UN-ESCWA, “Strengthening the Statistical Capacity of ESCWA Member Countries in Producing and Disseminating Short-term Economic Indicators for Sustainable Growth”

Analytical Report on the use of Short-term Turnover Indices to improve Quarterly GDP estimates

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*The report was one of the output of ESCWA project on Short Term Economic Indicators. It was prepared by Robin Youll as the key author of the report, with a significant contribution of Markus Gintas Sova and in coordination with the project manager Fathia AbdelFadil from UNESCWA.

Introduction

Quarterly estimates of Gross Domestic Product (GDP) are an essential element of the information set required by analysts and policymakers in the context of economic management. Many countries, including all OECD member countries and an increasing number of developing countries, produce quarterly estimates of GDP to meet the needs of these users. The estimates play a vital role in the development and monitoring of sound economic policies and programmes.

This report is aimed at national accounts compliers with an interest in either developing or improving existing quarterly estimates of GDP. It aims to demonstrate how key short-term turnover indicators can be used in the context of producing quarterly GDP for the industry and retail trade sectors. Although, in fact, many of the methods and practices are quite generic, and are applicable to other economic activities, including the service sector.

Structure of the report

The report consists of five chapters, which provide a roadmap for the use of short-term turnover indicators within the context of measuring GDP growth each quarter.

Chapter I gives an overview the pre-requisites, data sources, and estimation methods for the three important short-term economic indicators which are the scope of this report: the Turnover Index for Industry (TII); the Index of Industrial Production (IIP); and the Turnover Index for Retail Trade (TIRT).

Chapter II provides a brief reminder of the conceptual framework for estimation of quarterly GDP, and considers some key issues relevant to understanding how short-term indicators can be used in their estimation.

Chapter III sets out the pre-requisites for using short-term turnover indicators to measure quarterly GDP.

Chapter IV introduces the concept of 'benchmarking' which is an essential operation needed to maintain consistency between short-term (monthly and quarterly) and annual time series. The chapter includes a description of the methods used, and provides illustrations of their application

and

Chapter V gives a step-by-step guide to how these indicators can be used as the basis of estimating quarterly GDP, including the procedures and methods needed.

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Glossary of abbreviations

ANA	**Annual National Accounts**
AR	Autoregressive
BI	Benchmark Indicator
BM	Benchmark
CD	Cholette-Dagum
CFC	Consumption of Fixed Capital
GDP	Gross Domestic Product
GVA	Gross Value Added
IIP	Index of Industrial Production
IPD	Implicit Price Deflator
NDP	Net Domestic Product
NSI	National Statistical Institutes
PAYE	Pay As You Earn
PPI	Producer Prices Index
QNA	Quarterly National Accounts
SA	Seasonally Adjusted
SBR	Statistical Business Register
SBS	Structural Business Survey
SNA	System of National Accounts
STTI	Short Term Turnover Indicators
SUT	Supply and Use Table
TII	Turnover Index for Industry
TIRT	Turnover Index for Retail Trade
VAT	Value Added Tax
VBA	Visual Basic for Applications

Chapter I: Overview the estimation of short-term turnover indicators

This chapter provides background on the estimation of the three important short-term turnover indicators (STTI) which are in the scope of this report, *i.e.*

- the Turnover Index for Industry (TII)
- the Index of Industrial Production (IIP), and
- the Turnover Index for Retail Trade (TIRT).

These indicators can be used as important components in the compilation of quarterly Gross Domestic Product (QGDP), as explained later in this report.

In addition, the STTIs are useful in their own right, and many countries' National Statistics Institutes (NSIs) produce at least one of them on a monthly basis. They are used mainly to provide early signals for the growth, and changes in growth, of economic activity in the key sectors of industry and retail sales. For example, when there is a turning point in a country's economy, such as at the start or end of a recession, these monthly indicators can give very timely evidence that something has changed, allowing policy makers to react more quickly than if the indicators were quarterly.

Some pre-requisites for measuring STTIs

The key pre-requisite for producing these STTIs is a list of businesses active in the sector of the economy which we wish to measure. Ideally, this will be a **Statistical Business Register** (SBR). A good SBR will have the following properties:

i) Good coverage: The list of businesses should be as complete as possible. Any under coverage should be limited to the very smallest businesses.
ii) Little duplication: Ideally, each business should appear of the SBR only once. However, if the SBR has been compiled from multiple data sources then it may be possible that two or more records referring to the same business have not been properly matched. This can be minimised by using a unique official business reference number across all the SBR sources and careful SBR maintenance.
iii) Classification of activity: Each business should be classified by its main activity (and possibly also its secondary activities, if it has any). The classification system should either be one that is internationally recognised, such as the UN's International Standard Industrial Classification of All Economic Activities (ISIC, see UN, 2008), or it should be based on such a classification system.
iv) Useful auxiliary data: The SBR should hold some data on each business which can be used to make sampling and estimation more efficient. This may include recent employment counts and recent annual turnover collected from an official source, such as a national tax office.
v) Contact information: The SBR should hold contact information for each business to facilitate data collection.
vi) Up-to-date: The information held on the SBR needs to be up-to-date to minimise the impact of errors.

UN (2015) gives comprehensive international best practice on SBR compilation and maintenance.

If a country does not have a formal SBS, at the very least it should maintain a business listing, which should include information on all of the largest businesses, and as many others as possible. One source for such a listing is a country's Income Tax (or similar) system. If there are separate Value Added Tax (VAT) or Pay As You Earn (PAYE) systems, these can be combined with an Income Tax list to create a 'master list' of businesses. One key issue here, as for a formal SBS, is that it is critical that such listings do not include duplicates. If there is a single tax identification number (sometimes referred to as a 'TIN'), this can help avoid such duplication.

A key consideration with either an SBS or a business listing, is that they are unlikely to provide good coverage of *informal* (unincorporated household) businesses. While a census of establishments may identify many such informal businesses at a single point in time, it is the nature of the informal sector that many such businesses will exist for only a short time. In addition, collecting data from informal businesses can be problematic, not least because they may have no fixed business premises, and are also unlikely to keep detailed records of their activities. Therefore, an SBS or a business list is most likely to provide information on the activity of businesses operating in the formal sector only. In fact, a business listing based on tax records is, by definition, one which covers businesses undertaking formal activity (in many countries the definition of 'formal' is indeed that they are registered for some form of taxation). The issue of under coverage of informal activity, and its relevance to using STTIs in the context of estimating QGDP, is considered in more detail in Chapter III.

There are two further pre-requisites for calculating IIP (and for the TIRT in constant prices):

- **Price Indices**
    - For the IIP it is necessary to have **Producer Price Indices** (PPIs) for deflating output.
    - For the TIRT, the relevant price indicators are **Consumer Prices Indices** (CPIs).

  In this report it is assumed that these price indices are available although, typically, NSIs calculate PPIs an CPIs outside of National Accounts.

- **Gross Value Added** (GVA) data for a recent year (the *base period*, which we shall formally introduce later). The GVA data are needed to calculate weights used for aggregation. Such GVA data will normally have been calculated as part of a balanced set of annual National Accounts.

Conceptual basis of the STTIs

Before considering which sources of data can be used to calculate our STTIs, it is important first to clarify the concepts which are being measured. This is different for each of the three STTIs, so we shall look at each in turn. We assume that we wish to calculate monthly indicators, although the same principles will hold for quarterly indicators. In what follows we refer to the period for which we are collecting data to calculate our STTIs as the *current month*.

Turnover Index for Industry (TII)

The TII is the most straightforward of the three. The population of interest is all enterprises in the country which are classified to ISIC Rev. 4 sections B (Mining and quarrying), C (Manufacturing), D (Electricity, gas, steam and air conditioning supply) and E (Water supply; sewerage, waste management and remediation activities). The data required are for businesses' turnover of their own output in the current month. For a complete definition of what is included in 'turnover', see Eurostat (2006, section 7.2).

Index of Industrial Production (IIP)

For the IIP, the population of interest is the same as that of the TII. The data required are some measures of the volume of each business's production in the current month. For some businesses, such as extractors of crude oil, this could be a direct volume, in this case millions of barrels. However, as we shall in Chapter III when considering how to deal with changes in quality of goods and services over time, the use of such direct volume measures is not ideal. If it is considered that there are changes in the quality of the goods or services produced then, in line with international best practice, the IIP should be based on *deflated turnover*, *i.e.* dividing the reported turnover in current prices by a relevant price index. See for example, Eurostat (2016). For this reason, for most businesses, we need data on their own-output turnover, which can then be deflated to remove the impact of changing prices, giving a *volume measure*.

Furthermore, for goods which are exported, these are likely to experience different inflationary pressures to those sold on the domestic market. Therefore, to remove the price effects more accurately, the own-output turnover needs to be split between the domestic and non-domestic markets so that appropriate deflators can be applied to each.

Finally, because we are interested in the current month's *production*, finished goods sold from businesses' inventories should be excluded. Similarly, finished goods produced but not yet sold which have been added to a businesses' inventories should be included, as well as any 'work in progress'. Thus, to calculate the actual production in the current month, we also need data on businesses' changes in inventories of finished goods and work in progress. In practice, it is not always possible to collect accurate and complete information on such changes in inventories each month. While businesses might be expected to keep good information on their sales, many will not have complete records of their inventories, particularly those inventories related to work in progress. In addition, in terms of the basis of valuation used by businesses, this is different from that required for the IIP and within national accounts. Specifically, business accounts value inventories according to their *historical cost,* whereas in the national accounts such inventories are valued according to their *current market value*. The difference between these two valuations is referred to as a *holding gain*. In times of significant price changes, such holding gains can lead to large differences between the value of inventories as recorded by a business and the value required for the IIP and national accounts. We will see shortly the lack of high quality data on inventories leads in to a simplifying assumption which may be needed when estimating the IIP.

Turnover Index for Retail Trade

For the TIRT, the population of interest is all enterprises in the country which are classified to ISIC Rev. 4 division 47 (Retail trade, except of motor vehicles and motorcycles). Ideally, as we shall see later, from the perspective of estimating QGDP, the data required relate to businesses' retail 'margins' in the current month, rather than their turnover. Box 2 in Chapter II explains the definition of margins and their relevance in the context of estimating on QGDP.

However, most often it is impractical to collect data on margins each month. This is because retail businesses would need to know the exact cost of their purchases for resale which they have sold in each period, as well as their sales. Generally, this will be accounted for less frequently than monthly. More often such data will only be available annually. When estimating QGDP, it is usually assumed that businesses' retail margins are constant, meaning that retail turnover and retail margins have the same percentage movements each period. With this assumption, the TIRT can be used as a proxy for changes in margins.

In fact, the TIRT has a wider purpose beyond being used as a basis for estimating the output of the retail sector in QGDP, since it provides an early indicator of an economic concept central to economic analysis: household final consumption. To see this, consider GDP expressed as the sum of expenditure components where we have:

GDP = Investment + Final Consumption Expenditures + Net Trade

The Final Consumption Expenditures comprise the expenditures of households and of the general government sector (as well as expenditures by non-profit institutions serving households). Generally, household expenditure is significantly larger than the other components, including investment, and may typically be 60% or more of total GDP.

Given its timeliness relative to quarterly estimates of GDP, the TIRT can therefore be used to provide an early indicator of growth in GDP. In many countries where a TIRT is produced, the series, suitably deflated, provides a key indicator of economic growth often several weeks before the first official estimates of GDP are available.

Further details on the scope of STTIs can be found in UN *et al.* (2009, chapters 6 & 15).

Data Sources for STTIs

Now that we have specified what needs to be measured, we can consider potential data sources. The two main potential data sources for STTIs are administrative data and regular surveys, typically conducted by the NSI. These are considered below, in turn.

Administrative sources

The availability of administrative data potentially useful for STTIs varies from country to country. However, we can consider two broad types.

Firstly, in some countries government ministries or regulators collect data on the production of certain products. For example, a Ministry of Oil might collect data on crude oil extraction from all businesses involved in this activity. The data might be direct volumes (such as millions of barrels) or monetary values or both. It is not unusual for such data to be a census or a near-census.

Secondly, a government's tax office may be able to provide on turnover subject to Value Added Tax (VAT), Goods and Services Tax (GST) or an equivalent. The appropriateness of such data would need to be carefully assessed because it is likely to refer to all turnover, as opposed to own-output turnover or retail turnover. However, if the data are sufficiently timely, at the same frequency as the STTIs and of sufficiently good quality, then they offer a very large source of turnover data for most industries without collection costs for the NSI or additional response burden for the businesses.

A significant limitation on such data is that they will not cover changes in inventories. They may also include within 'turnover' some sales which are out of scope of the definition used for the STTIs, e.g. sale of goods purchased for resale by non-traders, and sales of capital assets. Some care is therefore needed when using such sources.

Survey sources

The other main source of data for producing STTIs are surveys conducted by the NSI. These have the advantage that the NSI can specify the precise data which need to be collected. Thus, a survey questionnaire can specify own-output turnover or retail turnover for a specific month.

Ideally, such surveys should be stratified by business activity (*e.g.* ISIC class) and business size (defined by SBR data, typically employment, turnover or both). The most common sampling schemes are *cut-off sampling* (whereby only businesses above a size threshold are sampled; the threshold may vary by business activity) and *stratified simple random sampling*.

A well-designed sample can be very efficient in terms of delivering good STTI accuracy with limited resources. However, conducting a survey comes with a cost to the NSI and imposes response burdens on those businesses selected into the sample.

Prices

As noted already, the relevant deflator for the IIP is the PPI, and for the TIRT is the CPI. It is assumed in this report that PPIs and CPIs, or some equivalent price indicators, are available.

Validation and Outlier Detection

As noted, administrative sources or surveys can be used to acquire the relevant turnover data. However, as with any statistical data, some quality assurance, in terms of validation and outlier detection, will be necessary before the survey results can be used in the context of estimating STTIs.

Outliers are observations which appear statistically unusual when compared with those from similar businesses. They can have an undesirably large impact on the statistics we wish to produce. Sometimes these arise at the point of data reporting by a business, or data capture by the NSI in the form of the inclusion or omission of zeroes. For example, a figure may be reported as 1000, whereas in fact the true value was 100. Alternately a true figure of 100 may be reported as 10. It is worth noting that such errors have an *asymmetric* impact on the aggregate statistics which they are used to compile. For example, if 10 businesses each have turnover of 100, but one accidentally reports turnover of 1000, then the average turnover for the 10 businesses will be 190, an error of 90, or 90% (since the actual average should be 100). Alternatively, if one business accidentally reports turnover of 10, the average will be 91, an error of just -9, or 9%. This asymmetry in errors of this kind arises because turnover data, like most economic data, follow an approximately *log-normal distribution*, meaning that if we took natural logarithms of the reported data they would follow an approximate (symmetric) normal distribution. As we shall see, this idea proves useful when we consider ways of identifying errors and outliers in economic data.

There are many different tests which can be applied as a means of identifying potential errors and outliers. We consider two such tests here.

Using Absolute thresholds

This first test is very simple and uses absolute thresholds. Any percentage changes in turnover from the previous month to the current month above certain thresholds are regarded as outliers.

Once identified, each outlier value should be verified with the business. Therefore, it is important that the test identifies a manageable number of outliers. An absolute threshold of 300% may be reasonable, but may need to be adjusted if it identifies too many outliers to verify.

As an example, suppose we have current month and previous month turnover data from 10 bakeries, as shown in Table 1.1. We can then calculate the percentage turnover growth for each bakery. We see that bakery 2 has a turnover growth greater than 300%, so we identify bakery 2 as an outlier in the current month, and we contact the bakery to verify the turnover data. If the bakery confirms that the data are correct, it is still regarded an outlier in the current month.

Table 1.1

Bakery	Previous month turnover	Current month turnover	Turnover Growth (%)
1	11	31	182
2	3	20	567
3	79	54	-32
4	1	2	100
5	16	23	44
6	5	4	-20
7	9	9	0
8	52	48	-7
9	74	75	1
10	27	79	193

Using Relative symmetric thresholds

Given the earlier observation about the asymmetry of turnover date, a more sophisticated test is to use relative symmetric thresholds. In this case, for each stratum and market (domestic or non-domestic) the mean and standard deviation of the *natural logarithm of the percentage growth factors* are calculated (excluding any imputed data). A growth factor here is simply the ratio of the value of turnover on the two periods considered. Any log growths factors below a lower standard deviation threshold or above an upper standard deviation threshold are identified as outliers. In this case lower and upper relative thresholds of 2 standard deviations may be considered reasonable.

As an example, we take the bakery data from table 1.1 and calculate the natural logarithms of the growth factors; see table 1.2. The mean of these logs is 0.439 and the standard deviation is 0.723. In this example, no bakery is more than 2 standard deviations below the mean, and only bakery 2 is more than 2 standard deviations above the mean. So we identify bakery 2 as an outlier in the current month.

Table 1.2

Bakery	Previous month turnover	Current month turnover	Growth factor	log (growth factor)
1	11	31	2.82	1.036
2	3	20	6.67	1.897
3	79	54	0.68	-0.380
4	1	2	2.00	0.693
5	16	23	1.44	0.363
6	5	4	0.80	-0.223
7	9	9	1.00	0.000
8	52	48	0.93	-0.080
9	74	75	1.01	0.013
10	27	79	2.93	1.074

Note, the separation of domestic and non-domestic market turnover is only relevant to the own output turnover required for IIP. This split is not required for TIRT. Neither is it required for TII, although asking businesses to report domestic and non-domestic market own output turnover separately allows this data to be used to calculate IIP.

