seasonal decline. To know whether the decline we observe is just a seasonal pattern or is signalling a downward trend, we need to do **seasonal adjustment** of the time-series.

We can isolate the seasonal variation by going back to the multiplicative model of time series decomposition described in equation 1. Remember from equation 4 that when we calculate the moving average, we are basically pinning down the trend and cyclical components of the time series. Hence if we divide the time-series for its moving average value what we get is a combination of the seasonal and random factor:

$$\text{Equation 6 } P = \frac{T * C * S * I}{T * C} = S * I$$

We can then easily get rid of the random component simply by averaging out the price value over many years. For example, if four years of monthly data are available, we get the seasonal component in the following way:

$$\text{Equation 7 } \frac{(S * I)_{Dec 2005} + (S * I)_{Dec 2006} + (S * I)_{Dec 2007} + (S * I)_{Dec 2008}}{4}$$

We thereby identify the seasonal component of the price variation. It is now possible to judge whether the price decline observed in December 2009 corresponds to the average seasonal variation for that month or differs from it. More formally, once we obtain the seasonal component S for every month, we can the original time-series can be divided by the seasonal index for the relevant month to obtain data free from seasonal variation:

$$\text{Equation 8 } \frac{P}{S} = \frac{T * C * S * I}{S} = T * C * I$$

Once the time series is so adjusted, we can analyse price movements without risking to be confusing seasonal movements for long run trends.

2.1.3 Price Forecasting

Early warning and mid-term analyses often involves predicting the future. Typically, for example, crop assessments take place in the harvest or post-harvest period, and there is a need to understand likely developments in the food situation for the following 10 or 11 months so that the right resources can be mobilized in time. This often entails making projections of important variables like belg crop production - or food prices.

The basic methods for price forecasting depend on the concept of extrapolation. Extrapolation means the extension of past and current values into the future, based on an analysis of trends. There are numerous types of extrapolation function and the subject is too wide to be covered here. However, it is possible to give a few useful explanations of the topic.

As with the identification of trends, extrapolation techniques require filled, deflated and de-seasonalized price data. The extrapolation techniques first identify a trend, using statistical techniques such as regression or auto-correlation models. Then the parameters of these functions are estimated. These parameters are then used to make the extrapolation or projection.

Consider the simplest method, which uses the linear regression model presented above. We suggest that prices of commodity i in a period t are a function of time itself or:

EQUATION 9: $P_{it} = a + b T$

For the above regressions we created a variable called T , which is a whole number series (1, 2, 3 ...12) for twelve months. For market 1 maize prices the regression gave these results for the parameters a and b :

EQUATION 10: $\hat{P}_{it} = 73 + 2.37 T$

Where \hat{P}_{it} is the price value as estimated by the regression model

We considered only the periods up to the twelfth month (12). Suppose we are now in December and wish to extrapolate prices for next January and February. We simply plug the sequential values for T in those months, 13 for January and 14 for February into equation 9. So the estimated price for January would be:

EQUATION 4: $\hat{P}_{13} = 73 + (2.37 \times 13) = 103.8$

or for February, using the same method, the estimated price is:

EQUATION 5: $P_{13} = 73 + (2.37 \times 13) = 103.8$

2.2 The Market for Storage

All food prices vary in time: they are more expensive in some years and in some times within the year. In this Unit, we look in more detail at **seasonal price patterns** or intra-annual price variability. We have already seen how prices are expected to rise and fall at different times of year. The critical policy question is: By how much? Are the seasonal patterns wild?

In Section 2, we provide a more detailed explanation of how storage works. With a competitive private trade, traders store food in peak supply periods and release it in the lean season. This tends to keep price variability down within a year. To some extent there may also be “year-on-year” or inter-annual storage, which will keep inter-annual price variability down. In section 3, we explain the common causes of market failure and the results of market failure in terms of prices and wellbeing. Then in section 4 we briefly assess the policy implications of the failure of the storage market.

2.2.1 How Storage Ought to Work - the Competitive Model

The competitive model depends on the following assumptions concerning the workings of the storage market:

- Adequate storage facilities either for rental or purchase
- Availability of credit for speculative purchases
- No red tape, special taxes on stocks or rules preventing hoarding
- Prices are determined by the market, there are no fixed prices
- Large numbers of non-colluding traders
- Information on prices
- Rational expectations concerning future prices

In rain-fed systems, characterised by seasonal harvests, all prices have seasonal pattern. In competitive markets, prices gradually rise after harvest to a peak just before the next harvest. Traders expect prices to follow this pattern and “speculate” against prices by purchasing in the harvest period, when prices are low, and storing for sales later in the year.

This process is called **temporal arbitrage**. According to the theory, if the market determines prices, stocks will be released gradually and at a price that reflects storage costs and interest charges in the intervening period. Traders in this model cannot make windfall profits by “hoarding food” or starving the market. If one trader tries others will quickly benefit from the additional price rise by releasing food onto the market - and the price will return to the equilibrium level.

Note that traders can also store from one year to another. This is “speculating” against bad harvests and high prices in the future. If, for instance, the harvest has been particularly good this year, traders might keep their stocks until after the next harvest. This is unlikely however. It is a high-risk strategy as the next harvest might just be another bumper crop, in which case the costs of the storage would not be recovered. In other words, long term speculation carries the risk of making a loss.

2.2.2 The Causes and Consequences of Market Failure

The following reasons can be given for why the storage market may fail to live up to the expectations of the competitive model:

- **Irrational expectations:** traders may make wrong decisions on how much prices will rise by or for how long they will stay high and for this reason they may store too much or too little. This is

especially likely if there is little information available on historic prices with which they can make guesses about seasonal patterns

- **Barriers to entry**, such as lack of credit, restrictive legislation, or limited storage facilities: the market is likely to be characterised by a few large traders. They may therefore be colluding. The traders can agree to hoard or “starve the market”, forcing prices up to a very high level and making windfall profits.

The effect of a failure in the storage market is to make intra-annual food prices very unstable and, when non-competitive behaviour is involved, prices tend to exhibit very high and damaging price fluctuations. Farmers in these circumstances will tend to want to store more on farm, usually in poor storage facilities and losses are high. In the absence of good storage facilities, traders might try to cut costs using cheaper open storage techniques resulting in losses and drops in food quality.

Consider now that there is also the possibility for trading out. If storage is not working, traders cannot expect to cover their costs by storing - so they have a larger incentive to trade food-stuffs out of the area in the post harvest period. It becomes more profitable to trade out rather than to wait. In such situations and outflows and/or hoarding can lead to very high lean season prices and a few traders making very large profits.

The result of high seasonal price variability may be damaging to both producers and consumers. If farmers do not have good storage facilities on farm, in a good crop year they may not be able to stock all their surplus produce and sell it immediately on the local market shortly after harvest. This means that prices will be particularly low in the peak supply period, which could reduce farm income and incentives for production. Similarly, in the lean season, when many households are purchasing on the market, supplies may be very tight and prices high, so consumers suffer. Both farmers and consumers find it difficult to plan and are likely to be disadvantaged by the high price variability if the storage market is not working.