Imputation

If no response is received from a business for the current month, it is necessary to impute its missing data. If we have data for the business from the previous month (real or imputed), its data may be imputed by multiplying its previous month's responses by a mean growth since the previous month of other businesses (excluding outliers) from the stratum, excluding outliers and imputed data. This calculation should be performed separately for each market (domestic or non-domestic). Two formulae are commonly used.

Imputation using mean of growths

In this case the missing value is imputed as follows:

$$\hat{y}_{imt} = y_{im,t-1} \frac{1}{n^*_{hmt}} \sum_{j \in h} \frac{y_{jmt}}{y_{jm,t-1}} \qquad \ldots(1)$$

where $\hat{y}_{imt}$ is the imputed market *m* response for business *i* in the current month, *t*,

$y_{im,t-1}$ is the actual market *m* response for business *i* in the previous month *t*-1

h is the stratum to which business *i* belongs, and

n^*_{hmt} is the number of non-outlier responses for market *m* in the current month in stratum *h*.

Note that the summation should include only non-outlier responses.

As an example, suppose that we have an eleventh bakery to our sample in table 1.1. Bakery 11 had a turnover of 12 in the previous month, but has not yet provided a turnover figure for the current month. Bakery 2 has been identified as an outlier for the current month, so we calculate the mean growth factor of the remaining 9 bakeries to be 1.334. Multiplying this by the previous month turnover of bakery 11 gives an imputed current month turnover of 16.0.

If there are insufficient returned data (*e.g.* fewer than 3 responses) for the stratum to calculate the mean growth, then data from a higher level of industrial classification should be used.

Imputation using growth of means

In this case the missing value is imputed as follows:

$$\hat{y}_{imt} = y_{im,t-1} \frac{\sum_{j \in h} y_{jmt}}{\sum_{j \in h} y_{jm,t-1}} \qquad \ldots(2)$$

Returning to our bakeries example, the previous and current month mean turnovers (excluding bakery 2, the current month outlier) are 30.875 and 30.750. The growth factor of the ratio of these means is 0.996, i.e. 30.750/30.875. Multiplying this by the previous month turnover of bakery 11 gives an imputed current month turnover of 12.0.

The growth of means method is generally the preferred formula if the sample is stratified. However, it gives more weight in its calculation to larger businesses. Therefore, under cut-off sampling, the mean of growths may be preferred.

Imputed data are used as real data in all subsequent calculations described in this report.

As before, the separation of domestic and non-domestic market turnover is not relevant to TIRT.

Quick Tip

If in the current period a business has been selected for sampling for the first time and has not responded, these formulae cannot be applied because there is no previous month's value to which to apply a growth. Formally, we may want to impute data based on the ratio model described in the next section. However, this is algebraically equivalent to assuming that the business had not been selected for the sample in the current month. In effect, the weighting procedure used will automatically impute for these businesses. For the purposes of this report, we shall take this approach, although for regular production we would recommend imputation.

Important Note: A Taxonomy of aggregation levels

To produce estimates of totals (e.g. total industry) and sub-totals (e.g. ISIC sections), it is necessary to have methods for aggregating lower levels of detail. The following terms are used throughout this report to distinguish the various levels of aggregation used in estimation:

Source Data
This is the basic data collected either from sample surveys or administrative sources, including turnover, inventories, prices, margins, etc.

Stratum Turnover Aggregates
Under stratified simple random sampling, these are the lowest-level aggregates. They are estimated from the Source Data, and are calculated for each stratum, for example combinations of ISIC 4-digit Classes and size bands.

Elementary Turnover Aggregates
Under cut-off sampling, these are the lowest-level aggregates. They are estimated from the Source Data, and are produced at the lowest level of activity detail available, for example ISIC 4-digit Classes.
Under stratified simple random sampling, they are estimated by summing the Stratum Turnover Aggregates for the activity of interest.

Elementary Turnover Indices
These are created from the Elementary Turnover Aggregates through the process of 'indexation' or 'referencing', which involves scaling the aggregates so that they are equal to 100 in some specified 'reference' period.

Elementary Volume Indices
These are created from the Elementary Turnover Indices, by removing price effects. They are still expressed in the form of indices, such that they are equal to 100 in some reference period.

Elementary Volume Measures
These are created from the Elementary Volume Indices, by scaling them to some specified 'reference' period monetary value so that they are expressed in currency units.

Higher Level Aggregates
These are aggregates of the either the Elementary Turnover Indices or Elementary Volume Indices to create all higher aggregates, e.g. ISIC Sections, Divisions, and Groups.

The estimation of each of these levels is set out in the following sections.

Stratum and Elementary Turnover Aggregates

We now consider how we can combine our data to produce the lowest level aggregates, for example ISIC classes.

The choice of method depends on the sampling scheme used to collect the data. We consider two cases, depending on the type of sampling (or source data) used.

Stratified simple random sample

In this case we can use a *model assisted ratio estimator*.

The formula is:

$$\hat{c}_{ahmt} = \sum_{i \in s_{aht}} y_{imt} \frac{\sum_{i \in U_{aht}} x_{it}}{\sum_{i \in s_{aht}} x_{it}} \qquad \ldots(3)$$

where $\hat{c}_{ahmt}$ is the estimated month *t*, market *m* own output turnover for stratum *h* in activity *a*,

s_{aht} is the month *t* sample for stratum *h* in activity *a*,

U_{aht} is the month *t* population for stratum *h* in activity *a*, and

x_{it} is the auxiliary data for business *i* in month *t*.

The auxiliary data for the business, x_{it}, will be either turnover or employment recorded on the SBR. This model is one of the most commonly used models in business statistics.

As before, for retail turnover estimates we drop the reference to markets.

From this we may estimate the month *t*, market *m* own output turnover for activity *a* by summing the stratum aggregates to give an elementary aggregate:

$$\hat{c}_{amt} = \sum_{h \in a} \hat{c}_{ahmt} \qquad \ldots(4)$$

Throughout this report we follow the statistical convention of using a 'hat' (^) to indicate an estimate.

The theory behind the model assisted approach to survey inference is comprehensively covered by Cochran (1977) and Särndal *et al.* (1992).

Cut-off sample or administrative data

In this case we can use a *model based ratio estimator*. The elementary aggregates are calculated directly from the data.

The formula is:

$$\hat{c}_{amt} = \sum_{i \in s_{at}} y_{imt} \frac{\sum_{i \in U_{at}} x_{it}}{\sum_{i \in s_{at}} x_{it}} \qquad \ldots(5)$$

A comprehensive treatment of the model based approach to survey inference can be found in Valliant *et al.* (2000).

Quick Tip

For some activities we may have direct volume data instead of turnover. An example would be monthly crude oil extraction in millions of barrels, the data being provided by the Ministry of Oil. In such cases we can derive a current month turnover figure by taking the turnover from the most recent annual Structural Business Survey (SBS), multiplying this by the ratio of current month oil to SBS year oil production, and then multiplying the result by the ratio of the current month PPI for crude oil to the SBS year mean PPI for crude oil.

This last step is called 'reflation'; it is the process of multiplying a volume measure (which we shall define below) by a price index by to give a monetary value in current prices.

Elementary Turnover Indices

Once we have our elementary turnover series, a set out above, we can use these to calculate turnover indices for the elementary level, e.g. ISIC 4-digit classes. Such indices are known as *elementary turnover indices*.

To calculate these elementary indices, we first need to specify the *reference period* for the index. This is the period where we force the index to be equal to 100. If the reference period is longer than one index period, *e.g.* it is common for the reference period for monthly and quarterly indices to be a whole year, then it is the *average* of the index over the reference period which is made equal to 100. This is achieved through a simple scaling.

So, for example, for the TIRT we can calculate the index as follows:

$$\hat{I}_{ar}(t) = \frac{\hat{c}_{at}}{\hat{c}_{ar}} \qquad \ldots(6)$$

where r is the reference period,

$\hat{I}_{ar}(t)$ is the turnover index for activity a, referenced to r, and

$\hat{c}_{at}$ is the turnover estimate for activity a in any month t.

If the reference period is a whole year, then $\hat{c}_{ar}$ is the average activity a turnover estimate over the reference period.

The same formula can be used for TII, but as stated above, we may wish to have separate calculations for domestic and non-domestic market own-output turnover.

Exercise 1.1: Calculating an elementary turnover index

Suppose we have the following monthly turnover estimates for ISIC class 1313 (Finishing of textiles):

Year	**Month**	**Turnover**
2015	Jan	25
	Feb	35
	Mar	40
	Apr	15
	May	20
	Jun	25
	Jul	20
	Aug	20
	Sep	40
	Oct	15
	Nov	25
	Dec	40
2016	Jan	15
	Feb	20
	Mar	25

Do the following steps:

1. Calculate the mean turnover for class 1313 over all months in 2015.
2. Calculate the turnover index for each month, referenced to 2015, by dividing each month's turnover estimate by the 2015 mean calculated in step 1 and then multiplying the result by 100. *(Hint: the turnover index for January 2016, referenced to 2015, is 56.3).*
3. Calculate the mean turnover index over all months in 2015 to verify that the index is referenced to 2015 *(i.e. check that the mean over 2015 is equal to 100).*

Elementary Volume Indices

The TII an TIRT are expressed only as current price value series. For the IIP, this can be expressed in current prices but also in 'volume' terms, i.e. after removing price effects. We call such an index an '*elementary volume index*'.

Before we proceed, for the IIP there are three complicating factors over TIRT and TII, which we need to consider. Firstly, it is a volume index, so we need to remove the contribution of inflation. Secondly, because domestic and non-domestic sales can be subject to different inflationary pressures, we need to treat these separately. Finally, as noted previously, we are in principle interested in what businesses *produce* in the current month, rather than what they *sell* in the current month. Thus, we need to exclude sales of inventories (which were produced in earlier months) and include own-output which is added to inventories (to be sold in the future).

We consider first the issue of deflation. Typically, price indices will be available within the NSI. The most appropriate price indices are those calculated from PPIs for the domestic and non-domestic markets. However, PPIs relate to products, whereas the IIP relates to industries. We therefore need to weight together PPIs to represent the combination of products produced by each industry. Note first that the IIP formula is that of a *Laspeyres volume index* (see UN *et al.*, 2009, chapter 15) and that, for a Laspeyres volume index, the correct deflator is a Paasche price index, *i.e.*

$$\hat{P}_{am}(b,t) = \frac{\sum_{i \in a} w_{mti}}{\sum_{i \in a} \frac{w_{mti}}{\hat{P}_{im}(b,t)}} \qquad \ldots(7)$$

where b is the IIP base period,

$\hat{P}_{am}$ is the industry a deflator for market m,

$\hat{P}_{im}$ is the market m PPI for (with the same base period as IIP) for product i,

w_{mti} is the month t market m weight for product i,

and the summations are over all products produced by industry a.

Note: see Annex 2 for more details on the relationship between Laspeyres and Paasche indices.

In practice, product weights are unlikely to be available for the current period. So a 'harmonic' deflator is calculated using product weights for the IIP base period. This is justified by the argument that the weights are relatively stable over time (this follows because, as prices fall, sales in volume terms increase because of what is known as consumer 'substitution' – and the aggregate value, i.e. volume x price, remains relatively stable). It may also be the case that the PPIs calculated within the NSI have a different base period, *b'*, to IIP. Thus, the formula becomes:

$$\hat{P}_{am}(b',t) = \frac{\sum_{i \in a} w_{mbi}}{\sum_{i \in a} \frac{w_{mbi}}{\hat{P}_{im}(b',t)}} \qquad \ldots(8)$$

We will see when we come to calculate the volume index that we need to re-reference these PPIs so that their referenced period is the same as the base period used for the IIP weights. The PPIs are re-referenced using this formula:

$$\tilde{P}_{amb}(b',t) = \frac{\hat{P}_{am}(b',t)}{\hat{P}_{am}(b',b)} \qquad \ldots(9)$$

Where $\tilde{P}_{amb}$ is the market *m* deflator for activity *a*, referenced to *b* (the IIP base period). Notice that the base period of the deflator has not changed; it is still *b'* which is different to the new reference period.
With these deflators in hand, we now have the ingredients to calculate the IIP. Algebraically, we have:

$$\hat{Q}_a(b,t) = 100\,\frac{\sum_{m=1}^{2} \frac{\hat{c}_{amt}}{\tilde{P}_{amb}(b',t)/100} + \frac{\hat{\Delta}_{at}}{\tilde{P}_{a3b}(b',t)/100}}{\sum_{m=1}^{2} \hat{c}_{amb} + \hat{\Delta}_{ab}}$$

…(10)

where $\hat{Q}_a(b,t)$ is the IIP for activity *a* in month *t*, with base period to *b*,
$\hat{\Delta}_{at}$ is the estimated change in inventories for activity *a* over any month *t*,
$\tilde{P}_{amb}(b',t)$ is the growth (expressed as a ratio) in the activity *a* deflator for market *m* from the IIP base period to the current period,
m=1 refers to the domestic market,
m=2 refers to the non-domestic market, and
$\tilde{P}_{a3b}(b',t)$ is the growth (expressed as a ratio) in the activity *a* deflator for changes in inventories, from the IIP base period to the current period.

Note that in the above formula, in practice, the deflator applied to the changes in inventories is typically either the same as the deflator which is applied to domestic market turnover, or the current month turnover weighted harmonic mean of the domestic market and non-domestic market deflators.

In practice, as described in Box 1, there are often significant practical difficulties in measuring changes in inventories. For many economic activities a simplifying assumption is that that these can be ignored. If they are, then the formula for the IIP becomes:

$$\hat{Q}_a(b,t) = 100\,\frac{\sum_{m=1}^{2} \frac{\hat{c}_{amt}}{\tilde{P}_{amb}(b',t)/100}}{\sum_{m=1}^{2} \hat{c}_{amb}} \qquad \ldots(11)$$

Finally, if we do not have separate PPIs for the domestic and non-domestic markets, then we have to apply the same deflator to both, in which case the IIP formula simplifies to:

$$\hat{Q}_a(b,t) = 100\,\frac{\hat{c}_{at} \big/ \tilde{P}_{ab}(b',t)/100}{\hat{c}_{ab}} \qquad \ldots(12)$$

Unfortunately, if the IIP base period is longer than one month (which is usually the case as it is typically one year), then the index is not yet referenced to the base period. In other words the average of the index over the base period is not equal to 100. So we need to re-reference it to the base period by a simple rescaling:

$$\begin{aligned}\tilde{Q}_a(b,t) &= 100\,\frac{\hat{Q}_a(b,t)}{\hat{Q}_a(b,b)} \\ &= 100\,\frac{\hat{Q}_a(b,t)}{\frac{1}{\chi_b}\sum_{\tau\in b}\hat{Q}_a(b,\tau)}\end{aligned}$$

where $\tilde{Q}_a(b,t)$ is the activity *a* IIP for month *t*, referenced to its base period, *b*, and χ_b is the number of IIP periods in the base period (this is 12 for a monthly IIP if *b* is one year) .

Note: in the context of the TIRT for retail sales, when we consider its use in estimating QGDP in constant prices, we need, in addition to the current price TIRT, a volume equivalent. This can be complied in precisely the same ways as the fort he IIP, using formula (11).

Quick Tip

The concept of a *base period* is different to the *reference* period of an index. The calculation of price and volume indices involves comparing prices or volumes in the current period to those of some base period. Higher-level aggregates of Laspeyres indices are calculated using weights from the base period. The index will by default take the value 100 in the base period – *i.e.* it is by default referenced to the base period. However, by a simple rescaling we can re-reference the index to a new reference period. Doing this does not change the base period, so the reference period is no longer the same as base period.

Exercise 1.2: Calculating an elementary volume index by deflation

Suppose that enterprises classified to ISIC class 1313 (Finishing of textiles) produce products classified to only two CPC subclasses – 26150 (Wool and fine or coarse animal hair, carded or combed) and 26160 (Cotton, carded or combed). (The actual set of products produced by enterprises classified to ISIC class 1313 will vary from country to country, and some products can be produced by more than one ISIC activity). Suppose we have the following monthly PPIs for subclasses 26150 and 26160, referenced to 2016:

Year	**Month**	**PPI (26150)**	**PPI (26160)**
2015	Jan	80	105
	Feb	80	105
	Mar	80	105
	Apr	80	105
	May	80	105
	Jun	80	105
	Jul	85	110
	Aug	85	110
	Sep	85	110
	Oct	85	110
	Nov	85	110
	Dec	85	110
2016	Jan	85	110
	Feb	85	110
	Mar	85	110

Suppose also that the the national accounts for 2015 show an annual turnover of 160 and 240 from ISIC class 1313 for CPC subclasses 26150 and 26160, respectively.

Do the following steps:

1. Calculate a harmonic deflator for class 1313 for each given month.
2. Re-reference the deflator to 2015, by dividing each month's figure by the 2015 mean and then multiplying the result by 100.
3. Taking data from Exercise 1.1, divide each month's class 1313 turnover by its corresponding deflator from step 2 and multiply the result by 100.
4. Calculate a volume index for each month by dividing the deflated turnover from step 3 by the mean (undeflated) turnover for 2015 and then multiplying the result by 100.
5. Calculate the mean of the volume indices from step 4 over 2015. Note that this series of indices is not correctly referenced, because this mean is not exactly 100.
6. Re-reference the volume indices to 2015, and verify that the mean over 2015 is equal to 100. *(Hint: the volume index for January 2016, referenced to 2015, is 54.8).*

Box 1 The importance of changes in inventories

Changes in inventories are estimated from a survey sample in a similar manner to turnover estimates. The inventories of interest are those for own output finished goods and work in progress, but they exclude raw materials. Changes in inventories are important for items which take a long time to produce, such as large ships. Excluding these would mean that the production of a ship would be measured in its entirety in the month when the ship is sold, whereas the actual production work takes place over many months and we wish IIP to reflect this.