2.2.3 Monitoring and Policy Implications

For monitoring purposes we can expect areas with poorly developed storage markets to experience very sharp intra-annual (within year) price variability. We might expect sudden price hikes which could cause sharp falls in food consumption.

There are a number of policies which, in the long run can help to improve the workings of the market, like:

- Improving credit services for traders
- Rental of Government storage facilities, if they exist
- Removing red tape: making it easier for potential traders to enter the market
- Removing price controls where they exist
- Providing price information

For the design and implementation of relief policies we have to consider the implications of very marked seasonal patterns to food prices.

Firstly, it is likely that a correspondingly higher proportion of households will be particularly vulnerable in the lean season. In areas where relief needs have been identified, more emphasis should be placed on lean season intervention (getting the intervention duration right) in areas where markets are not working well. The impact of direct distribution and food for work programmes in the lean season will be greater as the value of food transfers to the recipients will be higher.

In areas where the seasonal patterns are particularly strong there may be an argument for increasing the ration scales as the pre harvest period approaches. In segmented markets where storage is not working, lean season monetisation (injections of relief food into the market when prices are highest) can be most beneficial in helping to avoid very large price hikes.

If, on the other hand, the storage market is working, it is important that policies do not distort or “disturb” the market. Large and untargeted relief interventions can make the lean season price lower than the market optimal. This will mean that traders lose money or have a disincentive to stock food in the future. In these situations, heavy lean-season local monetisation in deficit areas should be avoided. Special care is also needed in targeting the most needy for food for work or direct distribution. The more needy the beneficiaries, the less likely it is that they will re-sell on the market and therefore the lower the impact on the market price.

EXAMPLE

Suppose that large quantities of relief food assistance are provided in a Woreda where only 2 FAs are really in need. In the remaining FAs, people generally prefer local varieties of wheat, barley, and teff. The relief assistance commodity is low quality imported wheat. In these FAs, people will tend to sell the food aid wheat on the local market, thereby depressing wheat prices.

Local traders are left with large and very low valued stocks of wheat. They will make losses, as they will not be able to cover their procurement or storage costs. Some may even go out of business, and all will be wary about stocking wheat in the next year. The result is that traders will be less willing and able to perform the role of storage (and market stabilisation) in the next season. They will find it less risky to transport their wheat purchases out of the area, so when the next lean season comes, the local market supplies will be tight and prices may skyrocket.

When the private storage fails, there are alternative possibilities for achieving some stability. The first is to improve external trade links. The second is the use of public stocks to stabilise prices. Stocks are bought in the harvest period, stored by the government and released in the lean season. Public stock policy can therefore substitute for private storage if the latter is not achieving the desired results.

Part III: Market Integration

In this Unit, we look in more detail at the role of the private trade in transporting food commodities from one place to another. This type of trade is called **spatial arbitrage** in economic jargon. Traders are motivated by profits. For a given level of transport cost, profits will depend on the **price differential** that is the difference in price between where they buy and where they sell. The higher the price differential, the higher too is the incentive to trade.

In section 1 of this unit we look at the competitive model for transportation in which markets are well linked by trade or are **well-integrated**. Well-integrated markets tend to be characterized by more stable prices and price hikes and dips last for a short time (the time it takes for traders to respond).

In section 2 of this unit we see why the competitive market model may not be applicable to the food market in many rural settings. We look at the reasons why **market failure** may occur. The result of failure in the transport market is **market segmentation**, when prices and market conditions are not strongly related between markets.

The consequence of market segmentation is discussed in section 4. Unnecessarily long and steep price hikes and dips occur. Local surpluses are not moved to where they are needed and local shortages last longer than they should. **Market segmentation** is generally harmful to both producers and consumers and certainly increases the chances of famines occurring. In section 5, we look at the implications of market failure for relief policy planning. We also provide a summary of the types of policy that can harm or improve market integration. Section 6 discusses the concept of import parity pricing.

3.1 How Transport Should Work

We can say very simply that a competitive transport market serves to take food from where it is in abundance to where it is most needed - with the result that supplies are more evenly spread over the country and there are no large price differentials between surplus and deficit areas.

A competitive transport market has these characteristics:

- the market is operated by a large number of traders who are not colluding;
- there are no physical obstacles to trade;
- there are no legal obstacles to trading in food commodities;
- prices in different parts of the country are determined by supply and demand and are not set by the government.

In this model price differentials between A and B should approximate the trading costs from A to B. Consider a country in which there are only two markets, A and B linked by a road. A is a surplus food producing market but B is a deficit market. The price of food in B will never exceed the price in A plus the price of getting food from A to B. If it did, this would mean that there were additional incentives for profit. Traders would simply increase the volume of trade, or more people would decide to become traders in search of easy money. Consequently, the price differential would again be reduced to the cost of transport.

Economic theory suggests that this will be so quick that there will never be big profits to be made. Traders will cover their costs exactly. Most important for consumers in B, prices will never rise much

below this level whereas if there were no trade, prices would always be very high, reflecting only local production and large demand.

Now consider market A. It is a surplus market, and this means by definition that it produces too much for the local demand. If farmers were to rely on local demand alone, prices would be very low, they would have little incentive to produce, and ultimately they would reduce their production. With trade to B however, prices reflect the additional demand in B. This gives them an incentive to produce.

If transport between areas is working well, we talk about **well-integrated** markets. To find out if two markets are **well-integrated**, compare the difference in price between them with the transport cost of getting food from one to the other. If the price difference is systematically higher than the transport costs, we can conclude that something has gone wrong with the competitive market.

EXAMPLE

Consider two markets, A and B, both of which are food crop producing and both are rain-fed, so crop production is variable.

Imagine a crop failure in A market and a normal crop in B. Assume that demand remains constant in both A and B markets. In the competitive model, prices in market A increase, temporarily. The result is that traders bring in food from market B until the price reflects the producer costs in B plus the costs of transporting from B to A. This means that the price in A will only exceed the cost plus price in B for short periods of time. As long as there is the incentive, traders will bring food in and keep prices down.

Well-integrated markets mean short-lived price hikes. This makes things better for consumers and worse for surplus producers (although, after a crop failure we can assume that most households will be net consumers). Scarcities tend to last longer with **market segmentation** because traders do not fulfill the role of stabilisation.

EXAMPLE

Now consider two segmented markets, X and Y, in rain-fed crop-growing areas.

Assuming demand remains constant in both X and Y markets, a crop failure in market X leads to a major price hike in X. Meanwhile, Y has gathered a normal crop so prices are stable.

The two markets are segmented by trade restrictions. Traders are not able to move food from Y to X. So, until the next harvest, prices remain high in X.

Note that the more remote, transport costs are higher and so the stabilising effects of integration are less.

3.2 The Causes and Consequences of Market Failure

We made plenty of assumptions about the competitive market. How far do these assumptions hold true in reality? In this section, we look at the reasons why markets may be segmented (poorly integrated).

We can make a distinction between temporary and underlying market failures. Underlying market failures are those which mean that the market is never working efficiently. Temporary market failures are when a market ceases to work because of a short-term shock.

Examples of temporary market failures in the transport market are:

- **Natural barriers to trade:** - in the case of extensive flooding, for example, or the collapse of a bridge or any key transport links. Natural barriers tend to be short lived.
- **Civil strife and blockades:** military road blocks or military activity which makes areas unsafe. Although it may be possible for trucks or small traders to move through, the risks are very high, especially when troops are imposing informal levies or simply impounded commodities. Military leaders usually do not like to see food commodities being moved across faction lines.

Underlying causes of market failure can be summarized as:

- **Credit constraints for long-haul transportation:** whereas short-haul trade makes use of pack animals and requires relative low set-up costs, the medium and long-haul truck trade may require credit for rental of trucks and for initial purchases of food. Without effective and competitive credit services it may be that it is difficult to enter the market. This in turn may mean that the medium and long haul trade is dominated by a few traders and there is a possibility of oligopoly and collusion (price fixing)
- **Red-tape:** Entering the trade (for medium and long haul trade) may also be difficult if the process of obtaining licenses is long and costly
- **Local levies on trade or restrictions on trading certain commodities:** Bylaws may impose heavy taxes on traders carrying food commodities from one zone to another. These taxes can be very discouraging, especially when they are high or imposed in an arbitrary fashion
- **Lack of price information:** poor communications between rural areas mean that traders may simply not know that there is the possibility of making profits. If information is unreliable and irregular, trading will become a high-risk activity. Traders may prefer to operate well known links between large urban areas with good communications rather than risking trade with remote "unknown" rural areas.

The main result of market failure in the transport market or market segmentation is that prices reflect local supply and demand conditions and are not influenced (in the case of fully segmented markets) or only partly influenced by conditions elsewhere in the country. It can be shown that, unless there is a third factor, which uniformly affects supply and demand in all markets in the country, this will lead to more unstable prices than in the presence of trade. Unless market conditions are perfectly correlated between markets, local price hikes and dips will last much longer in a segmented market than in an integrated market.

The effect of poor market integration is that local crop failures will tend to lead to strong and prolonged local price rises. Although there may still be some surplus farmers in deficit areas, who benefit from the high prices, the majority is likely to suffer. This will increase the risk of famine in vulnerable areas. Similarly, if particularly large harvests are reaped in a surplus area, prices will tend to show a deep and prolonged dip that will mean that farm income from crop production will suffer a major blow.

Of course, market dependent households living in food surplus areas will benefit from the lower consumer prices. In high potential areas, limited access to the main centers of demand will mean that the farm-gate prices are not as favorable as they could be, and farmers will have little incentive to produce.

More generally, we can say that prices are always likely to be less stable in segmented markets than in integrated market, especially in rain-fed systems, where food production is highly variable. Price instability benefits nobody. Farmers find it difficult to make plans and consumers are subject to high fluctuations in food prices.

The general conclusion is that although some groups may benefit from market segmentation, its consequences for food security, in terms of the total impact on well being are generally negative. People would generally be better off if there were effective trade.

3.3 Policy Implications of Segmentation

As we have suggested, the more remote the area the more prone it is to large price fluctuations and resultant “vulnerability” - even if markets are well-integrated. This means that we are likely to find bigger price hikes in remote areas in bad crop years. In the long term, only investment in the roads infrastructure will help to solve this problem.

Poorly integrated markets will tend to exhibit prices that are more variable, unless market supply and demand conditions are perfectly correlated. This means that people living in areas of poorly integrated markets will tend to experience more variable prices with much higher prices in a bad local crop year and much lower in a good year. For monitoring purposes, this means that we have to be particularly careful in assessing poorly integrated markets. We can expect to find a much stronger correlation between local supply conditions and prices in these areas.

There are a number of possible policies to improve market integration:

- Provision of transport infrastructure, lowering transportation costs and hence widening the scope for spatial arbitrage;
- Removal of red-tape and tariffs on local trade to improve the possibility of entering the market and the incentives for trade;
- Trust-busting: legislation to prevent monopolies or cartels (colluding oligopolies);
- Credit schemes to help small traders to start the business;
- Provision of price information and investment in the communications infrastructure.

3.4 Testing for Market Integration

There three main methods to test for market integration.

First, the analyst can perform **price spreads analysis**. This consists of a simple descriptive analysis. Remember from the discussion above that when markets are integrated, the price spread is supposed to reflect only the transportation costs involved in moving a commodity from the surplus to the deficit market. Suppose now Market A is experiencing a deficit of wheat and Market B a surplus. The cost of transporting one unit of wheat from B to A is c . If A and B were integrated we would expect the price spread minus transportation costs to equal zero:

$$\text{EQUATION1} \quad (P_a - P_b) - c \cong 0$$

If such difference was positive, there would be incentive for traders to move more wheat from B to A. Such movement of wheat would increase supply in A, bringing P_A down, and decrease supply in B, increasing P_B . The price-spread would thus be reduced, up to the point where it will equal transportation costs. Similarly, if the difference above resulted in a negative number, traders would be losing money by bringing wheat from market B to A. They would thus reduce the amount transported, so that price will rise in market A due to reduced supply, and decline in market B due to increased supply, increasing the price spread up to equality with costs c .

The second method is **price correlation analysis**. This consists in looking at the correlation coefficient between the price of the same commodity in two markets. Prices in integrated markets are expected to be highly correlated. With perfect integration (equation 1 above holding as an equality), we know that the difference between the prices in the two markets will always amount to c . Hence any shock in one of the two markets (or both) will be immediately spread so that the difference between the two prices stays unchanged. For example, imagine market B experiences a positive production shock, bringing the price of wheat down. Since supply in A is not changed, price in A stays unchanged at first, but this creates favorable arbitrage opportunities that traders in B will exploit, transporting some of the excess supply to Market A and hence lowering prices there as well. Hence, P_A and P_B move together.

Price correlation is a statistical measure to capture co-variation of two variables. It is a value from 0 to 1, where 1 signals perfect co-movement of the two variables. It can be calculated easily using most popular statistical packages or Microsoft Excel. A rule of thumb often used for interpreting the correlation coefficient is that coefficients of 0.6 or above are evidence of integration.

The third and most rigorous method is **co-integration analysis**. This method is more complicated and has to be implemented using a statistical software. It is outside the scope of this course.