However, as noted earlier, many businesses may not keep good information on their inventories, particularly for work in progress. In addition, there is the complicating factor of the basis of valuation used by businesses, compared to national accounts. Specifically, that businesses include *holding gains* in the value of their inventories, but this needs to be removed from the national account estimates.

In practical terms, therefore, many countries *use changes in turnover as a proxy for changes in production* on the assumptions that i) changes in inventories are typically small relative to total turnover, and ii) that they average zero over a long period (so that turnover is not a biased estimate of long-term growth in production).

Each NSI must decide, on the basis of knowledge of the country's economy, for which activities it is critical to collect high quality data on the changes in inventories (valued in current market prices), and for which activities the simplifying assumption can be made that changes in turnover is a reasonable proxy for changes in production.

Finally, if the required turnover data come from an administrative source, then the data are likely to relate to turnover and not to the value of production. In such cases, the simplifying assumption above has to be applied, by default.

Elementary Volume Measures

An *elementary volume measure* is an elementary volume index that has been rescaled so that in the reference period it is equal to the current price own output value of the reference period, instead of equal to 100.

Putting this algebraically:

$$\hat{M}_{ar}(b,t)=\frac{\tilde{Q}_a(b,t)}{\tilde{Q}_a(b,r)}\left(\sum_{m=1}^{2}\hat{c}_{amb}+\hat{\Delta}_{ab}\right) \qquad \ldots(13)$$

where $\tilde{M}_{ar}(b,t)$ is the is the activity *a* volume measure in month *t*, with base period *b*, and the sum in the numerator is the total own-output turnover for the reference period in current prices.

We note that if the reference period is the same as the base period of the IIP then the denominator, $\tilde{Q}_a(b,r)$, becomes 100. In this situation, assuming that changes in inventories can be ignored, we have:

$$\tilde{M}_{ab}(b,t)=\frac{\tilde{Q}_a(b,t)}{100}\sum_{m=1}^{2}\hat{c}_{amb} \qquad \ldots(14)$$

This is the most common form of volume measure calculated in practice.

Exercise 1.3: Calculating an elementary volume measure

Using the data and calculations from Exercises 1.1 and 1.2, do the following steps:

1. Calculate a volume measure for each month, referenced to 2015, by multiplying the volume index (referenced to 2015) by the mean monthly turnover over 2015 and dividing the result by 100. *(Hint: the volume measure for January 2016, referenced to 2015, is 14.6).*
2. Verify that these volume measures are correctly referenced to 2015 by calculating their average over 2015 and noting that it is equal to the mean turnover for class 1313 over 2015.

Box 2 Why Laspeyres volume measures are called 'constant price' series

The formula for a Laspeyres volume index expressed in prices and quantities is:

$$Q(b,t) = 100 \frac{\sum_i p_{bi} q_{ti}}{\sum_i p_{bi} q_{bi}}$$

where q_{ti} is the quantity of item *i* sold in current period, and

p_{bi} is the base period price for item *i*.

The corresponding volume measure is:

$$M_r(b,t) = \frac{\sum_i p_{ri} q_{ri}}{Q(b,r)} Q(b,t)$$

because $\sum_i p_{ri} q_{ri}$ is the total monetary value of all items sold in the reference period (since price multiplied by quantity equals monetary value).

Now, if the reference period is the same as the base period, this becomes:

$$M_b(b,t) = \frac{\sum_i p_{bi} q_{bi}}{Q(b,b)} Q(b,t)$$

$$= \frac{\sum_i p_{bi} q_{bi}}{100} Q(b,t)$$

Writing out the volume index formula in full, we get:

$$M_b(b,t) = \frac{\sum_i p_{bi} q_{bi}}{100} 100 \frac{\sum_i p_{bi} q_{ti}}{\sum_i p_{bi} q_{bi}}$$

$$= \sum_i p_{bi} q_{ti}$$

The expression inside the summation is the turnover of each item valued at base period prices. Volume measures are not usually published in isolation, but as a series for a range of current periods. Laspeyres volume measures thus hold their prices constant. This is why Laspeyres volume measures when referenced to the base period are called *constant prices* series (abbreviated to *KP*).

Higher-level Aggregates

We now look at aggregating our elementary indices and volume measures to some higher level. In principle this means extending the calculations to a larger set of activities (such as an ISIC division).

For TII and TIRT this is relatively simple. The current price turnover estimates are additive, i.e.:

$$\hat{c}_{kt} = \sum_{a \in k} \hat{c}_{at} \qquad \ldots(15)$$

where $\hat{c}_{kt}$ is the current price month *t* turnover estimate for domain *k*.

Note that domain *k* is <u>any set of activities</u> (such as an ISIC division) for which we want to calculate indices.

We can then calculate the indices directly from these higher-level turnover estimates:

$$\hat{I}_{kr}(t) = 100 \frac{\hat{c}_{kt}}{\hat{c}_{kr}} \qquad \ldots(16)$$

Alternatively, we can calculate a higher-level index by weighting together the contributing lower-level indices:

$$\hat{I}_{kr}(t) = \sum_{a \in k} \hat{I}_{ar}(t)\, w_{ar} \qquad \ldots(16')$$

where $w_{ar} = \frac{\hat{c}_{ar}}{\hat{c}_{kr}}$ is the reference period turnover weight of activity *a* in domain *k*.

For IIP in volume terms, we use the Laspeyres volume index aggregation formula (see UN *et al.*, 2009, chapter 15):

$$\hat{Q}_k(b,t) = \sum_{a \in k} \hat{Q}_a(b,t)\, w_{ab} \qquad \ldots(17)$$

where w_{ab} is the base period GVA weight of activity *a* in domain *k*, where the weights have been scaled to ensure that $\sum_{a \in k} w_{ab} = 1$

Similarly, for the volume measure of retail activity, formula (17) can be used.

Exercise 1.4: Calculating a higher-level aggregate volume index

Suppose that in addition to the volume indices we calculated in Exercise 1.2, we also have the following monthly volume indices for ISIC classes 1311 (Preparation and spinning of textile fibres) and 1312 (Weaving of textiles), referenced to 2015:

Year	**Month**	**volume index (1311)**	**volume index (1312)**
2015	Jan	78.27	91.20
	Feb	117.40	91.20
	Mar	39.13	121.60
	Apr	156.54	76.00
	May	156.54	45.60
	Jun	78.27	152.01
	Jul	36.96	57.42
	Aug	110.88	129.20
	Sep	110.88	86.14
	Oct	70.03	106.40
	Nov	105.04	91.20
	Dec	140.06	152.01
2016	Jan	35.01	163.21
	Feb	105.04	95.20
	Mar	105.04	68.00

Suppose also that the the national accounts for 2015 show an annual GVA of 120, 400 and 320 for classes 1311, 1312 and 1313, respectively.

Do the following steps:

1. For each month, calculate the volume index for group 131 (Spinning, weaving and finishing of textiles), referenced to 2015, by aggregating the three class indices using their 2015 GVA weights. *(Hint: the group 131 volume index for January 2016, referenced to 2015, is 103.6).*
2. Calculate the mean volume index for group 131 over all months in 2015 to verify that the index is referenced to 2015 *(i.e. check that the mean over 2015 is equal to 100).*

Chapter Summary:

In this chapter we learned:

- The coverage, pre-requisites and data sources for TII, TIRT and IIP, especially the importance of a Statistical Business Register.

- How to calculate stratum and elementary turnover aggregates.

- How to calculate elementary turnover and volume indices, and elementary volume measures.

- How to calculate all higher-level aggregates of turnover and volume indices, and elementary volume measures.

Chapter II: The conceptual framework for estimating quarterly GDP

This chapter gives an overview of the place of quarterly estimates within the wider System of National Accounts 2008 (SNA[1]), see UN *et al.* (2009) and illustrates how high frequency STTIs can be used to support the estimation of QGDP.

What is QGDP in the context of National Accounting?

Before looking in detail at the use of STTIs to measure QGDP, it is helpful to be reminded of the context in which Quarterly National Accounts (QNA) are set, and the place of QGDP within that.

In principle, the SNA can be applied to any length of time, and so the general framework set out in the SNA can be equally applied to quarterly as to annual estimates. The QNA is an important specialty within national accounting and is increasingly recognized as an essential tool for the management and analysis of the economy. The QNA consist of a system of integrated quarterly time series which adopt the same principles, definitions, and structure as the Annual National Accounts (ANA). The QNA can be positioned between the ANA and short-term indicators like the IIP and the TII.

The QNA itself includes estimates of GDP each quarter, but much else, including a full sequence of accounts, and balance sheets. In this report, we limit consideration to just the quarterly estimates of GDP.

More detail on compiling quarterly accounts is provided in

- The Quarterly National Accounts Manual: Concepts, Data Sources and Compilation, 2001 (https://www.imf.org/external/pubs/ft/qna/2000/Textbook/ch1.pdf)
- Its update (http://www.imf.org/external/pubs/ft/qna/), and
- The Handbook on Quarterly National Accounts, Eurostat, 1999, (http://ec.europa.eu/eurostat/documents/3859598/5936013/KS-GQ-13-004-EN.PDF/3544793c-0bde-4381-a7ad-a5cfe5d8c8d0).

These manuals consider such issues as using indicators to extrapolate data and benchmarking quarterly estimates to annual data.

However, it is fair to say that none of the international manuals provides detailed guidance on 'how to' compile estimates. Rather they set out the 'what to do', including advice on methods and data sources, and leave considerable scope in terms of how countries develop the estimates. That said, we can consider some high-level 'dos' and 'don'ts', related to best practice, which include that:

- QGDP should use timely and accurate quarterly data that directly covers most activities
- QGDP should not use econometric methods as a substitute for actual data.
- QGDP should be made consistent with their annual equivalents.
- QGDP should be presented as consistent time series.

Within these guidelines, the actual sources, methods, and scope of each country's QGDP will differ according to circumstances. These include user preferences, the availability of source data, and the economic conditions. As such, the objective in this report is not to set out precisely

[1] https://unstats.un.org/unsd/nationalaccount/docs/SNA2008.pdf

how national accounts' compliers should proceed when using STTIs to compile QGDP, but rather to indicate a range of alternatives and set out the general principles that can be applied.

What does QGDP measure?

Gross Domestic Product, GDP, is the most frequently used indicator in the national accounts. It combines in a single figure, with no double counting, all the output (or production) carried out by all the firms, non-profit institutions, government bodies and households in each country during a given period, regardless of the type of goods and services produced, provided that the production takes place within the country's economic territory.

Notice that this definition refers to the total amount of 'output'. We'll define this shortly. But just to note that GDP can also be considered as the total amount of 'expenditure' made by relevant institutions (including Households, Government and Private sector firms), and equally as the total amount of 'income' generated within the economy by these institutions. In theory these three different approaches, known as the output (or production) method, the expenditure method, and the income method, all produce the same single estimate of GDP. In practice, it is not possible to measure exactly the activity of each institution of interest within the economy, so some approximations are needed. As a result, some reconciliation (or 'balancing') of the different measures of GDP is needed to produce a single estimate. In this report we are largely concerned with just the production measure of GDP, although some refence is made to the other measures where relevant.

Quick Tip
A key point to note is that GDP represents a 'flow' of production (or, equally, of expenditure or income) across the relevant accounting period. It does not represent a measure of a 'stock' at a single point in time.

As its name suggests, Gross Domestic Product, is a 'gross' measure of the 'production' within a 'domestic' territory. The term 'domestic territory' consists of all institutional units (essentially all firms, government and non-government agencies, and households) operating within a national territory whose predominant economic interest lies within that territory. The word 'gross' refers to the fact that GDP includes what is known in the SNA as 'consumption of fixed capital' (CFC). CFC is the amount that the stock of capital is estimated to have been reduced during the accounting period in the process of generating the observed output. This is broadly equivalent to the business accounting concept of 'depreciation' (although CFC differs from the accounting concept in terms of the specific method of valuation). In fact, the concept of 'Net Domestic Product' (NDP) removes the cost of capital consumption, thereby recognising that this capital was needed to produce the output. In theory, NDP provides a more accurate measure of the value of economic activity than does GDP. However, estimating CFC is difficult in practice, and attempts to ensure consistency between different countries' estimates of CFC have proven difficult. For this reason, GDP remains the most popular basis for estimating economic activity.

That leaves the term 'production' (often referred to as 'output') still to be defined. In short, output measures the value of the amount of goods and services produced. For a single institutional unit, this is normally straightforward: we simply add up the amount of goods and services produced in the period of interest (normally a year or a single quarter). For example, for a manufacturer of pasta, it is just the value of the production of pasta produced for sale in the period. But note first that it is not the value of the *sales* of pasta during the period. This may differ from the value produced in the period because some of the sales may be of pasta produced in an earlier period. Additionally, it may be that some of the production within the period in question was not sold in the same period, i.e. the pasta was added to the stock to be sold in a future period. It may also be that some production has been started but not finished (for example pasta which has been prepared by which has not yet been packaged). This also counts as production during the period, but is classified as 'work in progress' rather than 'finished goods'. Thus, output differs from sales because of these changes in stocks, or inventories, of finished goods and work in progress during the period. More precisely:

Output = Sales
plus inventory of finished goods and work in progress at the start of the period
less inventory of finished goods and work in progress at the end of the period.

More succinctly:

Output = Sales *plus* changes in inventories …(18)

We'll see shortly why this distinction between sales and output is important in the context of using STTIs to estimate QGDP.

In practice, there are some exceptions to this definition. Notably, in the context of the economic activities covered by the STTIs considered in this report, the output of 'distributive trades' which includes wholesale and retail trade. This requires a different definition to formula (18), see Box 3 for details.

Box 3: Output of Distributive Trades

In the case of distributive trades, which includes wholesale and retail traders, if formula (16) were applied this would significantly overestimate output, since sales of wholesalers and retailers include the value of the goods created by the actual producers of those goods (whether these are domestic or non-domestic producers). In effect this value would be counted twice – once as the output of the producer, and once as the sales of the retailer (or wholesaler).

The output of these distributive services is therefore defined as the 'margin', which is the value of all sales in the period less the cost of goods purchased for re-sale. So, for wholesale and retail trade output is defined as:

Output(Distributors) = Sales *less* Cost of Goods Purchased for Resale …(18')

The concept of value added

If there was only one institution in the economy, it would be necessary only to measure its output to estimate GDP. However, an economy consists of very many different institutions, each interacting with the others. The pasta manufacturer buys flour and other raw materials from other businesses which it uses as inputs to produce its output. If we added the output of the flour manufacturer to the output of the pasta manufacture, we would be doubled counting the value of the total production by including the value of the flour twice: first as the output of the flour manufacture, and then again as part of the total value of the pasta produced by the pasta manufacture. To avoid this double counting, we need to remove from the value of output the value of the *inputs* used by each institution to produce their output. These inputs are referred to as the '*intermediate consumption*' of the institutions. The difference between the output and the intermediate consumption is known as the 'gross value added' (GVA), i.e.,

Gross Value Added = Output *less* Intermediate Consumption …(19)

Note: when we come to measure total GDP, we need to sum the GVA of all institutions and add to that any taxes on products and subtract any subsidies on products to derive total GDP.

Quick Tip

Remember that Gross Value Added is valued in basic prices, meaning that it includes the cost of production plus any taxes (less subsidies) on production which do not vary with the amount of production (for example, business and professional licences, taxes on pollution, and taxes on payroll or work force), but not including taxes (less subsidies) on products (i.e. ones which vary with the amount of production, like import taxes, excise duties, sales taxes, and value added taxes).

Other issues concerning the use of STTIs to measure GDP

In this section we consider some other issues which need to be understood when using STTIs to measure QGDP: these can be characterised as the issues of value versus volume, levels versus changes, and quantity versus quality.

Value versus Volume

In the example given above of a manufacturer of pasta, we took their contribution to the total GVA within the economy as the *value* of their output less the *value* of their intermediate consumption (of goods and services used up in the process of producing their output). This is the 'value approach'. Alternatively, we might have considered the *volume* of their output less the *volume* of their intermediate consumption. For example, we might have considered the that they produced 150 tonnes of pasta and consumed 120 tonnes of flour in the process. This is the 'volume approach'. The value approach produces an estimate of GVA in current prices which reflects the actual monetary value of production. The volume approach effectively removes the impact of price changes, and produces what is known as a *volume estimate* of GDP. This is more usually expressed in 'constant price' monetary units, for example 'GDP in 2015 prices'.

In practice, both the current price and volume estimates of GDP are of interest for the purposes of economic analysis. In fact, the ratio of the estimate of GDP in current prices to the estimate of GDP in constant prices is also of interest in its own right, and is an index of the *prices changes* over the period, often referred to as an Implicit Price Deflator (IPD).

In terms of QGDP, it is generally the volume, or constant price, measure which is of most interest since this shows the evolution of the economy after removing the impact of price changes. The IPD for GDP is also of some interest, since it reveals the impact of whole economy price pressures (not just those affecting sectors, like the Consumer Prices Index which relates only to household spending, or the Producer Prices Index, which relates to the cost pressures on domestic producers).