Notice that all these methods provide evidence of market integration, but do not amount to conclusive tests. Market integration rests on the existence of trade (or, when no arbitrage opportunities exist at a given time, in the possibility of trade, were prices to diverge above transportation costs). The result of such trade is co-movement of prices. But there are other reasons why prices in two different markets can exhibit similar movements. For example, even if there is no trade between Gambela and Tigray, it could be that on a given year both experience a early starting and good Meher season. In this case, prices are likely to decrease simultaneously in both regions. Market integration is clearly not the cause of this correlated price movement. Hence, in order to avoid this kind of spurious inference from observing the price time series, data analysis should be complemented with qualitative information from the field. Is trade taking place between the two markets? What is the road infrastructure like? What do traders say in traders' surveys? Etc..

Part IV: Integration to the International Market: An Import Parity Pricing Tool¹

4.1 What is Import Parity Pricing?

Import parity pricing is defined as the import price at the border in domestic currency. Literally, an import parity price (IPP) is the price of an imported good at the border, which includes world price plus international transport costs and tariffs, or any price wedge as a result of any quantitative restrictions. If a good is cheaper abroad, i.e. the domestic price is higher than the IPP, then traders have a strong incentive to import the good, and the vice-versa. This has clear implications for domestic food market stabilization and prices. If a country is well integrated into regional or global food markets and trade is basically free, food supply shortages, which would normally cause rising domestic prices, are likely to be met through private imports if there is domestic purchasing power. As a result, prices will stabilize at import parity.

A clear understanding of how much the domestic market is integrated to regional or international markets remains crucial in the analysis of domestic food markets. One way of doing this is by comparing the time series of domestic wholesale prices of the main staple food, import parity prices and import quantities (Dorosh, 2001; PDPE, 20iii2007). This can be a good tool to provide indication of whether traders are responsive to price changes. The key question is whether private sector imports take place when domestic prices rise to levels approximating the IPP. If this is the case, the domestic market is integrated with regional or world markets and domestic shortfalls in food supply are likely to be mitigated through imports and the IPP is likely to provide a ceiling for domestic prices.

4.2 What insights can this market analysis tool provide?

The tool helps to understand whether the national market is integrated into the regional or world markets. This could have important implications for decision making, including on food aid needs, government food procurements, and putting proper trade policies in place. For example, overly pessimistic assessments of import supply responses can lead to overestimates of food aid needs. If too much food aid is distributed, food prices could fall, leading to disincentive effects on traders and possibly on future food production. Conversely, overly optimistic expectations of import quantities will lead to the underestimation of the food gap. On the other hand, announcements on food aid can have an effect on private traders. They have to be transparent and credible. Furthermore, for procurement purposes, if domestic wholesale prices are above the IPP, food is likely to be scarce on the domestic market and should not be purchased locally. On the other hand, non-responsiveness of domestic traders to international price arbitrage may indicate that trade is hindered by other factors such as restrictive trade instruments or bureaucratic red tapes, which the government may need to check.

4.3 How to analyze, interpret and use the data

Rising imports, in response to domestic wholesale prices at or slightly above the IPP, indicate that the private sector responds to price incentives and a shortfall in production should be compensated by imports. If, on the other hand, a domestic wholesale price above the import parity level does not lead to an increase in imports, it indicates that markets are not integrated with external markets. This could be explained by weak trader capacity, lack of competition, import/export barriers or government policies affecting imports and exports (see also Limitations of the tool below). Further analysis to understand the specific reasons why imports do not respond to rising prices should be carried out.

For a simple visual examination of whether imports react to a positive price difference between the domestic wholesale price and the import parity price, plotting the time series data of these prices in the same graph (as given below) can be helpful (see below). To better understand these relationships, we

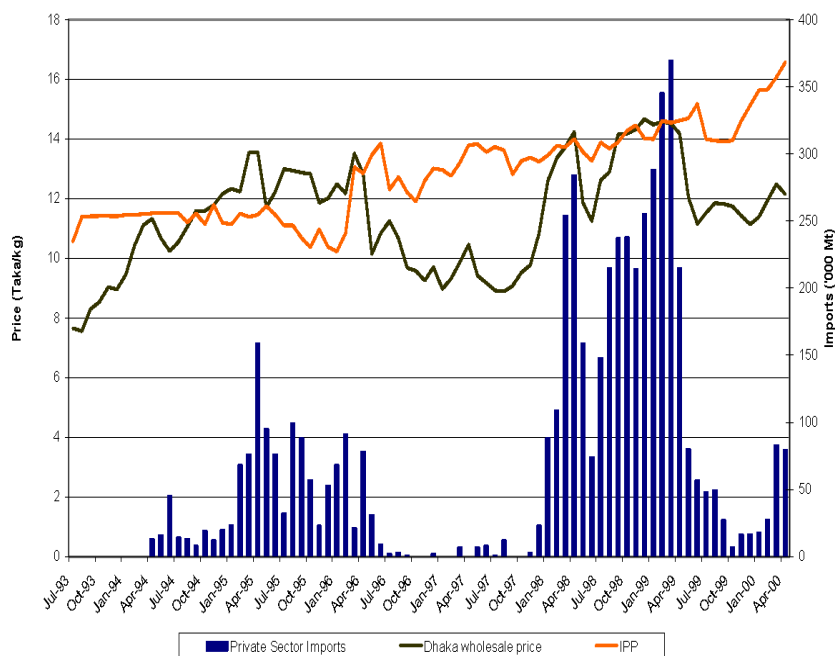
¹ Much of this section is adapted from a WFP material (PDPE, 20iii2007)

take real data example of what happened in Bangladesh in 1998 after a flood shock. Note that there are a number of similarities between Bangladesh and Ethiopia. One of these similarities is the recurrence of shocks (flood in Bangladesh and drought in Ethiopia), and possibly aftermath effects in these two countries.

Example: Rice imports after the 1998 Bangladesh flood²

Rice flows between India and Bangladesh nearly came to a halt between 1996 and 1997. Favorable weather and stable input supplies helped boost rice production in Bangladesh and domestic market prices dropped below import parity levels. But, following a poor rice harvest in Bangladesh in November/December 1997, rice prices rose sharply and soon reached import parity levels. The Government encouraged private sector food imports and removed a surcharge on rice imports. From December 1997 to May 1998, 917,000 Mt of rice were imported by the private sector. A good rice harvest in Bangladesh in May 1998 brought a sharp decline in rice imports from India, as prices dropped below import parity. But from July to September 1998, floods in Bangladesh destroyed large quantities of rice crops, leading to a sharp rise in wholesale prices for rice, surpassing import parity. Government rice policy was based on the realization that government imports and food aid alone would not be sufficient to make up for the projected shortfall in rice supply before the next harvest in April-June 1999. Consequently, the Government of Bangladesh encouraged private sector imports and the private sector responded with importing more than 200,000 Mt of rice per month from August 1998 to March 1999 (see graph below).

Import parity price, wholesale prices and imports in Bangladesh, 1993-2000



Source: Dorosh (2001)

² The example is based on Dorosh, P. 2001. Trade Liberalization and National Food Security: Rice Trade between Bangladesh and India. *World Development* 29(4): 673-689.

In comparison with private sector rice imports, government interventions in the domestic rice market were small — only 399,000 Mt from July 1998 to April 1999. Private sector rice imports, equal to 2.42 million Mt over the same period, were 6.1 times larger than government distribution.

4.4 How to calculate the indicator

The import parity price is defined as the import price at the border of the importing country in domestic currency. The IPP includes the world price plus international transport costs, insurance and, if applicable, the import tariff. It could be difficult to get monthly data on transportation costs. As a first approximation, one could assume constant transportation costs.

$$IPP = [(P_{fob} + Tr) * XR(1 + T)]$$

IPP:	Import parity price (<i>LC/Mt</i>)
P _{fob} :	World (or cheapest cif import) market price for rice (<i>US\$/Mt</i>)
XR:	Exchange rate local currency vs. US\$ (<i>LC/US\$</i>)
LC:	Local currency unit
US\$:	US dollar (or currency of source country)
Mt:	Metric ton
fob:	free on board, i.e. price of a good in the country of origin
cif:	cost, insurance and freight, i.e. price of a good in the country of destination (at the border)
T:	ad valorem ³ tariff (<i>in %</i>)
Tr:	transport costs, port handling, etc. (<i>US\$/Mt</i>)

Example: Import parity price for rice at the border of Bangladesh for April 2000 (see Dorosh, 2001):

P _{Delhi} =	10.03 Rs/Kg
XR =	1.172 Tk/Rs
Tr1 =	1.30 Rs/Kg (transport from New Delhi to border)
Tr2 =	1.10 Tk/Kg (transport from border to Dhaka)
Tr3 =	1.53 Tk/Kg (transaction costs from border to Dhaka)
T =	5% (tax)

$$IPP_{border} = \left[\left(10.03 \frac{Rs}{Kg} + 1.30 \frac{Rs}{Kg} \right) \left(1.172 \frac{Tk}{Rs} \right) \right] * [1 + 0.05] = 13.94 \frac{Tk}{Kg}$$

Possible refinements

- Imports might not respond instantaneously to a widening gap between domestic wholesale prices and IPP. The graph might therefore show a clearer picture if the import series is lagged against the price series.
- If imports arrive discontinuously, e.g. because they arrive by ship, and if in one month by coincidence 3 ships arrive, imports are huge and bias the analysis. In that case, it might be better to use 3-month averages.
- The assumption that transportation costs are constant could be weakened. Volumes and fuel prices are two important determinants of transportation costs. If fuel prices change significantly, transportation costs could be inflated by the increase in fuel prices. Transportation costs could also be adjusted by the volume of imports.

iv) Internal transportation costs could be taken into account. Dorosh (2001) calculates the import parity price for Dhaka, rather than the border, to compare it with the wholesale price in Dhaka. He adds the transportation costs, marketing costs and margins to the IPP at the border. Dorosh assumed that these costs were constant, except for a one-off jump in transportation costs in November 1998. For April 2000 the calculation is as follows (see also graph above):

$$IPP_{Dhaka} = 13.94 + 1.10 + 1.53 = 16.57 \frac{Tk}{Kg}$$

4.5 Data needs to do this analysis

i) Import Parity Price

- 1) P_{fob} : time series (monthly) of prices of potential sources of supply for the major staple food or world market prices
- 2) Tr : Transportation costs (if possible monthly)
- 3) T : Ad valorem tariffs or ad valorem equivalents of other tariff-like restrictions levied on imports
- 4) XR : Time series (monthly average) of the exchange rate local currency/US\$ or local currency/currency of source country (possible source: IMF/International Financial stat./National Bank)

ii) Wholesale Prices

- 5) Time series (monthly) of domestic wholesale prices for the major staple food.

iii) Imports

Module IV

Further Topics

Objective of this module

To enable participants to further their analysis of food markets by including and interpreting qualitative supply ratings data and by looking at terms of trade between two commodities as a tool to study and monitor food security of groups relying on different income generating activities.

Expected Outputs

Participants will be able to:

- Understand and reproduce the analysis behind a food balance sheet at national level;
- Understand the rationale for using information on demand and supply conditions in order to better interpret price data;
- Use supply ratings to better interpret price data;
- Use information on demand conditions to better interpret price data;
- Calculate Terms of Trade for any pair of commodities;
- Use terms of trade analysis as a tool to study food security of different livelihood groups: select the appropriate commodities for the analysis , interpret the significance and implications of the observed trends.

Summary

Part I: Analyzing Domestic Food Supply

- 1.1 Food Supply at National Level
- 1.2 Market Analysis at Local Level
- 1.3 Food Supply Analysis at Local level
- 1.4 Demand Analysis at Local Level

Part II: Terms of Trade Analysis

- 2.1 Terms of Trade and Food Security Monitoring
- 2.2 Calculating Terms of Trade
- 2.3 Use in Analysis

Part I: Analyzing Domestic Food Supply

1.1 Food Supply at National Level

The analysis of domestic food supply and demand at national level is best done using a food balance sheet. The food balance sheets are primarily developed to give an overview a country's food security situation over a specified reference period. The net food security situation (reflected by the difference between domestic food supply and food utilization) is derived from aggregating total domestic production with imports (adjusted for changes in stock prior to begin of reference period) less the domestic utilization and exports. Domestic utilization is constituted by: consumption, seed use, feed use, waste due to storage/transportation and industrial uses (food and non - food uses). The table below elaborates the content of a food balance sheet of a country for a given commodity. In instances where the net cereal balance is negative the magnitude would determine the need of external assistance to bridge that food gap.

Table 1. Structure of a National Food Balance Sheet

Annual Average Estimates	Quantity (MT)
Domestic Supply	A= (b+c+d)
Stock balances from before reference period	b
Domestic maize production	c
Total maize imports	d
Domestic Utilization	E = (f +g+h+i+j)
Food consumption	f
Feed use	g
Seed use	h
Wastage (post harvest losses)	i
Industrial use (food and non – food use)	j
Net Food Balance	K = E – A

The primary data required for analysing domestic food supply and demand can be obtained from secondary sources and whenever possible secondary data can also be validated through spot – check primary data collection.

With regards to domestic food supply its two prime constituents (domestic food production and food imports) have to be well analysed and their roles weighted in terms of contribution to a country's total food supply. Together with a demand analysis, information on food production and imports is vital at determining whether a country is a net food importer or food exporter. Knowing the net importer and exporter status guides in understanding the degree at which the country's food security is exposed to global food price fluctuations.

Knowing the potential or actual availability of marketable food surpluses at household level guides effectively in planning for activities like local food procurement and other developmental interventions like food processing projects that may boost farmers' income and increase commodity storage life. Absence of marketable surpluses in a food growing area could also give indications about inherent production problems that may need to be investigated further. The magnitude of commercial food imports and public food stocks could help in gauging a country's capacity to bridge gaps in domestic

food demand. When the two are found insufficient the need for external assistance to bridge the gap may be raised.