Levels versus Changes

Estimates of GDP are usually presented in the form of time series, in either current or constant price monetary units. As noted earlier, it is important that such time series use consistent methodology, as far as possible, to avoid breaks in the series. The time series itself presents the amount, or level, of production in each period, i.e. as a flow and not in as a stock. In current prices this level represents the best estimate of the actual value of production in each period.

In constant prices (i.e. GDP shown as a volume) the time series is also presented in monetary units, but in this case, it is more difficult to interpret it as a flow of production. In fact, while the constant price series is presented as though it has some monetary value, in fact, the units used do not represent actual money at all. Rather, the use of monetary units for the volume series is a convenient basis for presenting the series, which really should be interpreted in terms of how the series changes over time. In that sense, the constant price series is in fact *an index of change,* and not a level in some monetary unit.

This is an important distinction: when interpreting the constant price series, the key information being conveyed is the change in GDP, not the level of GDP. In fact, when GDP statistics are reported each quarter, usually the key number of interest is the growth of the series compared with some historical period, e.g. the annual percentage change in GDP in the last quarter compared with the same quarter in the previous year (or sometimes, for seasonally adjusted series) compared to the previous quarter.

Similarly, when interpreting the Implicit Price Deflator, which is the ratio of the current price GDP series to the constant price GDP series, and takes the form of an index (with the value of the index being set equal to 100 in the reference year for the series), the key information being conveyed is the *change in the aggregate price of GDP*.

In short, quarterly GDP is useful primarily as a measure of how economic activity has changed compared to an earlier period, rather than what its absolute level is. This is similar to the way in which the STTIs themselves are presented and used. These short-term measures are mainly concerned with measuring changes, in current or constant prices.

Quantity versus Quality

Finally, in this section we consider how changes in quantity and changes in quality are reflected in the estimates of GDP. If the quality of a product improves over time, how is this to be accounted for in the value and the volume measures of GDP? The answer to this question lies in the fact that volume measures in the national accounts include not just increases in the number of products, but also the utility derived from them by the consumers.

By way of example, let us consider the case of a manufacturer which produces two kinds of cheese: a standard variety (s) and a luxury variety (l). Consider the sales of these cheeses in 2015 and 2016, as set out in table 1

Table 1

Sales of cheese			
2015	Quantity (000s kg), (Q)	Price (P)	Value in Current Prices (Q x P)
Standard	40	50	2000
Luxury	30	70	2100
Total			**4100**
2016			
Standard	30	50	1500
Luxury	40	70	2800
Total			**4300**

Notice that, in this case the prices are assumed to be the same in 2015 and 2016 and, although the total quantity of cheese sold (in 000s of KGs) is also the same in each year (i.e. 40 +30 = 70), the value of sales has increased by 4.9%, i.e. 4300/4100 - 1. This is because the demand for luxury cheese has increased, and the demand for standard cheese has decreased. More consumers are prepared to pay the extra to buy luxury cheese. Let us see how this change is accounted for when we calculate the change in volume, or constant price terms.

Using 2015 as the constant price base, Table 2 shows the sales expressed in constant 2015 prices, i.e. by applying the prices in 2015 to the sales quantities in each year:

Table 2

Sales of cheese				
2015	Quantity (Q)	Price (P)	Value in Current Prices (Q x P)	Value in 2015 Prices (Q x P in 2015)
Standard	40	50	2000	2000
Luxury	30	70	2100	2100
Total			4100	4100
2016				
Standard	30	50	1500	1500
Luxury	40	70	2800	2800
Total			4300	4300

Again, we see than the change in consumer preference for more luxury cheese is reflected in the percentage change in constant prices, which again shows a 4.9% increase between 2015 and 2016. In this case the change in value (4.9%) is *fully reflected as a change in volume* of 4.9%, because the prices of both varieties of cheese did not change between 2015 and 2016. What if the prices had changed? How would this be taken account in the value and volume changes? Consider table 1’:

Table 1'

Sales of cheese, with price increases				
2015	Quantity (Q)	Price (P)	Value in Current Prices (Q x P)	Value in 2015 Prices (Q x P in 2015)
Standard	40	50	2000	2000
Luxury	30	70	2100	2100
Total			**4100**	**4100**
2016				
Standard	30	60	1800	1500
Luxury	40	80	3200	2800
Total			**5000**	**4300**
		% Change 2016/2015		
			Value in Current Prices	Value in 2015 Prices
		Total	22.0%	4.9%

Now we see that the total change in value was 22% (5000/4100-1), whereas the volume change, expressed in constant 2015 prices, was still 4.9% (4300/4100-1). In the national accounts we can consider this as a 'quality change', because consumers derive more utility from the higher volume of their consumption of luxury cheeses in 2016.

To complete the picture, we should calculate the price change. To do this, we can calculate an index of the price in each year. This is the IPD we introduced earlier. In 2015 the IPD was 4100/4100x100=100, i.e. the current price value in 2015 divided by the constant price value in 2015, multiplied by 100 to express it in index form. In 2016, the same calculation yields an IPD of 116.3, i.e. 5000/4300 x 100. Thus, the price change is 16.3%, i.e. 116.3/100.0 -1.

More generally, whenever we observe changes in both the quantity of goods produced and change in their relative prices, we can separate out the price effects from the volume effects in this way. The changes in consumer preference – buying a greater quantity of luxury cheese at a higher price, allows us to reflect this quality change within the volume measure of GDP. This depends on the fact that the luxury cheese has a higher price. In effect, price is used as a proxy for quality: consumers are prepared to pay more for a higher quality product.

Usually, this relationship is found to hold: consumers will pay more for better quality goods or services. However, it is important to note that this is not the case for all types of goods. The development of computers and other information technology goods in recent year has witnessed improvements in the quality of the goods (laptops are getting faster, have larger hard drives, better graphics cards etc.), while the price of these goods has remained the same, and in many cases prices have fallen. In a sense, consumers are getting 'more in the box' when they buy a laptop today than they did 20 years ago (or even 5 years ago), and yet the prices have in many cases fallen. In such cases it is not possible to use the above approach to capture the change in quality over time within the estimates of GDP, because higher price cannot be used as an indicator of higher quality. As a result, methods, known as 'hedonics', have been developed in some counties to try to capture the changes in quality of these Information Technology goods within the volume measures of GDP. However, there is as yet no internationally agreed basis on the precise hedonic methods which should be used, so most countries just accept the fact that their GDP in volume terms may be understated.

Exercise 2.1: Capturing quality change in a volume index

To further illustrate how quality changes are captured through changes in composition (stratification), consider the output of the 'Olive Canning Company'. The company has a factory producing tins of olives for sale. For many years the factory has produced tins of only 'whole' olives, i.e. those which include the olive 'pit' or stone. Changes in consumer preference in recent years have led to greater demand for olives which have the pits removed, known as 'pitted olives'. Tins of 'pitted olives' can be sold at a higher price, because they are considered to be of greater quality.

The factory itself has a limit on its capacity so that it can only produce 80,000 tins of olives each quarter. The following table shows the production of the factory over the period 2014 Q1 – 2017 Q1, as well as the prices for each type of type ('whole' and 'pitted'):

		Production (number of tins, thousands)				Price per tin	
		Whole	Pitted	Total		Whole	Pitted
2014	Q1	50	30	800		1.5	2.0
	Q2	50	30	800		1.5	2.0
	Q3	45	35	800		1.5	2.0
	Q4	45	35	800		1.6	2.0
2015	Q1	45	35	800		1.6	2.2
	Q2	40	40	800		1.6	2.2
	Q3	40	40	800		1.6	2.2
	Q4	40	40	800		1.6	2.2
2016	Q1	40	40	800		1.8	2.2
	Q2	30	50	800		1.8	2.2
	Q3	30	50	800		1.8	2.4
	Q4	30	50	800		1.8	2.4
2017	Q1	25	55	800		1.8	2.4

Calculate:

1. The average price of each type of tin of olives in 2014. *Hint:* take the total sales value of each type in 2014 divided by the total production (in tins) of each type.
2. Use the average price from step 1 to calculate a 2014 constant price series for each type of olive.
3. Use step 2 to calculate a 2014 constant price series for total production (of tins of whole and pitted olives combined). *What was the total growth over the period 2014 Q1 to 2017 Q1 of total production in 2014 constant prices?*
4. The total value of production. *What was the total growth over the same period in value terms?*
5. The implicit price deflator *What was the total change in the price?*

What do you conclude?

Chapter Summary:

In this chapter we learned:

- Quarterly GDP is complied using the same framework provided by SNA 2008 as used for annual estimates.

- The definition of GDP is total Gross Value Added at basic prices *plus* taxes on products *less* subsidies on products

- GVA = Sales turnover *plus* changes in inventories of finished goods and work in progress *less* intermediate consumption

- The value of output and GVA can be decomposed into price and volume effects

- Quarterly GDP is useful primarily as a measure of how economic activity has changed compared to an earlier period, rather than as a measure of its absolute level

- Changes in the quality of goods or services need to be included in the volume measure of GDP (and excluded from the implicit price deflators). This can be achieved for most goods and services if sufficient detail in terms economic activities is used in the compilation of GDP (on the assumption that, in line with standard economic theory, consumers are prepared to pay more for higher quality goods)

- For some types of goods, mainly those produced by the Information Technology sector, it is necessary to make 'hedonic adjustment' to the price indicators used for deflating current price GVA, to take account of the fact that, for such goods, it is possible that the quality increases and the price decreases over the same period.

Chapter III: Some pre-requisites for estimating QGDP using STTIs

The last chapter introduced some of the basic principles needed to understand how GDP is calculated, including the definition of value added, the relationship between output and sales, and the issues of volume and value measurement, levels and changes, and how to deal with changes in quality of goods and services produced. This chapter considers other elements which need to be in place when developing an estimate of quarterly GDP, with particular reference to the role of STTIs in that process.

Source of Gross Value Added Weights

As we shall see, to aggregate the production of different activities across the whole economy, it is necessary to have some measure of their relative 'size'. Specifically, we need to have an estimate of the gross value added of each activity in the economy. The proportion of gross value added of an activity compared with total gross value added for all activities is sometimes referred to as the 'weight' of the activity.

What source should be used for these weights? When considering only the production measure of GDP, it may be possible to use an Establishment Survey to estimate weights for a particular year, which can be referred to as the 'base year'. If resources allow, it may even be that such a survey can be undertaken each year, so that the weights can be updated every year. However, more usually, such surveys are undertaken less frequently, perhaps every three to five years.

While the use of Establishment Surveys to estimate value added shares is legitimate, the SNA recognises that a more robust basis for estimating the GVA weights needed to aggregate the output of different economic activities is to develop a Supply and Use Table (SUT). In brief, a SUT consists of two or three sub-tables, which show the supply of goods and services by product (including domestic production and imports), the demand (or 'uses') of these products, split between intermediate uses and final uses of households, government and non-profit institutions serving households, and exports. There can also be a table which shows, for each economic activity, the income components of value added, which include compensation of employees, gross operating surplus and mixed income, consumption of fixed capital and other taxes on production.

The benefit of an SUT is that it allows data from multiple sources to be compared and for each product and activity in the table to be 'balanced' in terms of ensuring that the total supply of each product is equal to the total demand and the total output of each activity is equal to the total input. In this way, it is possible to use data on international trade, government expenditure, household consumption, and much else, in addition to the data from Establishment Surveys on domestic production. This is particularly relevant for economies which have a significant informal sector, where Establishment Surveys are often inadequate.

The importance of Informal Activity

In many countries the economic production of unincorporated businesses, essentially households operating in what is referred to as the 'informal sector', can be significant. Developing countries may have between 30% - 50% of their total economic production undertaken within this sector. Measuring the amount of informal activity is generally more difficult than measuring the production of the formal sector (usually defined as those businesses which are registered with the national tax authorities). As such, the types of data discussed in Chapter I for measuring the activity on a quarterly basis, i.e. sample surveys or tax records of formal businesses, will not represent the activity of informal businesses. The usual assumption is that extent of *informal activity changes in line with that of the formal sector*. In the short term this might be reasonable: both formal and informal activity is likely to respond to changes in demand or prices in similar ways. However, the 'short-term', might at best be a few quarters, rather than years. In terms of the methods for using STTIs for estimating QGDP presented in this report, it is important that the annual estimates of GVA within each economic activity include the production of informal businesses. These annual estimates can then be used to 'benchmark' the STTIs, which will include such production (the process of benchmarking is the subject of Chapter IV). In this way, any bias in the STTIs in terms of their underrepresentation of informal activity, can be removed.

In practical terms, measuring the informal sector may best be undertaken through household surveys, which can collect data on the production of the sector. Labour Force Surveys can also be used in this context, by identifying the number of workers employed in informal activities. These data can be used together with data on the production of formal activities and some assumptions about the relative productivity of informal and formal workers (which depends to some extent on the relative degree of capitalization of these sub-sectors) to produce a modelled estimate of informal production. The data can also be used in the context of a SUT, as described earlier.

Another method is to use informal sector surveys, which attempt to measure the activity directly. The main problem with such surveys is the quality and completeness of the sample frame used. Given the nature of the sector, where households may undertake many different production activities, including small-scale (or 'cottage') manufacturing, distribution (buying-selling), and construction, and the fact that the lifetime of any individual 'business' may be as little as a few days, it is extremely difficult to even identify such businesses.

On balance, the most effective way to measure informal activity is probably through a SUT, where it is possible to use data on both the demand for goods and services with their supply, to identify the activity of informal businesses as a residual between the total demand and the formal supply.

Relationship between quarterly and annual estimates of GDP

Another consideration when compiling QGDP is whether there exist already annual estimates of GDP. In some countries, e.g. Rwanda and Uganda, there is no independent estimate of annual GDP, with the annual estimates being simply the sum of quarterly estimates. In other countries, e.g. most European countries, as well as Kenya, Nigeria, Tanzania, Ethiopia and many other African countries, the compilation of annual and quarterly estimates of GDP are undertaken separately. The reason for this is that many sources needed to produce complete estimates may only be available annually. For example, it may be that data from the Income Tax system on the sales of businesses is only collected once a year. Similarly, with the definitive data on the expenditure of General Government. As such, the quality, in terms of the data content, of the annual estimates may be greater than that available on a quarterly basis. As we shall see, it is for national accounts' compilers to judge what is the best source of data for each component of GDP, and to attempt to incorporate such data into the estimates. This raises the question of how to reconcile the annual and the quarterly estimates, to ensure consistency between the elements of different frequency. This is the role of 'benchmarking' which will be considered in detail in Chapter IV.

Level of detail in quarterly and annual estimates

It is usual that estimates of QGDP are produced for higher level aggregates than the annual estimates. For example, if annual estimates are published for ISIC groups (3-digits), it may be that QGDP is only published for ISIC divisions (2-digits). This is to be expected, since the quality, coverage, and completeness of the annual sources is likely to be greater than those available for the STTIs. In fact, while estimates of QGDP are compiled using the same framework as the annual estimates, it is reasonable to think of the short-term estimates as being short-term approximations to the annual estimates (which themselves are approximations to the actual level of economic activity, of course).

Which STTIs should be used to estimate QGDP?

This report has presented methods for estimation three different STTIs, the TII the IIP, and the TIRT. In terms of estimation of GVA for the industry sector of QGDP, if a IIP has been compiled in both current prices and in volume terms, this is preferable to using the TII as an indicator. This is simply because the IIP is a measure of industrial *output*, which is a closer concept to GVA than *turnover*, as measured by the TII. If the IIP is only produced in volume terms (i.e. in constant prices), it will still be possible to use relevant price indicators, for example the PPIs, to 'reflate' the volume IIP into current prices (i.e. multiply the IIP by a relevant price index). In fact, as discussed in the IIP methodology, it is more usual that the current prices estimates of output are produced first, and then deflated (i.e. dividing the current price IIP by a relevant price index). In cases where volume data have been collected to estimate the IIP, e.g. gigawatt hours of electricity produced, it should still be possible to convert this into a current price index by multiplying by the price for the relevant unit, in this case the price per kilowatt hour.

Only if the IIP is not produced should the use of the TII be considered as a possible basis for estimating QGDP.

With regard to retail sales, i.e. ISIC 47, Chapter I described how the current price TIRT can be expressed in constant prices, using the CPI as a suitable indicator. If the constant price equivalent of the TIRT is aggregated using weights which represent sales, rather than the retail margins, this may introduce some short-term bias in the estimation, but the TIRT and its constant price equivalent will still be useful indicators.

Chapter Summary:

In this chapter we learned:

- A Supply and Use Table should ideally be used as the basis for establishing a base period level for GDP, which can be used as the source of the weights needed to estimate quarterly volume measures of GDP.

- STTIs will not generally measure informal activity each period. Some assumptions are therefore implicit in the use of STTIs to estimate total GDP, notably that the percentage changes in formal and informal activity are approximately the same in the short run (i.e. between base years). It is critical that the SUT base year includes estimates of informal activity.

- QGDP is generally published at a more aggregate level than the annual or base year equivalents.

- It is possible to use the STTIs to estimate annual as well as quarterly GDP, if annual estimates are not compiled separately.

- The IIP should be used as the basis of estimation of QGVA for the industrial sector. If this is not available, it is permissible to use the TII together with relevant price indices (e, g., the Producer Price Index).

- The TIRT can be used to estimate GVA for the retail sector, together with the Consumer Prices Index as a deflator.

Chapter IV: Benchmarking methods

This chapter describes the mathematical operation of benchmarking, and an associated function in MS Excel. Benchmarking is used to ensure consistency between time series of different frequencies. The operation can be applied to monthly series and corresponding quarterly or annual series. For example, the monthly TII can be benchmarked to the corresponding annual estimates based on a larger survey like a Structural Business Survey. As we shall see in Chapter V, it can also be applied to quarterly time series where there is an annual equivalent, for example, the quarterly volume IIP and the annual level of gross value added in constant prices from the annual national accounts.

What is benchmarking?

As noted already, there are conceptual links between the monthly STTIs, QGDP, and their annual equivalents. For example, the TII may be based on a monthly survey, while there may also be annual estimates from a Structural Business Survey (SBS) which provide more accurate and complete estimates of the levels of industrial turnover by economic activity. We therefore need some way to ensure that the TII in each year is consistent with the data from the SBS. As another example, we have seen how the monthly IIP can be used as an indicator for components of QGDP. However, if annual estimates of GDP are also compiled (separately), based on more comprehensive data, again we need a way to ensure consistency between the QGDP series based on the IIP and the annual series for the equivalent components of GDP. This chapter describes how this consistency can be achieved between the various frequencies of time series involved through a procedure known as 'benchmarking'.

The central motivation for benchmarking is that it is assumed that the lower frequency series, for example the annual SBS, is of better quality than the higher frequency equivalent, for the example the TII. This is justifiable in most cases since the annual data are generally based on larger surveys, and perhaps have additional detail which better represents the concepts being measured. For example, in the context of estimating GVA, as we have seen, at the most elementary level the IIP indices are usually based on data for 'output', which are then weighted together using GVA weights. Output is therefore used as a proxy for GVA. In fact, it may be that the IIP is based on data for 'sales', which is used as a proxy for output. On the other hand, the SBS may have data on the changes in inventories and on intermediate consumption, which enable direct estimation of the annual level of GVA in each activity.

Benchmarking performs two functions:

1. It ensures consistency between estimates of different frequencies, which is desirable for users.
2. It incorporates the additional quality available in the lower frequency series into the higher frequency series.

The main issue with benchmarking is that it leads to revisions to the higher frequency estimates.

What are the objectives of benchmarking?

There are essentially two objectives of a benchmarking procedure (using benchmarking quarterly to annual series as an example):

1. To preserve as much as possible the quarter to quarter movements of the quarterly series subject to the constraint that the sum of the four quarters in each year must be equal to the annual benchmark level.
2. To ensure, for the forward series, that the sum of the four quarters for the current year is as close as possible to the unknown future annual data.

The first objective is desirable because the quarterly series after benchmarking should follow as closely as possible the 'path' of the original (benchmarked) series. Thought of another way, the intention of this objective is to keep the total revision to the original series as small as possible after benchmarking.

The second objective relates to the series *after the last period* for which a benchmark annual series is available. For example, if QGDP has been published for all periods up to quarter 3 2017, and the annual GDP series is available up to 2016 (since 2017 is not yet complete), the quarters from Q1-Q3 2017 do not yet have an annual level against which they can be benchmarked. However, it is desirable that the benchmarking procedure should *anticipate* the annual series for 2017, so that when this becomes available, the revisions which will result when series is benchmarked up to and including 2017 will be as small as possible. This is clearly more difficult to achieve than the first objective, since the annual level is unknown at the time when the series is being benchmarked. We discuss below how this objective can be best achieved.

Quick Tip

The benchmarking procedure can be applied to any two time series of the relevant frequencies, e.g. monthly and annual, or quarterly and annual, and it will always produce a result. However, benchmarking is a purely mathematical procedure, and so has no knowledge of what the two series actually represent. So, for example, it would be possible to use the procedure to benchmark a quarterly series for egg production in kilograms to an annual series for sales of tractors expressed in dollars. Clearly this would not make any economic sense. Therefore, when benchmarking keep in mind the following:

- The high and low frequency series should either be estimates of the same phenomenon, e.g. they both measure sales of eggs in dollars, or at least be closely related phenomenon, perhaps quarterly sales of eggs in kilogrammes and annual production of eggs in kilogrammes, or quarterly retail sales by predominately food, stores, and the (estimated) annual margin on retail sales by predominately food stores.
- Always (meaning *always*) compare the two series to be benchmarked by calculating the annual growth of the quarterly series (taking the sum, or average, as appropriate, of the quarterly series in each year and calculating from this its growth) and comparing this the growth in the annual series. Better still, plot the annual level of both series, expressed in index form, so they are presented on the same scale. If the two series have very different movements, or there is a clear divergence between them, then the benchmarking procedure **should not be used**. In such cases, an alternative indicator series should be identified.
- There are conceptual reasons why we should expect the growth in the STTIs to be different from the growth in annual estimates, and these are considered more fully in Box 4.

Box 4: Bias in the estimated growth of STTIs compared to their benchmark equivalents

As a reminder, whatever the causes and extent of bias in the STTIs compared with the annual SBS estimates, these will only affect the quality of the short-term estimation if the rates of change between the short-term and annual estimates are different. The levels of the estimates can be quite different, and this will have no effect on the benchmarked short-term estimates. With that in mind, we consider sources of potential bias in each of the STTIs

Bias in the growth of TTI

As discussed in this report, the TII may be based on a specific monthly survey or surveys, or administrative sources. If there is an annual structural business survey (SBS), which has greater coverage and/or more detail about the type of sales, it is likely that there will be differences between the annual estimate of total turnover in the short term data in any given economic activity and the equivalent estimate from the SBS. The complier should investigate the reasons why these differences might have come about. It may be, for example, that the TII survey sample is not representative of the population in ways that the SBS addresses. If VAT sales from the revenue system are used as the basis of the TII, and equivalent data from the annual income tax system are used as the basis of annual estimates, it may be that the monthly VAT system misses some important businesses which only report for Income Tax purposes, perhaps smaller businesses. The absence of the informal sector from the TII data sources, as discussed in Chapter III, is also a potential source of bias.

Bias in the growth of the IIP

In terms of the production volume indices, as discussed in the data sources section in Chapter I, the IIP may be estimated using monthly data on output, or it may just use the same data on sales turnover as used for the TII. If it is based on output data, then the key issue may be the value of intermediate consumption, which may be estimated in the annual GDP figures but not in the IIP itself, at least not at the elementary level of aggregation (remember, these elementary IIP series are weighted using GVA weights). Essentially, unless actual data are available each month for the IC, an underlying assumption with the IIP is that the ratio of IC to output is stable in the short term. If this assumption is violated, say during a recession when firms may reduce the extent of their 'discretionary' expenditures on training, new computers etc., it may be that the ratio of IC to Output reduces. This will mean that the growth in GVA as estimated by the IIP index will overstate growth in GVA. In practice, without introducing new monthly data collections related to IC, there is little the complier can do about such short-term biases. This is why it is important to have regular annual estimates of the level of GVA to which the IIP can be benchmarked (see Chapter IV for details of this procedure).

If sales turnover, rather than output, is used as the basis of the IIP, this creates a further source of potential bias, because changes in inventories are being ignored. Usually, changes in inventories are relatively small compared with the total output (although this may not be the case for large equipment goods like the production of ships, oil rigs, aeroplanes and special purpose machinery, where the work-in-progress component of inventories is significant). But during an economic cycle inventories tend to vary. Typically inventories build-up as the economy expands (to meet rising demand), and are reduced as economic activity slows down (to avoid holding excessive inventories for which demand is expected to fall). This ‘stock cycle’ can mean that, if inventories are not adequately measured in the monthly survey on which the IIP is based, but are well-measured in the annual surveys on which annual GDP is based, then there is a further source of bias. In practice, in response to such cycles, IIPs based purely on turnover will tend to underestimate growth as the economy expands and understate the decline in growth as the economy contracts.

As with the TII, informal activity, which is not well-represented in the sources for the IIP, is another source of potential bias. Differences in the growth of formal and informal activity can arise, for example, in response to short-term problems with supply, perhaps because of changes in the international trade regime, where informal activity may be quicker to respond to such changes than formal activity. In such situations it will be important to capture these changes in the annual estimates if possible, which can then be reflected in the IIP through the benchmarking process.

Bias in the growth of the TIRT

In the case of the Turnover Index for Retail Trade, as described in Chapter I, this is based on data on the sales of retailers each month. In addition to the bias issues discussed above for the TII and IIP, there is a further potential source of bias in the context using a TIRT for estimating the growth in *value added* for the retail activity. The implicit assumption when using the TIRT as a proxy for changes in GVA is that changes in the total retail margin, i.e. the sales value less the cost of purchases, is the same as for the sales value itself. This is equivalent to assuming that the ratio of the margin to the cost of sales remains fixed, at least in the short term. Any deviation from this assumption will lead to bias in the estimation of the growth of GVA for retailers if the TIRT is used. For example, if retailers increase their average margin from, say, 30% to 31%, then estimates of the changes in retail GVA will be understated, since the TIRT only records the change in total sales and not the change in the margin. A simple numerical example may help to illustrate this.

	Sales	Cost of sales	Margin	Margin %	Intermediate Consumption	GVA
2016	130	100	30	30%	20	10
2017	131	100	31	31%	20	11
Annual % change, 2017 compared to 2016						
	0.8%	0.0%	3.3%	3.3%	0.0%	10.0%

In this case, the cost of sales and intermediate consumption are assumed to be unchanged between 2016 and 2017. But retailers have increased their average margin rate from 30% to 31%. In terms of totals sales, this increases from 130 to 131 and increase of 0.8%. However, the GVA for these retailers increased by 10%. If the change in sales is used to estimate the change in GVA for these retailers, it will significantly underestimate the actual growth. The converse will be the case if retailers reduce their margins.

How is benchmarking performed?

To achieve the two objectives set out in the previous section, benchmarking consists of the following two aspects (again using benchmarking of quarterly GDP to the annual GDP series as an example):

1. ***Quarterization of annual data***: This involves constructing a quarterly time series of historical QGDP aligned to the available annual data

2. ***Extrapolation:*** this creates a series after the last quarter for which annual data are available at the time of benchmarking based on the movements in the QGDP series

There are many different methods for undertaking these two aspects, and software which can perform them. This report considers the two most popular, which are recommended by the IMF's Statistics Department in their updated Quarterly National Accounts manual (see http://www.imf.org/external/pubs/ft/qna/index.htm (Chapter 6).

These are:

1. Denton's Proportional Method
2. The Cholette-Dagum Method

These are considered in turn below.

1. Denton's Proportional Method

Denton's method was developed in 1971 and performs a quarterization procedure in such a way that the following minimization constraint is met:

$$\text{Min} \sum^{T}_{t=2} (X_t / I_t - X_{t-1} / I_{t-1})^2 \qquad \text{for } t=1\ldots 4y \ldots T \qquad \ldots(20a)$$

Subject to the restriction that:

$$\sum^{4y}_{t=4y-3} X_t = A_y, \qquad \text{for } y = 1\ldots Y \qquad \ldots(20b)$$

Where

t	is time;
X_t	is the derived QGDP estimate for quarter t;
I_t	is the level of the indicator for quarter t;
A_y	is the annual data for year y;
Y	is the last year for which an annual benchmark is available; and
T	is the last quarter for which quarterly source data are available.

The minimisation function, (20a), ensures that the total squared revision (the difference between the series before and after benchmarking) is as small as possible. The constraint, (20b), ensures that the resulting benchmark series is the same as the annual series in each year.

So, Denton's method is a 'least-squares' procedure in terms of how it performs the 'quarterization' aspect of benchmarking.

What about the extrapolation aspect? Here, there are two methods which can be used, which we consider below.

i) Denton's Basic Method.

This simply applies the growth in the indictor series from the last benchmarked quarter to extrapolate the benchmark series, specifically, the benchmarked QGDP estimate at time T+n, i.e. X_{T+n} is given by

$$X_{T+n} = X_T \times I_{T+n} / I_T \qquad \ldots(21)$$

In this way the growth in the benchmarked series after the last benchmarked quarter is the same as the growth observed in the indicator over that period.

If the indicator series (in this example, QGDP) is a good predictor of the annual known series, then this 'basic method' is recommended. Strictly, we need to ensure that the indicator series is an unbiased estimate of the low frequency (in this case annual) series. Unbiased here just means that the expected growth in the indictor series over a period is sufficiently close to the annual series that revisions resulting from the benchmarking procedure will be small. But how can we assess whether an indicator is unbiased in this sense? One way is simply to apply the benchmarking procedure over a few years and observe the revision which would have occurred ha~~s~~ the procedure been used over this period. Remember, any persistent differences (say the QGDP series is observed to always grow faster than the annual series) will result in revisions which can be considered as predictable.

To avoid this potential bias, there is a second 'enhanced' method which allows the complier to 'anticipate' the bias, known as 'Denton's enhanced method'

ii) Denton's Enhanced Method

This allows for an *explicit adjustment* in the extrapolation aspect of benchmarking to counter any observed bias in the growth of the indictor when compared to the annual series. In the literature the annual series is referred to as the 'benchmark', so that the measure of the extent of any bias is taken as the ratio of the benchmark to the indictor series, known as the 'BI ratio'. For example, considering QGDP as an indicator for annual GDP, the BI ratio in any year is given by the ratio of the annual level of GDP compared to the sum of QGDP in the four quarters in the equivalent year[2]. A BI ratio of '1' means that the indicator is a perfect predictor of the benchmark series. A BI ratio of 0.95 would indicate that the annual series grew by 5% less than the indicator series, and a BI ratio of 1.05 would mean that the indictor series grew by 5% more than the annual series. The IMF QNA manual, and other literature on this subject, provide detailed guidance on how to evaluate the BI ratios over a number of periods in order to estimate an average BI which best represents the bias in the indicator. This can then be used in the enhanced method to adjust the extrapolated series so that the bias can be anticipated.

[2] Strictly, the BI ratio should be based on index series for both the low and high frequency series. The reason for this is that, for example, the low frequency (indicator) could be in different units to the low frequency series, perhaps the indicator is 'number of bricks produced' and the low frequency series is sales of construction materials'. However, in the context of this manual, where we are considering the TII, IIP and TIRT, each of these is referenced to some base period level which has the same units as the low frequency series (because it is based on that series), so it is possible to construct the BI ratio in any year as the annul estimate from the low frequency series divided by the sum of the low frequency indictor series over the same period.

For example, if we observe an average BI ratio of 1.05 (meaning that that annual series has grown 5% more than the indicator average over a number of years), we can make a 'BI adjustment' of '5' to counter this, which will add 5% to the annual growth of the benchmarked series in the extrapolated period (i.e. after the last quarter for which the benchmark annual series is available). In this way the bias can be anticipated.

However, ***a significant word of caution here***. In practice it is rare that there is a completely stable relationship between the annual series and the sum of the indicator series in each year, meaning that the BI ratio itself is stable. More often, the BI ratio can vary considerably from year to year. If it is persistently greater than 1 (meaning the annual series is always greater than the sum of the indicator series), then there is a problem with the choice of indicator. It is better to try to identify the reasons for the bias in the indicator and either eliminate this bias or find a better indicator.

More generally, in relation to Denton's method, in practice the complier should examine plots of the two series and look for any clear biases (i.e. persistent differences in the growth rates). This may be better examined by comparing plots of the actual growth rates of the series. More formal tests of the bias can also be carried out, and these are described in detail in the IMF's QNA manual. However, for practical purposes, it is normally sufficient to simply make a judgement about the extent of the bias, if any. The implications of making an explicit BI adjustment are that, if the complier overstates the bias, say, they make an adjustment of +3% to the annual growth, this will add (approximately) $^{3}/_{4}$% to the extrapolated growth rate in each quarter. If the actual annual estimate (when it becomes available), turns out to have grown exactly in line with the indicator, then each period will need to be revised down $^{3}/_{4}$% to correct for the fact that the expected bias did not actually occur. Simply put: this is all about revisions. If compilers add growth to the extrapolated part of the series, they will need to revise the series at a later time if the original indicator turned out to be a good estimate for the growth in the annual series (i.e. no additional growth was needed). Box 5 provides a walk-through scenario of how compliers should approach the issue of BI bias adjustment.

2. *The Cholette-Dagum Method*

The second method which the IMF recommend for benchmarking, and which again is used widely around the world, is that attributed to Cholette and Dagum (1994).

The Cholette-Dagum (CD) method is based on a generalized least-squares regression model. The model considers (i) the presence of bias in the indicator, and (ii) the presence of autocorrelation and heteroscedasticity of errors in the original data. This makes the Cholette-Dagum method very general, and in fact the Denton method can be considered as a particular (approximated) case of the Cholette-Dagum model.

In fact, the quarterization of the series described above is generally very similar whether undertaken using the Denton or the CD method. The key difference, and the main benefit, of the CD method is that it can be used to improve the basis on which the extrapolation aspect takes place. As noted above, in Denton's method, an explicit estimate of the BI bias is needed in order to benchmark a series. If the bias is deemed to be zero, then, using Denton's method on the forward part of the series (i.e. for all periods after the period for which the benchmark series is available) the extrapolation is simply based on the growth of the indictor. The CD method uses an autoregressive model to estimate the extent of any bias in the indicator and *automatically* correct for this. There is no need to make a prediction of this bias. Of course, it is not guaranteed that this automatic adjustment will turn out to be the correct one needed once the actual annual series is known, but, in simulations, on average, the CD method leads to lower revisions than the Denton's Basic Method.