However, food supply at lower level markets such as district markets in Ethiopia is not easily quantifiable: it is difficult to obtain precise figures describing the existing food supply situation. WFP Ethiopia country office uses qualitative ways of gauging the supply of cereals food commodity based on reality-based judgments of suppliers and purchasers in the markets. These judgments are known as **supply ratings**. The next section deals more in detail with this topic.

1.2 Market Analysis at Local Level

Analysis of food supply and demand at local level helps us to understand the workings of the local economy better. In particular, it is an essential in order to investigate the causes behind observed price changes. Effective policy on food markets can only be formulated on the basis of a certain understanding of what is driving price movements.

In order to understand what is causing the movement of prices we go back to basic demand/supply framework outlined in Module 1. On the basis of such understanding, qualitative data can then be used to interpret price data.

In the basic model, price changes are determined (caused) by changes in supply and/or demand. Supply is the quantity of food available on the market. This includes local production and food brought into the area by traders or as food aid. Demand is the quantity of food that is purchased at the prevailing price.

Food supplies are a positive function of the market price. This means that the quantity supplied will tend to increase when the price rises. Demand, on the other hand, is a negative function of prices. The higher the price, the less people buy. Supply and demand can be presented as upward and downward sloping lines on a graph respectively. In basic economics these lines are presented as lines but are, confusingly, referred to as curves.

1.3 Food Supply Analysis at Local Level

Both DRMFS and WFP collect qualitative data on market supply conditions or “market supply ratings”. These ratings can be combined with price data to identify changes in price because of changing supply. Qualitative data is based on the impressions of Woreda official who are able to compare current conditions with conditions in the past.

Supplies of a given commodity are “rated” according to table 1 below

Table 1: Qualitative Market Ratings

RATING	EXPLANATION
0	not available on the market
1	much higher than usual market supplies
2	higher than usual market supplies
3	about normal market supplies
4	lower than usual market supplies
5	much lower than usual market supplies

households' typical consumption basket. Households' expenditure shares can be easily obtained from national surveys (such as the HICE in Ethiopia). In much the same way, when aggregating across geographical areas, there is a need to use markets weights to allow for the fact that markets have sometimes very different volume of interactions and have different numbers of market participants. A rigorous way to select market weights can be based on estimates of the value in birr of the total transactions in each market for a given period of time, or estimates of the number of markets' participants. Lacking these more precise statistics, estimates of the total populations living in what is considered as the "catchment area" for that market (that is, the geographical area where inhabitants mostly choose to use a particular market) can be used. In the latter case, it has be clear to the analyst that the weights are based on an approximation only of the real relative importance of each market. Because of this, it would be important to always quote the un-weighted averages across all markets and reflect on the causes behind possible divergences between the weighted and un-weighted figures. Finally, when data on the catchment area is not available or is unreliable, it is best to use the un-weighted average only.

The indices have exactly the same interpretation as the qualitative rating for an individual commodity on one market. A value of close to 5 implies exceptionally tight supplies, values around 3 express "normal" conditions and so on. For example, if the index of cereal supply ratings for a Woreda was 4.3 we can conclude that cereal supplies are below normal to well below normal for this time of year.

Before undertaking time-series analysis, we have to ensure that the data has undergone the correct manipulation. Remember that there are likely to be seasonal patterns in market supplies - so we should use de-seasonalised data to avoid false trends. Secondly, we need to use an interpolated series, otherwise missing values will tend to distort the results. Provided the correct data series is used, we can perform the following analyses:

- comparison of current supply rating with mean supply rating in corresponding months in previous years
- comparison of current price with mean of de-seasonalised supply rating in previous months
- mean-variance analysis
- identification of trends from de-seasonalised data

Let us now look more in detail at how food supply analysis can be used for interpreting price changes. In economic theory (and common sense) there is a negative relationship between market supplies and prices. The higher the level of supplies, the lower the price should be (all other things being equal). For this reason, supply is a determinant of price. Changes in supply should lead to changes in price.

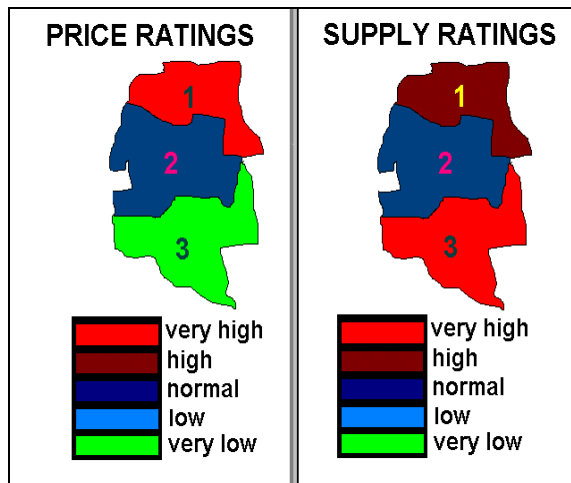
So, if we identify a price change, the supply rating could be used to tell us whether it is related to a change in supply. Note that price changes could be caused by changes in either supply or demand. A price rise is not necessarily the result of a drop in supplies. Nevertheless, the qualitative supply rating can be used to answer part of the question of causality.

The simplest method of assessing causality is to create a map of market supplies and market prices. Using the 1 to 5 ratings method (for both prices and supply ratings) we can create computerized maps and make visual comparisons. The following table can be used to ascertain the probable causes of price changes:

Table 2: Visual Comparison of Price and Supply Rating Values³

Market Price Rating	Market Supply Rating				
	1 =very low	2 = low	3 = normal	4 = high	5 = very high
1	demand related	demand related	demand related	supply related	supply related
2	demand related	demand related	demand related	supply related	supply related
3	not applicable	not applicable	not applicable	not applicable	not applicable
4	supply related	supply related	demand related	demand related	demand related
5	supply related	supply related	demand related	demand related	demand related

Market price and supply data is mapped for 3 Woredas in zone x. The results are presented in Map 1 below.



Note that in Woreda 1 the price rating is “very high” and the supply rating is “high”. This implies that the high prices are probably a result of high demand rather than low supply. In Woreda 2 both supplies and prices are “normal”. In Woreda three, very low prices combine with very high supplies suggesting that this is “supply related”. Having identified a supply related price rise in Woreda 3 we might now want to look into the issue in more depth. What has happened to production in the area? Have trades not been getting through?