So which method is best? The IMF's preferred method is to use Denton's Enhanced Method, and make a bias adjustment based on observation of the actual data over a period. However, in the 2017 update of the their QNA manual, they also suggest that the Cholette-Dagum method be considered as an alternative to obtain bias-adjusted extrapolations of QGDP series based on its historical relationship with the indicator.

In some ways Denton's Basic Method (i.e. with no BI bias adjustment) is the simplest to explain to users, and for that reason is often preferred by NSIs. Ultimately, each NSI must make its own decision about which method to use. However, it is advisable that, within any particular NSI, there is an agreed policy on which method should be used in the context of national accounts, and that this method is used consistently.

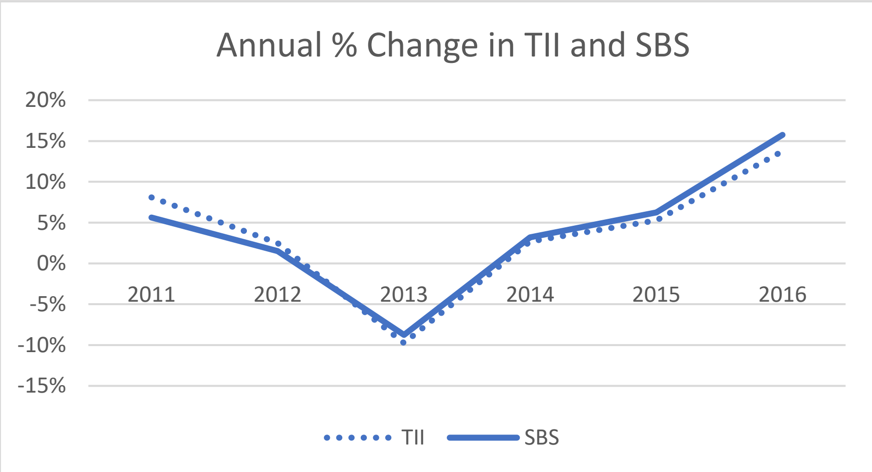
Box 5: Use of the BI Adjustment: a walk-through example and a cautionary tale

Consider a possible scenario:

A compiler compares the growth rates in the TII for ISIC 1312 'Weaving of textiles', as estimated directly from survey data and before being benchmarked, with the growth in the equivalent series from the annual SBS inquiry over the years 2010-2016. This is what they observe:

Based on data for ISIC 1312 'Weaving of textiles'							
	2010	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*
TII	370	400	410	370	380	400	455
SBS	373	394	400	365	376	400	463
	Annual % change						
		2011	*2012*	*2013*	*2014*	*2015*	*2016*
TII		8%	2%	-10%	3%	5%	14%
SBS		6%	1%	-9%	3%	6%	16%
	Difference	2.5%	1.0%	-1.0%	-0.5%	-1.0%	-2.0%

A plot of the growth rates of the two series shows:



The complier observes that, over this period in each of the four years 2013-2016, the SBS grew a little faster than the equivalent TII series. On average over this period, in fact, the TII grew 1.1% slower than the SBS. In January 2017, the compiler has data for the TII indicator, but not yet for the SBS survey for the whole of 2017 (of course). For simplicity we'll assume this becomes available in January 2018. But in January the compiler publishes a benchmarked series for the TII so that each year, 2010-16, is identical to the SBS series (this is the 'quarterization' aspect of benchmarking discussed above). But, the complier thinks the estimate for January 2017 (and subsequent months of 2017) will be too low, because of the seeming bias observed in the earlier years. The complier therefore decides to use Denton's Enhanced Method to add to the growth of the indicator in each of the months in 2017, in such a way that by December 2017, 1.1% has been added to the whole series (in practice to do this, it is necessary to multiply each month's STS month to month growth figure by $(1.011)^{1/12}$). By the end of the year, in December 2017, the complier has produced the following:

Levels series	***2010***	***2011***	***2012***	***2013***	***2014***	***2015***	***2016***	***2017***
TII original series	370	400	410	370	380	400	455	470
Benchmarked TII series *before* SBS 2017 is available	373	394	400	365	376	400	463	483
SBS	373	394	400	365	376	400	463	
Annual % Changes		*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*
TII original series		8.1%	2.5%	-9.8%	2.7%	5.3%	13.8%	3.3%
Benchmarked TII series *before* SBS 2017 is available		5.6%	1.5%	-8.8%	3.2%	6.3%	15.8%	4.4%
SBS		5.6%	1.5%	-8.8%	3.2%	6.3%	15.8%	

Notice that:

- i) the benchmarked TII series is the same as the SBS in all years from 2010-16;
- ii) the published TII series in 2017 is '483', which is the observed figure of '470' from the original TII series plus 1.1% for the bias;
- iii) the annual growth rate in 2017 for the benchmarked series is 1.1 percentage points greater (at 4.4%) compared to the observed growth of 3.3% in the original TII series.

What happens when the actual SBS series becomes available in January 2018? If the compiler is lucky, in that the estimated bias of 1.1% turns out to be correct, then there will be no revisions needed to the benchmarked series. However, let us assume that the actual SBS figure is '475' for 2017, implying a 2.6% growth between 2016 and 2017. When the complier updates the benchmarked series (by 'quarterizing' the whole series including 2017), the revised figures will look like this:

Levels series	***2010***	***2011***	***2012***	***2013***	***2014***	***2015***	***2016***	***2017***
TII original series	370	400	410	370	380	400	455	470
Benchmarked TII series *after* SBS 2017 is available	373	394	400	365	376	400	463	475
SBS	373	394	400	365	376	400	463	475
Annual % Changes		*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*
TII original series		8.1%	2.5%	-9.8%	2.7%	5.3%	13.8%	3.3%
Benchmarked TII series *after* SBS 2017 is available		5.6%	1.5%	-8.8%	3.2%	6.3%	15.8%	2.6%
SBS		5.6%	1.5%	-8.8%	3.2%	6.3%	15.8%	2.6%

The implication is that the annual growth in 2017 of 4.4% published in December 2017 must be revised to 2.6%, a revision of -1.8 percentage points. In fact, in each month the previously published benchmarked TII series will need to be adjusted a little (by approximately 1/12th of the 1.8 percentage points) to keep the revised benchmarked series in line with the now known annual SBS series.

The lesson here is that the use of the BI adjustment in this way *may lead to more revisions* than just using Denton's Basic Method (i.e. without the BI adjustment). Only where there is a clear and stable bias in the growth of the indictor compared to the annual benchmark series should the BI adjustment be considered. Even then, it is better to try and identify the source of the bias, i.e. the reasons it is occurring, and try to resolve these, for example by making improvements to the STS survey methodology.

Chapter Summary:

In this chapter we learned:

- Benchmarking is an operation for reconciling high and low frequency time series which estimate the same concept.

- Benchmarking consists of two processes
    - 'quarterization' which ensures that the benchmarked series reflects as closely as possible the period to period movements of the indicator, while also ensuring that the aggregate annual benchmarked series is consistent with the original annual series.
    - 'extrapolation' which generates the series after the last period for which annual data are available at the time of benchmarking, based on the movements in the indicator series.

- There are two main methods which can be used: Denton's method (and its enhancement) and the Cholette-Dagum method.

Chapter V: Step-by-step guide to the use of STTIs for estimation of QGDP

In this final chapter we present a step-by-step guide to using turnover indicators, together with relevant price indicators, to estimate components of QGDP. The method presented here is referred to as the 'single indicator' approach, which is the simplest of the available methods advocated in the IMF's 2017 *Quarterly National Accounts Manual* (see IMF, 2017, Chapter 3, paragraphs 36-41 for a summary of the rationale for this method). The manual notes that the ideal method of deriving value added in volume terms, known as 'double deflation', is to derive value added at current prices (as the difference between output in volume terms and intermediate consumption in volume terms) so that the current values of output and intermediate consumption are each deflated by appropriate price indices. However, as noted in the manual,

> '…the [double deflation] method, while conceptually sound, requires a large amount of data that may not be available on a quarterly basis and in a timely manner. Double deflation may also be prone to measurement errors of both output and intermediate consumption'. As a result, compilers may opt to use a 'single indicator' method. One widely used method is to extrapolate value added based on the volume index of output.'

That is the method considered in this chapter.

As noted, the single indicator method is most used when very limited or no data on intermediate inputs are available, which is often the case for quarterly series. The method assumes a fixed relationship between output and value added. This makes it most applicable to constant prices (i.e. volume) measures of quarterly GDP, where it amounts to assuming that the production process has not been subject to significant technology change since the last time the relationship between outputs and inputs was measured, i.e. the last benchmark period. As noted in the IMF manual, 'The impact of technological change may not be significant in the short term and can be handled through the benchmarking process if such change happens gradually over a longer period.'

It is important to note though that the single indicator method is essentially generic, and can be used with any current price short-term turnover indicators and associated price indices, and is not limited the specific industry and retail indictors considered in this report. For example, many countries use surveys of turnover, or equivalent data from the tax system, to measure the activity of many service sector activities. Broadly, the methods considered here can be applied to turnover data and prices for ISIC sections B, C, H, I, J, L, M, N, Q, S, and T. In practice, the data used to compile quarterly estimates of GDP vary considerably between countries. A range of possible sources for both estimating QGDP in current price values and in volume terms (i.e. in constant prices). is presented in Appendix 1.

Based on the single indicator method, we will consider two distinct situations:

1. **Annual base year estimates only**. In this case there exists an annual estimate of the level of GDP by economic activity in a single 'base' year. This may be based on an SUT, as described in Chapter III. But there are no regular annual estimates of GDP. This is the case discussed earlier where the annual estimates are simply the sum of the quarterly estimates.

2. **Annual base year and regular annual estimates**. Here, there exist separate annual estimates of GDP each year based on a more comprehensive source, as well as a 'base' year estimate. The base year may again be taken from an SUT. The annual estimates may use more comprehensive data than are available for the quarterly estimation, for example from a Structural Business Survey, or from Annual Income Tax records etc.

The methods needed to use STTIs in each of these situations are described in turn below.

Note: In all cases, the 'indicators' referred to are the quarterly indicators of the IIP, TTI or TIRT as appropriate. These are derived from the equivalent monthly series by either summing the value of the indicators over the three months in each quarter (if the indicators are expressed in currency units), or taking the mean of the indictor in each quarter for series expressed in index form.

1. *The case of annual base year estimates only*

We consider sub-cases of *current price* estimation and *constant price* estimation separately.

1.1 Current Price QGDP, with annual base year estimates only

There are 2 steps:

Step 1: Extrapolate the base year level of GVA for the relevant economic activity using a current price indicator, e.g. the current price version of the IIP, or of the TII, if no IIP is produced. This procedure should be applied to each of the elementary level series, e.g. ISIC class level.

Algebraically we have:

$$G^t_{CP,i} = G^b_{CP,i} \frac{I^t_i}{\sum_{\tau \in b} I^\tau_i}$$

where $G^t_{CP,i}$ is the estimated current price GVA for industry *i* at time *t*, and,

I^t_i is the value of the current price indicator at time *t*. and,

$\sum_{\tau \in b}$ indicates summation over all periods in the base year, *b*.

Note the 'indicator' here can be a series expressed either in index form (i.e. set equal to 100 in the base year) or in currency units. See Box 8 for details on this point.

[**Optional Step: Seasonal Adjustment:** although not covered in this report, if seasonally adjusted series are complied, in most situations, this step should be undertaken after extrapolation but before aggregation. Box 9 provides an explanation on this point.]

Step 2: Aggregate the extrapolated series from step 1 by simply adding them together. For example, if the elementary level of the series is ISIC Classes (4-digit), then to produce the quarterly series for ISIC Group 221 ('Manufacture of rubber products') the two Classes within this group (2211 and 2229) are just added together.

Algebraically:

$$G^t_{CP,k} = \sum_{i \in k} G^t_{CP,i}$$

where $G^t_{CP,k}$ is the current price series for domain *k*, and

summation takes place across the domain of interest, e.g. all ISIC Classes (*i*) within a Group, *k*.

Box 6 Extrapolation

As described earlier in this report, the elementary STTIs are designed to measure the *change* in output (in current prices for the TII, and in volume terms for the IIP) or the *change* in retail sales (in both current prices and volume terms for the TIRT and its volume equivalent).

In fact, the STTIs can be presented in index form, i.e. as time series which take the value 100 in a period known as the **reference** period, which may be a month, although is more usually an *average value* of 100 over a year. Alternatively, they may be expressed in monetary units (for example in local currency or US dollars). Either way, they should only be considered as 'indicators of change' measured from the specified base level. Ideally, this base level itself is established from a benchmark survey or a SUT, as described above.

In the context of estimating QGDP, the process of extrapolation for a particular economic activity (say, industry *i*), involves taking the level of GVA in the base year (referred to in what follows as time = *b*). and multiplying this by the ratio of the indicator in each period (time *t*) to the sum of the values of the indicator in the base period (*b*). Mathematically, this can be expressed as:

$$G_i^t = G_i^b \frac{I_i^t}{\sum_{\tau \in b} I_i^\tau} \qquad \ldots(21)$$

where G_i^t is the estimated GVA for industry *i* at time *t*, and,

I_i^t is the value of the indicator at time *t*. and,

$\sum_{\tau \in b}$ indicates summation over all periods in the base year, *b*.

If the indicator in this formula is in current prices, e.g. a current price version of the IIP for activity *i*, then the resulting estimate of GVA will be in current prices. On the other hand, if the indicator in this formula is in constant prices (where *b* is the base year for those prices), or is a 'pure' volume indicator (e.g. the number of kilowatt hours of electricity production for ISIC group '351'), then the resulting estimate of GVA will be in constant prices relating year *b*.

A critical point to understand with the extrapolation procedure is that the actual *level* of the STTI series is not relevant at all, only how it has *changed* over a period. This is because the ratio $\frac{I_i^t}{\sum_{\tau \in b} I_i^\tau}$ in formula (21) is 'unitless' (i.e. it had no units, like $s or KGs or whatever) – it is simply a factor, like 1.05 (meaning a 5 per cent increase) or 0.97 (meaning a 3 per cent decline).

The extrapolation procedure in formula (21) is used to estimate GVA for each detailed economic activity, so it is important that base year estimates of GVA, i.e. the G_i^b, are available at required level of detail. This will generally be the case since, as noted previously, typically estimates of QGDP will be complied at a less detailed level compared to the annual series. So, for example, if QGDP is compiled at the 2-digit (Division) level of the ISIC, then the base year estimates of GVA must be available for this level or lower levels, i.e. the 3-digit (Group) or 4-digit (Class).

Exercise 5.1: *based on the following data for ISIC 268 'Manufacture of magnetic and optical media'*

ISIC 268 'Manufacture of magnetic and optical media'					
		IIP volume measure			GVA
2014	Q1	50		2014	136
	Q2	70			
	Q3	30			
	Q4	20			
2015	Q1	60			
	Q2	65			
	Q3	35			
	Q4	25			
2016	Q1	75			
	Q2	90			
	Q3	45			
	Q4	35			
2017	Q1	80			
	Q2	85			

Note, in this example, 2014 is taken as the 'base year', and the value of GVA in 2014 is presumed to be taken from an SUT or an Establishment Survey.

Calculate an extrapolated series for the estimate of GVA in each quarter from 2014 Q1 – 2017 Q2.

Box 7 Seasonal Adjustment: at which step should it be undertaken?

The SNA 2008 and the international manuals on the estimation of QGDP recommend that seasonally adjusted and calendar adjusted estimates should be produced. This topic is not covered in detail in this report. However, one subtle but important point to note here is that, in terms of the methodology for using STTIs to estimate QGDP, seasonal adjustment is included as *step 2*, i.e. it comes *after* extrapolation (and/or benchmarking) of the detailed STTI series, and *before* aggregation. This is to ensure consistency between seasonally adjusted (SA) estimates and non-seasonally adjusted (NSA) estimates (sometimes called 'original' or 'gross', or even 'raw', estimates).

If seasonal adjustment was undertaken before benchmarking, and then the SA and NSA series where benchmarked separately, the integrity of the seasonal adjustment would be lost: i.e. it would not be possible to take a NSA series produced in this way and seasonally adjust it to produce the published SA series. Put another way, the order in which these operations are carried out affects the result, i.e. if B( ) is the operation of benchmarking and S( ) is the operation of seasonal adjustment, and *I* is an NSA time series, then we have:

$$S(B(I)) \neq B(S(I))$$

i.e. seasonal adjustment and benchmarking do not commute mathematically, and the order in which they are undertaken matters.

1.2 Constant Price QGDP, with annual base year estimates only

There are 2 steps:

Step 1: Extrapolate

This involves the following sub-steps

1.1 First extrapolate the **current price** level of GVA for the relevant economic activity using the equivalent current price indicator from the base year level. The procedure is identical to step 1 for the current price series above. For example, if estimating the constant price series for ISIC 2219 (Manufacture of other rubber products) extrapolate the current price GVA series for ISIC 2219 (from an SUT, for example), using the equivalent IIP, or the TII, if no IIP is produced. This procedure should be applied to each of the most elementary level series, e.g. ISIC class level. See Box 8 for details.

As before, algebraically we have:

$$G_{CP,i}^{t} = G_{CP,i}^{b} \frac{I_i^t}{\sum_{\tau \in b} I_i^{\tau}} \qquad \ldots(22)$$

where $G_{CP,i}^{t}$ is the estimated current price GVA for industry *i* at time *t*, and,

$G_{CP,i}^{b}$ is the base year current price GVA for industry *i* at time *t*, taken from the SUT, and,

I_i^t is the value of the current price indicator at time *t*. and,

$\sum_{\tau \in b}$ indicates summation over all periods in the base year, *b*.