³ Notice that a price rating of 1 corresponds to “very low prices” and so on up to 5, corresponding to “very high prices”

his mapping approach can be time-consuming. With large numbers of markets being monitored it will take time to do a full visual interpretation of the data. It is quicker to make one map or table with a composite index for prices and supply conditions. From table 1 above, we can make a rating of market conditions as follows:

1. supplies below normal + prices above normal = probable supply related price hike
2. prices above normal + supplies normal or above normal = probable demand related price hike
3. prices about normal + supplies about normal = normal market conditions: no change in supply and demand
4. prices below normal + supplies above normal = probable supply related price drop
5. price below normal + supplies normal or below normal = probable demand related price drop

Market supplies are typically influenced by the following factors:

- local production arriving on the market
- commodities brought in from other areas by traders
- local stocks injected into the market

Any of these factors can change and have an influence on supply. Table 3 describes some of these changes and their probable impact on market supplies:

Table 3: Factors Leading to Changes in Supplies

Change	Probable Impact on Market Supplies
fall in food production	reduction in supplies
increase in food production	increase in supplies
physical restriction to trade (e.g. caused by civil strife)	reduction in supplies
improvement in road conditions to market	increase in supplies
increase in local stock holdings	increase in supplies
local stock losses	decrease in supplies

To assess which factor has led to a supply change in a particular market, we need to look at supplementary information. We could, for example, examine data on recent harvests, on security conditions or on the prevalence of storage pests in that area. If a market is located in an area that has recently experienced a poor harvest, prices are high, and supplies are low, we may reasonably conclude that these events are related. Rapid market assessments (Not covered in this course) can be used to determine the causes of changes in market conditions, if no other data is available.

1.4 Demand Analysis at Local Level

Market demand refers to the amount of a particular good that consumers and other buyers want to purchase at a given price. There are several demand concepts that are important to consider.

Household demand (effective demand): Households with the ability to pay for food are said to have effective demand and only those households with effective demand will play a role in the market. There are households that would like to consume more of a good, but are unable due to monetary constraints: they are considered to have limited or no effective demand, hence limited or no effect on market outcomes. This group is generally represented by the poorest households. Household consumption from own production, gifts, and government or humanitarian programs (e.g., food aid) is not considered to be part of market demand.

Derived demand (e.g., industrial demand): Derived demand is defined as demand for a commodity to be used as an input to another productive activity (e.g., the demand for maize as feed for poultry production). For certain commodities and places, it is possible to underestimate total market demand if only household demand is considered. Some examples of derived demand include cereals used for poultry feed, grain for bread production, and maize for breweries. Derived demand can also have an effect on prices; when a large-scale industry or business requires a commodity as an input and expands purchases, it can push up demand relative to supply and exert upward pressure on prices.

Demand for strategic grain reserves and humanitarian programs: Government and non-governmental organizations make local purchases to support humanitarian and social safety net programs or strategic grain reserves (in the case of the government). The purchasing agent – government or humanitarian institution is included in demand. In some countries or in certain areas of a country, this type of demand can be substantial and a significant share of total market demand.

Part II: Terms of Trade Analysis

Up to this point in the course, we have either focused on the price of one commodity at a time, or looked at the price of one commodity relative to a all other prices (for example, when deflating prices for general inflation). In this unit we look at how the ratio of the prices of two commodities alone can be an important tool for studying the food security implications of price changes. Such ratio is called “terms of trade”.

The term originates from the field of international trade where it denotes the relative piece value of a country’s export to its import (Look at Module 3 for more on this). In the context of market analysis for food security, the expression “terms-of-trade” refers to the relative value of one commodity to another commodity. The commodity terms-of-trade helps gauge a situation’s impact on one group of a society in comparison to another one. For example, in many developing countries drought conditions often lead to a hike in cereal prices while at the same time prices for animals are falling. Under these conditions animal herders will rush to sell – off their animals to avoid losing them through death thereby creating a glut on the animal market thereby leading to a slump in prices. In such situations the terms of trade shift in favor of crop farmers with cereals and worsen for animal herders as the exchange value of livestock in terms of cereals has fallen.

The objective of this unit is to provide an overview of terms of trade and it how they can be used to perform food security analysis and reporting. Instead of looking at price levels and trends of discrete commodities, the terms of trade allows analyst to look at these prices and trends in relation to the power of exchange. More specifically, this section will:

1. Describe the different types of TOT that can be used in food security monitoring and reporting and the utility of each
2. Provide examples of TOT analysis that can be used in reporting
3. Describe how to calculate TOT
4. Discuss the limitations of using TOT as purchasing power indicator

2.1 Terms of Trade and Food Security Monitoring

Terms of trade is the rate at which one good or service can be exchanged for another and is typically expressed as a ratio or relative prices. It is an indicator used to measure the purchasing power of households. Food security analyst often uses it to assess current food access or make projections about future purchasing power. Looking separately at wages, income, assets and prices of staple foods is important, but making comparisons provides a more specific meaning and is thus a more useful measure for food security, early warning and to study the purchasing power consequences of price trends. TOT can help answer questions such as:

- How are wage rates moving in relation to food prices at market?
- Will households be able to purchase more or less over time?
- How is the value of livestock changing relative to cereals and will pastoralists face improved or deteriorated access to food?
- Are coffee producers becoming relatively more or less wealthy relative to their own consumption needs (food costs)?

Calculating terms of trade is simple, but selecting the two components of the ratio to use for comparison can be challenge – which asset, what quality or specification of asset (eg age and sex of animal), which staple food? Knowing what food the target households prefer and what assets they typically possess and accumulate is integral in defining the most appropriate terms of trade indicator. Do

households in particular area rely on the sale of livestock to purchase food? What are the foods that households purchase at market? Knowledge of household livelihoods and consumption pattern is imperative.

The four basic types of terms of trade are:

1. Livestock to cereal
2. Wage to cereal
3. Cash crop to cereal
4. Food crop to food crop

1. Livestock to cereal terms of trade

Livestock asset and sales are important to many households, particularly pastoralists. Many households keep livestock as a form of “saving” to sell when other forms of income are insufficient to meet basic needs. When most households sell their livestock, it is in order to acquire cash for purchase of basic necessities at the market. Most of these necessities are staple foods, particularly for poorer households. For this reason, it is necessary to determine which staple foods livestock producing households are purchasing in order to correctly define the terms of trade ratio relevant to the household of focus. Commodities can vary across one group; pastoralists in one part of the country may be largely purchasing maize while pastoralists in other parts of the country have ready access to maize and sorghum. Livelihoods information is generally useful for making these decisions.

The livestock to cereal ratio gives an indication of the purchasing power of households selling livestock and purchasing staple foods. A livestock producer may sell directly to consumer or to a trader who will then market the product. For this reason, livestock prices should be those that producers or pastoralists receive when selling their animals.

Within any species of animal, there are also different types of animals – breeds, age sexes etc. It is important to choose and monitor prices that best reflect the target population group. Monitoring data should be collected and reported with both the type of animal being monitored (eg., goat, sheep, cattle) and the size/unit of sale(eg., medium size livestock). Again, price information should be acquired in the same unit form in which producers are making sales.

Livestock to cereal terms of trade is very important to monitor for food security and early warning analysis for a number of reasons.

- Livestock sales are often a signal of distress. Household may try to sell their livestock holdings when cereals and other prices are high in order to improve their cash flow and subsequently food access. When many households begin to sell stock, the livestock market supply increases relative to demand, and livestock prices fall, all else being equal;
- Pastoralist communities are often the first to exhibit signs of hardship in drought conditions. At the onset of drought, pastures brown, meaning less food for livestock, contributing to deteriorating livestock body conditions. With less robust animals, livestock producers often are forced to lower prices at the market. Demand might also decrease given less desirable livestock (poor quality), further depressing price.

Despite its usefulness as a purchasing power indicator and pervasiveness in food security monitoring, there are several limitations of livestock to cereal terms of trade that make the indicator hard to accurately interpret

- Livestock is not a homogenous commodity. There is typically more than one type of livestock being raised and sold such as sheep, goat, cattle etc. An analyst needs to which type of livestock should be used as the indicator for all livestock holders. Within one species, there are animals of different ages, sexes, sizes, body condition etc. Which one should be used and how will an

animal be assessed consistently for monitoring purpose? Alternatively, a weighted index can be created (See Module 2, Unit 6 for indications on how to select the weights)

- Higher or rising prices of livestock and thus high terms of trade ratio do not necessarily translate to improved condition for livestock owners. Prices are often high when livestock owners are not selling animals. If there is specific time of year when poor and vulnerable livestock producers are selling, this is the most important time of the year to monitor.
- Many factors can result in variability of livestock prices and high prices could be as a result of some combination of body condition, low supply and high demand. Likewise, low prices might result from poor body conditions, high supply or low demand. For this reason, it is difficult to provide an adequate context for the movement in livestock prices without a good understanding of the normal market setting at a particular time of a year and how those conditions compare to the current year that is being monitored. Qualitative supply ratings and demand analysis, discussed in Unit 1 of this Module, can be helpful here for disentangling the various possibilities.

2. Wage to cereal terms of trade

Wages are means of earning income for many households, particularly for landless households, and those relying on seasonal migratory labor. With their wage income, most households purchase food staples either immediately for consumption or will store food for months when labor opportunities are scarce or less lucrative.

Households relying on wage labor often tend to be the most vulnerable to shocks in labor market. If wages are low or labor opportunities are scarce, these households will have a particular difficult time accessing food. If labor opportunities are scarce due to a poor production year, it may coincide with food availability problem that exacerbates food access through higher consumer prices. In this instance using the TOT indicator and its component parts will allow an analyst to better understand the impact on households.

Despite its utility, wages to cereal terms of trade has limitation as well. If labor opportunities are few but wages high, the terms of trade look favorable for wage laborers and suggest good food security conditions for wage laborers when, in fact, the laborers may not be able to find work.

3. Cash crop to cereal

Cash crops are grown and sold as a means of acquiring income for households in many countries. In many cases, these households may rely solely on cash crop production and sale for income.

There are a number of reasons that cash crop to cereal terms of trade is relevant in food security analysis

- Many cash crop dependent areas may not produce their own food and rely on markets for the purchase of their staple. Terms of trade provides them a good indication of purchase power and exchange value of the cash crops sold.
- Areas producing and selling cash crops may be particularly vulnerable to shocks in the international market. Given the volatility of international prices, cash crop dependent households will likely experience greater variability in income source over time. Thus, terms of trade will help understand the purchasing power ramifications of changes in international prices on cash crop dependent households.

Like other types of terms of trade, cash crop to cereal has its own limitation in food security analysis

- Cash crops normally have seasonality associated with them, meaning producers harvest and sell at one particular time of year and save their earnings to smooth consumption over times of the year; therefore, the utility of monitoring the TOT indicator is limited to a short time frame during the year

2.2 Calculating Terms of Trade

Calculating the ratio is generally the easiest part of the monitoring and analyzing terms of trade and what is more difficult is interpreting food security implications given the existence of confounding factors.

Steps for calculating terms of trade include:

1. Choose the target group: what is the target group of interest? This is especially important when disaggregating an analysis by population group and answering questions about the food security situation of a given group of people.
2. Choose the asset: What is the main cash or income source of this group?
3. Choose the consumption commodity: What is the main staple consumed by this group? Multiple terms of trade can be calculated in case of more than one main consumption commodity
4. Select the data: the data should be in the form of a time series and monitored regularly. Be sure to choose data with units relevant to sale or form of earning (medium goat, one day of labor etc) and how purchases of staple foods are made (kg, bags etc). All the remarks about cleaning and interpolating time series made in Module 2 and 3 apply here as well.
5. Set up the ratio: The terms of trade indicator is simply the unit of the product or service being sold or offered over the unit of a staple food being purchased.

Terms of trade = Price of 1 unit of asset sold / Price of commodity bought

Asset - what is being sold

Commodity - what is being purchased for consumption

6. Interpret the significance of TOT indicator: it is often useful to think the terms of trade as how much of a commodity one unit of an asset can purchase. This demonstrates how much food can be procured given a unit asset/income/wage.

2.3 Uses in Analysis

To understand the meaning of the terms of trade, it is important to place the indicator in context. Some of the issues to think about while interpreting the data are the following:

1. How does the current value of the indicator compare to normal value? In order to understand the current situation, put the indicator in the context of what is normal given historic averages and comparison with the normal situation. This will add meaning to the current figure. If terms of trade ratio is normally 1: 40 (eg., one goat is equivalent to 40kg of wheat) but for the past few months it has been about 1: 80, there has been an improvement in the terms of trade of that population. The group is able to purchase twice as much of the given commodity;
2. How has the TOT changed over time? The trend in TOT is also important and generally even more informative;
3. Is there seasonal variability in terms of trade that should be accounted for? There may be specific times of year when terms of trade are generally declining or increasing. Accounting for seasonality is important when drawing conclusions about the food security implications of changes in TOT

4. Are terms of trade favorable to specific population group? The term favorable is often used to describe terms of trade, and generally refers to an improvement, eg., pastoralists are able to acquire more sacks of cereals per animal sold
5. What are the limitations of using a particular terms of trade definition as a purchasing power indicator for the chosen population group? While important to provide readers with what an indicator mean, it is almost equally important to convey what it doesn't mean and suggest caution in drawing conclusions where necessary.
6. What are the variables that might change the current trend in the terms of trade? How the terms of trade are likely to behave in the near future and what the food security implications are need to be looked at.

In addition to graphs showing the trends of the terms of trade, including a narrative is very useful, mentioning focus population group, geographic area of reference, trends, and implication for food security.

These are two examples of such narrative:

“The terms of trade between shoat and maize for pastoralist communities in eastern region of XXXXX have been declining over the past few months, potentially signaling decreasing purchasing power for those pastoralists attempting to sell livestock. Shoat sale season is approaching, meaning terms of trade between a shoat and maize will remain important to monitor closely”

“The term of trade ratio between wage rates and sorghum in the northern region of XXXXX is normally 1:3, but current terms of trade is approaching 1:6, allowing those with wages to purchase twice compared to normal situation. Labor opportunities are abundant with a good harvest, allowing for improved level of purchasing power and food security for those who depend on wage”