1.2 Re-reference the relevant **quarterly price index** so that required base year is equal to 100 on average. This may be the Producer Price Index for the IIP or the Consumer Price Index in the case of the TIRT. For example, for the PPI, this is achieved by dividing each value of the PPI by the mean average of the PPI in the base year and multiplying by 100.

Algebraically:

$$\widehat{P}_i^t = \frac{P_i^t}{\sum_{\tau \in b} P_i^\tau / 4} \times 100 = \frac{P_i^t}{\sum_{\tau \in b} P_i^\tau} \times 400 \qquad \ldots(23)$$

where $\widehat{P}_i^t$ is the price indicator for activity *i* at time *t*, rescaled so that the relevant base period equals 100 on average and,
P_i^t is the original value of price indicator for activity *i* at time *t*. and,
$\sum_{\tau \in b}$ indicates summation over all periods in the base year, *b*

Note: this step is needed to ensure the price index uses a consistent reference period to that required for the constant price GVA series. ***The step is only needed if the 'original' price index has a different base to the GVA series,*** *for example if the PPI section are using 2012=100 and we need GVA based on 2014 prices.*

1.3 Create a constant price **indicator** series by deflating the quarterly current prices series from step 1.1 by the price deflator from step 1.2, and multiplying by 100.

Algebraically:

$$\widehat{G}_{KP,i}^t = \frac{G_{CP,i}^t}{\widehat{P}_i^t} \times 100 \qquad \ldots(24)$$

where $\widehat{G}_{KP,i}^t$ is a constant price indicator of GVA for activity *i* at time *t*, and,
$G_{CP,i}^t$ is the value of the current price GVA series for activity *i* at time *t* from step 1.2 above. and,
$\widehat{P}_i^t$ is the price indicator for activity *i* at time *t*, rescaled so that the relevant base period equals 100 on average, from step 1.2 above.

Important note: it is key to note at this stage that the series created in this step is **not** the final constant price series that we need. This is because the sum of this series in the base period will not be equal to the current price total in the same base period. This is a critical point: in the base year the sum of the constant prices series *must* equal the sum of the current price series. With annual series this is guaranteed, since the deflator in the base year would have been set equal to 100 in the base year in step 1.2, and (in the base year) this step would involve simply dividing the current price series by 100 and then multiplying the result by 100 to give back the same current price value. However, for quarterly series, because we have a deflator which is *different in each quarter of the base year* (and only averages 100 – i.e. it is not equal to 100 in each quarter), it will not generally be the case that the sum of the deflated series in the base year from step 1.3 will be equal to the sum of the current price series in the base year. An additional step is therefore needed to *scale* the constant price indicator from this step to ensure that the series does in fact sum to the same value as the current price series in the base year.

1.4 Create the constant price series by scaling the series from step 1.3 so that the total in the base year is equal to the current price value in the base year. This is undertaken by multiplying each value of the series from step 1.3 by the ratio of the current price value of the series in the whole of the base year to the sum of the four quarters of the series from step 1.3 in the base year.

Algebraically:

$$G_{KP,i}^{t} = \widehat{G}_{KP,i}^{t} \frac{G_{CP,i}^{b}}{\sum_{\tau \in b} \widehat{G}_{KP,i}^{\tau}} \qquad \text{…(25)}$$

where $G_{KP,i}^{t}$ is a final constant price series of GVA for activity *i* at time *t*, and,

$\widehat{G}_{kP,i}^{t}$ is the constant GVA indicator for activity *i* at time *t* from step 1.3, and

$G_{CP,i}^{b} = \sum_{\tau \in b} G_{CP,i}^{\tau}$ is the base year current price GVA for activity *i* at time *t*, taken from the SUT, and,

$\sum_{\tau \in b}$ indicates summation over all periods in the base year, *b*.

See Exercise 5.2 as an example of the application of these steps.

[**Optional Step: Seasonal Adjustment:** as before, if seasonally adjusted series are complied, this step should be undertaken after the extrapolation but before aggregation.]

Step 2: Aggregate:

To produce aggregate series based on the elementary constant price series from step 1.4, simply add the series together. For example, if the elementary level of the series is ISIC Classes (4-digit), then to produce the quarterly series for ISIC Group 221 (Manufacture of rubber products) the two Classes within this Group (2211 and 2229) are just added together.

Algebraically:

$$G^t_{KP,k} = \sum_{i \in k} \widehat{G}^t_{KP,i} \qquad \ldots(26)$$

where $G^t_{KP,k}$ is the constant price series for domain *k*, and summation takes place across the domain of interest, e.g. all ISIC Classes (*i*) within a Group, *k*.

Note: the fact that the aggregate constant price series for any level of ISIC is simply the sum of all lower level constant prices series within the same ISIC heading, implying that the constant prices series is actually of the Laspeyres form. Annex 2 explains why this is the case, and expands on the relationship between Laspeyres-type and Paache-type series. Annex 3 explains further how to *explicitly* calculate the value of the annual *implicit* price deflator.

Exercise 5.2

This uses the data from Exercise 2.1 for the 'Olive Canning Company'.

In that exercise you were asked to calculate a 2014 constant price series for the total production of tins of olives. Data on the actual quantity of tins produced and their prices were provided. In practice, it is rare that such information will be available. Instead, we normally have, for an economic activity, some measure of the value of production and some associated price indices. To convert the data from Exercise 2.1 into the 'ingredients' we need for this exercise, we first need to calculate a value index, I_i^t*, and a price index,* P_i^t*, for both 'whole' and 'pitted' olives.*

Hints: i) for the value index, for whole and pitted olives separately, multiply the quantities by the prices in each period, and then scale the resulting value series into index form by dividing the series by the average in 2014, and multiplying by 100, ii) for the price index, just divide each price series by its average in 2014 , and multiplying by 100.

Once you have these index series, calculate the series for 2014 constant price of total olive production, and verify that this is the same as in Exercise 2.1.

You should treat the actual value of production in 2014 as the value added series in step 1.1, and note also that the price index you have created is already referenced to 2014, so there is no need to re-reference as in step 2.2

We now turn to the second case,

2 The case of annual base year and regular annual estimates

In this case, remember, there exist separate annual estimates of GDP each year from a more comprehensive source, as well as a 'base' year estimate. These annual estimates are assumed to be based on more comprehensive data than are available for the quarterly estimation, for example from a Structural Business Survey, or from Annual Income Tax records etc.

Again, we consider the case of current price estimation and constant price estimation separately.

2.1 Current Price QGDP, with annual base year and regular annual estimates

Step 1: Benchmarking/Extrapolate

Again, the first step is to extrapolate the elementary level series (e.g. the ISIC Classes). However, unlike the case where we only had a base year level of GVA where we simply multiplied the base year value by the growth in the elementary current price series, in this case, where in each year we have a separate annual current price level, we need to ensure consistency between these annual levels, which are considered to be based on better quality data than the quarterly series, and the quarterly series itself. Chapter IV provided a procedure for achieving this: i.e. benchmarking.

Earlier we defined $G^t_{CP,i}$ as the estimated current price GVA for activity *i* at time *t*,

$$G^t_{CP,i} = G^b_{CP,i} \frac{I^t_i}{\sum_{\tau \in b} I^\tau_i}$$

where $G^b_{CP,i}$ was the base year current price GVA for activity *i* at time *t*, and,

I^t_i was an *indicator* of current price GVA at time *t*. and,

$\sum_{\tau \in b}$ indicated summation over all periods in the base year, *b*.

In this case, we must also ensure that the extrapolated series is equal to the annual series in each year, not just in the base year.

To proceed, we can define the operation of benchmarking any quarterly series benchmarked to an annual series as follows:

$$\mathbf{Q} = \mathrm{B}(\mathbf{I}, \mathbf{A}) \qquad \ldots(27)$$

where $\mathbf{Q}$ is the benchmarked quarterly time series vector,

$\mathbf{I}$ is an indicator time series vector,

$\mathbf{A}$ is a vector of the definitive annual series, and

$\mathrm{B}(,)$ is the operation of benchmarking described in Chapter IV (of either the Denton or Cholette-Dagum variety).

Note: the indicator variable I^t_i, will be the current price IIP, or the TII (if an IIP is not available), or the TIRT depending on the domain of interest.

In the case of the current price GVA series, we have:

$$G^t_{CP,i} = \mathrm{B}\left(I^t_i, \mathbf{G}^A_{CP,i}\right) \qquad \ldots(28)$$

where $G^t_{CP,i}$ as the estimated current price GVA for activity *i* at time *t*,

I^t_i is the *indicator* of current price GVA for activity at time *t. for example it may be the IIP expressed in current prices*, and,

$\mathbf{G}^A_{CP,i}$ is a vector of the current price GVA for activity *i* based on the annual series.

Note that, as a result of this benchmarking procedure:

i) In each year, *Y*, for which an annual estimate of GVA is available:

$$\sum_{t \in Y} G^t_{CP,i} = G^Y_{CP,i}$$

where $G^Y_{CP,i}$ is the element of the annual GVA vector for year *Y*.

ii) The quarterly series for current price GVA will follow *as closely as possible* (as defined in Chapter IV) the period to period growth rates of the indicator variable I^t_i

[**Optional Step: Seasonal Adjustment:** as before, if seasonally adjusted series are complied, this step should be undertaken after the extrapolation but before aggregation.]

Step 2: Aggregation

Once the benchmarked series has been created for each of the elementary series (e.g. ISIC Classes), the procedure to aggregate is simple addition.
Algebraically:

$$G^t_{CP,k} = \sum_{i \in k} G^t_{CP,i} \qquad \ldots(29)$$

where $G^t_{CP,k}$ is the current price series for domain *k*, and summation takes place across the domain of interest, e.g. all ISIC Classes (*i*) within a Group, *k*.

See Exercise 5.3 which demonstrates these steps.

Exercise 5.3

This demonstrates the basis of calculation for the benchmarked elementary current price series in the case where there exists separate annual estimates of current price GVA, in addition to a base year estimate.

Given the following current price data for turnover

	ISIC	1311	1312	1313
		Preparation and spinning of textile fibres	Weaving of textiles	Finishing of textiles
2014	Q1	40	90	90
	Q2	45	75	55
	Q3	30	70	75
	Q4	25	95	70
2015	Q1	30	100	100
	Q2	50	90	60
	Q3	35	95	80
	Q4	45	115	80
2016	Q1	35	120	60
	Q2	55	100	80
	Q3	45	105	80
	Q4	55	130	100
2017	Q1	40	135	60
	Q2	60	115	40

...and annual levels of current price GVA in years 2014-2016

	Preparation and spinning of textile fibres	**Weaving of textiles**	**Finishing of textiles**
2014	170	360	250
2015	200	430	275
2016	225	470	265

- ***i)*** ***Use the 'bench' function to create a benchmarked current price series for all quarters. Use Denton's basic method.***
- ***ii)*** ***Repeat i), but using the Cholette-Dagum procedure.***
- ***iii)*** ***Calculate the aggregate constant 2014 prices series.***

2.2 <u>Constant Price</u> QGDP, with annual base year and regular annual estimates

Step 1: Benchmarking/Extrapolate

As with the case where there were no annual estimates, and just a base year, estimation of the constant price series is more complex than for current prices. Here, we must undertake the following sub-steps:

1.1 Calculate the benchmarked current price series as in step 2.1 for the current price series, above.

1.2 Aggregate this current price series in each year to create an annual current price series (simply adding the series within each year)

1.3 Make sure the price index to be used has been referenced so that for the required base year it is equal to 100. If necessary, to do this divide the index by the mean of the index in the base year.

1.4 Calculate and aggregate the price index in each year by taking the mean value of the index from step 1.3 in each year.

1.5 Deflate the series from step 1.2 by the annual price index form 1.4 to give and annual KP indicator.

1.6 Deflate the quarterly current price series from step 1.1 by the quarterly price index from step 1.3 to create quarterly constant price indicator.

1.7 Benchmark the quarterly constant price series from step 1.6 to the annual constant price series from step 1.5 to create the final quarterly constant price series.

[Optional Step: Seasonal Adjustment: as before, if seasonally adjusted series are complied, this step should be undertaken after the extrapolation but before aggregation.]

Step 2: Aggregation

Once the benchmarked constant price series has been created for each of the elementary series (e.g. ISIC Classes), the procedure to aggregate is simple addition.

Algebraically:

$$G^t_{KP,k} = \sum_{i \in k} \widehat{G}^t_{KP,i} \qquad \ldots(30)$$

where $G^t_{KP,k}$ is the constant price series for domain *k*, and summation takes place across the domain of interest, e.g. all ISIC Classes (*i*) within a Group, *k*.

Remember, this is equivalent to Laspeyres aggregation using base period weights.

See Exercise 5.4 which demonstrates these steps.

Exercise 5.4

This demonstrates the basis of calculation for the benchmarked elementary constant price series in the case where there exists ~~a~~ separate annual estimates of constant price GVA, in addition to a base year estimate.

Start from the result of Exercise 5.3.

In addition, we have the following price indices, with 2016=100

		Preparation and spinning of textile fibres	Weaving of textiles	Finishing of textiles
2014	Q1	80	90	75
	Q2	80	90	75
	Q3	85	90	80
	Q4	85	85	80
2015	Q1	85	85	80
	Q2	85	85	80
	Q3	90	90	85
	Q4	95	85	85
2016	Q1	95	95	85
	Q2	100	95	95
	Q3	100	105	110
	Q4	105	105	110
2017	Q1	115	105	115
-	Q2	120	110	115

Calculate:

- ***i)*** ***The annual current price series in each year 2014-16 (in this case this will be the same as the annual GVA from Exercise 5.3).***
- ***ii)*** ***The re-referenced price indices, with 2014=100***
- ***iii)*** ***The annual (mean) average price index for each series for 2014-16***
- ***iv)*** ***The deflated annual series for each year 2014-16***
- ***v)*** ***The deflated quarterly series for all quarters***
- ***vi)*** ***The benchmarked quarterly series***
  - ***a. Use the Basic Denton method***
  - ***b. Using the Cholette-Dagum method***
- ***vii)*** ***Verify that the annual total in each year is the same as the deflated annual series from iv)***
- ***viii)*** ***Calculate the aggregate series for ISIC Group 131 in current and constant prices***
- ***ix)*** ***Calculate the implied price deflator (IPD) for ISIC Group 131***
- ***x)*** ***Verify that the harmonic average of the IPD in 2014=100 exactly (use as weights the values from the benchmarked current price quarterly series (see Annex 2 for details)***

Further practice in the use of the methods set out in this chapter are provided in the following exercises.

Exercise 5.5

This demonstrates the case of a single base year estimate of Gross value Added in constant prices, and how this can be used, together with monthly turnover data, and producer prices, to create volume measure of GVA.

Given the following information:

	Base year	**2015**					
	Base Year GVA	100	150	70			
	Sales Turnover based on short term survey (000s US $s)				**Producer Price indexes, 2016 Q1 =100**		
	ISIC	1311	1312	1313	1311	1312	1313
		Preparation and spinning of textile fibres	Weaving of textiles	Finishing of textiles	Preparation and spinning of textile fibres	Weaving of textiles	Finishing of textiles
2015	Jan	10	30	25	85	85	95
	Feb	15	30	35	85	85	95
	Mar	5	40	40	85	85	95
	Apr	20	25	15	85	85	95
	May	20	15	20	85	85	95
	Jun	10	50	25	85	85	95
	Jul	5	20	20	90	90	95
	Aug	15	45	20	90	90	95
	Sep	15	30	40	90	90	95
	Oct	10	35	15	95	85	95
	Nov	15	30	25	95	85	95
	Dec	20	50	40	95	95	100
2016	Jan	5	60	15	95	95	100
	Feb	15	35	20	100	100	100
	Mar	15	25	25	105	105	100

Calculate:

i) Quarterly indexes of turnover for each activity
ii) Quarterly PPI indexes for each activity, with 2015 = 100
iii) Deflated turnover indexes with 2015=100 (hint, remember to scale the series so that 2015=100)
iv) Constant 2015 price GVA series, including the total for ISIC Group 131
v) Current price GVA series, including the total for ISIC Group 131
vi) The IPD for the total ISIC Group 131
vii) Verify that this IPD for the total is a harmonic mean of the Price indexes from step 2, with weights taken from the current price GVA in step 5

Exercise 5.6

This demonstrates the case of a annual estimate of Gross value Added in constant prices, and how these can be used, together with a quarterly index of production volumes to create quarterly volumes measure of GVA.

Given the following information:

	Index of Industrial Production, 2016=100				
	ISIC	B	C	D	E
		Mining & Quarrying	Manufact-uring	Electricity & Gas	Water Supply
2016	Q1	105	98	99	105
	Q2	95	99	99	100
	Q3	100	101	99	98
	Q4	100	102	103	97
2017	Q1	105	102	103	96
	Q2	106	104	103	95
	Q3	109	107	105	95
	Q4	110	112	111	95
2018	Q1	112	115	120	98
	Q2	109	110	106	100
	Annual GVA, in 2016 prices				
	2016	50	250	20	20
	2017	60	260	15	25

Calculate:

i) ***A benchmarked series for GVA by activity in 2016 prices***
ii) ***Total GVA for ISICs B-E in 2016 prices***

Chapter Summary:

In this chapter we learned:

- The chapter has set out detailed steps needed to compile quarterly estimates of GVA in both current and constant prices.

- The method is different if we have an annual base year estimates only or if, additionally, we have regular annual estimates.

- Laspeyres indices are a natural basis for production volume (constant price) series.

- Laspeyres constant price series have the property that the sum of the detailed series is equal to the aggregate series, known as 'additivity'.

- If Laspeyres is used as the basis of aggregating elementary series into constant prices then, implicitly, the price deflators (i.e. the ratio for the current price series to the volume series) will be of Paasche-type. This arises because of what it known as Paasche-Laspeyres 'duality'

- If seasonally adjusted series are to be produced, the seasonal adjustment procedure should be undertaken on the elementary series after extrapolation/benchmarking has been undertaken, but before aggregation. In this way the aggregate seasonally adjusted series will be the sum of the (benchmarked) elementary series, i.e. 'additivity' will be maintained.

Conclusion

This report has set out the basis on which short term turnover indexes can be used to improve the quality of estimates of GDP, specifically in relation to the TII, IIP and TIRT. Notably these indicators provide a basis for estimating changes in gross value added, in both current prices and in volume terms. The timeliness of the data used for these indexes means that they can be used to speed up the availability of preliminary estimates of GDP each quarter.

The indicators must be used with care, however, since they contain numerous sources of bias, in particular those arising from the conceptual relationship between sales and gross value added. It is important therefore that annual estimates, or at least 'baseline' estimates, based on more comprehensive and conceptually relevant data sources are available. The STTIs can then be benchmarked to these annual estimates, and the report has set out in detail the procedure for undertaking this operation. In addition, a tool (in the form of an Excel macro) has been provided with this report which can be used for this procedure.

Key throughout the use of STTIs when estimation quarterly GDP is to monitor how well these indicators anticipate the estimates of growth in annual GDP based on the more complete annual sources. Any shortcoming in the suitability of the STIIs for this purpose (i.e. any biases) will lead to revisions to the quarterly estimates of GDP. It is important therefore that national accounts compliers are alert to the potential for bias in the STTIs, and take action when necessary to improve the quality of the indicators to address this concern.

Finally, the report contains numerous examples and exercises to illustrate the use of the STTIs in estimating quarterly GDP. To become fully conversant with the methods described, it is recommended that users attempt all of the exercises, which have been designed to test understanding of the concepts and methods described, as well as their practical application.

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Appendix 1: Typical Indicators used in estimation of QGDP

General:

It is important to remember that the objective of QGDP is to predict what is happening in the economy before more complete annual data become available. So the best indicators will be quarterly measures of the annual data. In this case, the sum of the quarterly series will be the annual estimate so the only revisions will be between preliminary and final data.

The main types of data/indicators include:

- Short-term surveys by economic activity
  - Industrial production
  - Sales/Turnover
  - Retail Trade
  - Labour force
- Prices/price indices
  - Consumer prices
  - Production prices
  - Agricultural prices
  - Export and import prices (or unit value indices)

Main administrative data sources

- Regulatory Data
  - Agriculture commodity prices, forestry permits, fish catch, etc.
  - Mining production, building permits, vehicle registration, tourist arrivals, etc.
- Customs Revenue and Tax Systems
- Formal sector exports and imports data – usually from Revenue Authorities
- VAT system data on turnover and inputs
- Excise, turnover and VAT taxes, import duties
- Social security/national insurance systems
  - Employment, weeks/hours worked, wages/salaries, contributions

Other sources

- Government
  - Budget data on revenues and expenditures
- Central Bank and other financial/insurance regulators
  - Financial intermediation and insurance companies
- Quantity information from large public/private corporations or business associations
  - Oil, electricity, water, communication, transportation

By Activity:

A - Agriculture

Crops: Annual crop estimates by region, crop calendar, farm-cost surveys, expert knowledge of farming practices. Ministry of Agriculture, marketing boards and exports data. Agriculture prices. It is better to get data per season by crop type for area cultivated, area harvested, harvested output, post-harvest loss, at least for the major crops. Need to develop the quarterly work-in-progress (WIP) ratios using crop calendars and input costs data.

Livestock: Detailed annual and quarterly output data, usually from output model. Farm-cost surveys, expert knowledge of livestock breeding patterns. Ministry of Agriculture, abattoirs, marketing boards and exports data. Agriculture prices. Census stock of animals, birth, death and slaughter rates along with imports of breeding animals and exports to develop a perpetual inventory model to generate quarterly output data.

Forestry: Log removal data, consumption trend data on charcoal and firewood, forestry growth models, data on timber plantations.

Fishing: Monthly fish catch data (values and quantities). Fish farm surveys.

B - Mining and Quarrying

Mining: Monthly/quarterly output data, cross-check with exports. Royalties data.

Quarrying: Monthly/quarterly output data, survey or VAT turnover and purchases. Index of Industrial Production (IIP), sometimes linked to construction.

C - Manufacturing:

Sample Surveys, or VAT turnover and purchases data, PPI (domestic and non-domestic market) and IIP.

D - Electricity:

Monthly/quarterly output data from main producer(s) in value and volume terms (KWH), IIP.

E - Water Supply and Sewerage:

Monthly/quarterly output data from main producer(s), IIP.

F - Construction:

Monthly/quarterly government and aid-funded expenditure on capital projects, monthly imports/local production of building materials, cement production. Building permits data where reliable, electricity connections, and building completion inspection certificates issued. Commodity flow approach for construction inputs. Expert knowledge of building costs.

G - Trade:

Retail sales surveys, VAT turnover and purchases data and PPI for formal sector. Indicators based on marketed output for non-taxed products like crops, livestock, forestry and fishing products. Commodity flow approach using domestic output and imports plus non-refundable taxes and percentage traded and trade margins at the product/product group level and various CPI, RPI and WPI price indices.

H - Transport and Storage:

Analysed by type of transport (passenger, freight etc.) and mode (air, water, road, rail, pipeline). Monthly/quarterly freight and public passenger vehicle registration data, cargo volumes by air/sea/land, air and water transport passenger numbers, airlines and shipping movements. Transport surveys/studies. Some extrapolation, seasonal holiday patterns, major products transported such as agriculture products, oil. Follow output patterns. VAT turnover and purchases data.

I - Accommodation and Food Service Activities:

VAT turnover and purchases data, SPPI. Tourism-cantered surveys, bed-nights, tourist arrivals, inter-household survey consumption trends, etc.

J - Information and Communication:

Regulatory data, VAT turnover and purchases data, CPI/SPPI. Monthly or quarterly volume indicators like airtime, call minutes, Internet hours. Inter-household survey consumption trends, etc.

K - Finance and Insurance Activities:

Regulatory data. Monthly data or quarterly surveys conducted by Central Bank or Statistics Offices. Insurance generally extrapolated, unless quarterly survey is affordable. Possible use of VAT turnover data.

L - Real Estate Activities

Inter-census and inter-household survey trend estimates by type of dwelling rented and owned, electricity connections, building completion certificates, survey of occupancy rates, also income from rents. VAT turnover on renting by formal sector operators and agent's commission/fees (mainly for commercial property).

M - Professional, Scientific and Technical Activities

Possible use of VAT turnover and purchases data, CPI. Value and volume indicators based on the quarterly current and constant price IC estimates of industries using these services.

N - Administrative and Support Service Activities

Possible use of VAT turnover and purchases data, CPI. Value and volume indicators based on the quarterly current and constant price IC estimates of industries using these services. Inter-household survey consumption trends. Tourist arrivals for tour operators.

O - Public Administration and Defence:

Usually monthly salary data to extrapolate GVA, ratios of IC to GVA to extrapolate IC, days open for business. Government employment data.

P - Education:

Same method for public education as used for public administration. Inter-household survey consumption trends. Student enrolments and teaching staff by level of education and sector, CPI school fees. Possible use of VAT turnover and purchases data for private schools. Need benchmark and ongoing data for NPISH and informal sector.

Q - Human Health and Social Work Activities:

Same method for public education as used for public administration. Inter-household survey consumption trends. Preferably by public/private sector for inpatients numbers or nights, outpatient visit numbers, CPI hospital services, CPI doctor and dentist fees. Possible use of VAT turnover and purchases data for private clinics/hospitals. Need benchmark and ongoing data for NPISH and informal sector.

R - Art, Entertainment and Recreation:

Inter-household survey consumption trends and tourist arrivals; visitors to national parks, museums etc. Possible use of VAT turnover and purchases data. Recreation CPI.

S - Other Service Activities:

Inter-household survey consumption trends. Possible use of VAT turnover and purchases data. Services CPI or Personal services CPI. Need benchmark and ongoing data for NPISH and informal sector.

T - Activities of Households as Employers:

Inter- household survey expenditure trends for domestic staff. Domestic services CPI.

Taxes less subsidies on products:

Government finance statistics on product taxes and subsidies, values and volumes of imports (preferably with breakdown by type of product), and values and volumes of goods and services produced/sold subject to tax/subsidy (preferably with breakdown of goods and services that closely correspond with type and rate of taxes).

Annex 2: **A note on 'Laspeyres aggregation' and Laspeyres Paasche 'duality'**

This annex considers the implications of the procedure set out in this report for producing aggregate constant pries series more closely to see what kind of aggregate series is created.

To recap the procedure, a current price series is deflated with a price index and then (after rescaling to ensure that the base year value of the resulting series is the same as for the current prices series) the series are simply added together to create aggregates. It can be shown that this procedure is identical to weighting together volume indicators using weights based on the base year current price values. That is, we have a 'Laspeyres quantity index', which is given by the formula

$$Q_L = \frac{\sum_i p_i^b q_i^t}{\sum_i p_i^b q_i^b}$$

where p_i^b is the price of the i^{th} good/service in period, *t*, and

q_i^t is the price of the i^{th} good/service in period, *t*

and *b* is the base period.

This can be re-written as follows:

$$Q_L = \frac{\sum_i p_i^b q_i^t}{\sum_i p_i^b q_i^b} = \frac{\sum_i \frac{q_i^t}{q_i^b} q_i^b p_i^b}{\sum_i p_i^b q_i^b} = \sum_i \frac{q_i^t}{q_i^b} \frac{q_i^b p_i^b}{\sum_i p_i^b q_i^b} = \sum_i \frac{q_i^t}{q_i^b} s_i^b$$

i.e.

$$Q_L = \sum_i \frac{q_i^t}{q_i^b} s_i^b \qquad \ldots(27)$$

where $s_i^b = \frac{p_i^b q_i^b}{\sum_i p_i^b q_i^b}$ is the base value share of sales of the i^{th} activity in the base year

In words we say that the Laspeyres volume index is a weighted arithmetic average of the volume relatives, where the weights used are the current price value shares in the base period.

The fact that the volume index has the Laspeyres form has implications for the aggregate price index which is constructed as the ratio of the current price series to the constant price series. Such a price index is known as an 'implied price deflator', or IPD. It is 'implied', because, generally speaking, it is not estimated directly. The current and constant price series are actually estimated directly, and the price series is then calculated simply by dividing the current price by the constant price series (because a price is the value divided by the quantity). This is an IPD. But what form of index is the IPD?

To answer this, first define $v_k^t = \sum_{i \in k} p_i^t q_i^t$ be the current price value series for domain *k* (say an ISIC Group), where p_i^t are the prices of the items in the domain, q_i^t and are the quantities, and summation takes place over all items in the domain.

The change in current prices compared to the base period (expressed as a ratio or an index) is given by:

$$\frac{v_k^t}{v_k^b} = \frac{\sum_{i\in k} p_i^t q_i^t}{\sum_{i\in k} p_i^b q_i^b} \qquad \ldots(1)$$

So that the ratio of the current price series to the Laspeyres volume series is given by:

$$\frac{v_k^t}{v_k^b}\Big/ Q_{L,k}^t = \frac{\dfrac{\sum_{i\in k} p_i^t q_i^t}{\sum_{i\in k} p_i^b q_i^b}}{\sum_{i\in k} \dfrac{q_i^t}{q_i^b} \dfrac{q_j^b p_j^b}{\sum_{j\in k} p_j^b q_j^b}} = \frac{\sum_{i\in k} p_i^t q_i^t}{\sum_{i\in k} \dfrac{q_i^t}{q_i^b} q_i^b p_i^b} = \frac{\sum_{i\in k} p_i^t q_i^t}{\sum_{i\in k} p_i^b q_i^t} = \frac{\sum_{i\in k} p_i^t q_i^t}{\sum_{i\in k} \dfrac{p_i^b}{p_i^t} p_i^t q_i^t} = \frac{1}{\sum_{i\in k} \dfrac{1}{\left(\dfrac{p_i^t}{p_i^b}\right)} \dfrac{p_i^t q_i^t}{\sum_{j\in k} p_j^t q_j^t}}$$

i.e.

$$\frac{v_k^t}{v_k^b}\Big/ Q_{L,k}^t = \frac{1}{\sum_{i\in k} \dfrac{1}{\left(\dfrac{p_i^t}{p_i^b}\right)} s_i^t} \qquad \ldots(2)$$

where $s_i^t = \dfrac{p_i^t q_i^t}{\sum_{i\in k} p_i^t q_i^t}$ s the current price value share at time *t*.

The right-hand side of this equation, i.e. $\dfrac{1}{\sum_{i\in k} \dfrac{1}{\left(\dfrac{p_i^t}{p_i^b}\right)} s_i^t}$ is a 'Paasche price index', P_P^t, which can be expressed in words as an harmonic mean of the price relatives, using current price weights for the current period, *t*.

In summary we have:

$$\frac{v_k^t}{v_k^b} = Q_{L,k}^t P_{P,k}^t \qquad \ldots(3)$$

i.e. the change in current prices can be expressed as the product of a Laspeyres *volume* index and Paasche *price* index. This provides a way to split out the price and volume effects from the measured change in current prices.

It so happens, that the reverse is also true, i.e.

$$\frac{v_k^t}{v_k^b} = Q_{P,k}^t P_{L,k}^t \qquad \ldots(3')$$

That is to say that the change in current prices can be expressed as the product of a Laspeyres *price* index and Paasche *volume* index.

Equations (3) and (3′) arise because of what is are known as 'Paasche Laspeyres Duality'.

What they mean is, if we wish to split the percentage change in current prices of any series into the amount which can be attributed to changes in prices and the amount attributable to changes in volumes, we can use either of the formula (3) or (3′). However, the first formulation, (3), using Laspeyres volumes and Paasche prices, is considered preferable for two reasons:

1. **The availability of the weights**: to construct a Laspeyres index we need only to know the current price values shares (the 'weights') in the base period. For a Paasche index we would need to be able to calculate weights in every period. Generally, information on the detailed GVA, for turnover etc. used to calculate the weights will not be available every period.

2. **The Laspeyres index has the property that it is 'additive'**, meaning that if we express the elementary indices which are being aggregated in currency terms as volume measures, then the aggregate Laspeyres index can be derived simply by adding together the components. Paasche indices, and in fact most other indices (Fisher, Walsh, Törnqvist etc.) are not additive in this sense. In the context of measuring constant price GVA, additivity is desirable because it means the total GVA for an economic activity (e.g. and ISIC Group) is the sum of the component activities (e.g. the ISIC Classes within the Group).

While some countries use other types of index to estimate changes in volume, for example the geometric mean of the Laspeyres and Paasche index, known as the 'Fisher index', or chained volume indices, most developing countries use the Laspeyres volume index. In 2016 the IMF's Statistics Department undertook a detailed analysis, comparing Laspeyres volume indices with chained-volume indices in the context of estimating GVA in sub-Saharan Africa (SSA). They concluded:

> *"There is a perception among national accounts compilers that implementation of chain linking provides superior estimates of volume measures of GDP under all conditions. However, this paper concludes that chain linking provides no substantial gains vis-à-vis the fixed-base approach in terms of providing accurate growth rates [in] SSA countries. Implementation of fixed-base [Laspeyres] approach at a detailed level (at least two-digit level of ISIC) using appropriate deflation techniques, and regular base year revisions yield more significant improvements in volume measures of GDP for SSA countries."*

See https://www.imf.org/external/pubs/ft/wp/2016/wp16133.pdf

In summary, the 'take-home' messages from this annex are:

- **The Laspeyres-type indices and Paasche-type index are closely related, and their product can be used to decompose (i.e. to 'split out') changes in current price GVA.**
- **The preferred basis for undertaking this decomposition is to i) estimate the change in current prices (the current price series can be calculated by simple addition) and ii) estimate the change in volume using the Laspeyres formulation.**
- **The change in prices can then be derived by dividing the value change by the volume change. This is the so-called Implied Price Deflator.**
- **Implied Price Deflators constructed in this way will be of the Paasche-type.**

Annex 3 Calculating the annual average implied deflator

An issue which compilers need to be aware of is the *form of the implied deflators*. As noted in Annex 2 of this report these are, implicitly, of Paache form if the volume series are of Laspeyres form (i.e. calculated using fixed base period weights). *But what is the average of the deflator in the reference period, or in fact in any year?*

For the reference period, we might expect this to be '100'. But what kind of average is needed? It turns out that, because the IPDs are of Paasche form (see Annex 2), taking an *arithmetic* mean of the index in the reference period, e.g. an average of four quarters, will **not** be equal to 100. The correct form of aggregation is to take the *harmonic mean* of the four quarters (which is the basis of Paasche indices), using the current price turnover series in each quarter as the basis of the weights.

As an example, using the data from exercise 2.1, we have the total production of olives in the base year (2014) is:

		Current price	Constant 2014 prices
2014	Q1	135.0	136.2
	Q2	135.0	136.2
	Q3	137.5	138.6
	Q4	142.0	138.6

Exercise

i) Calculate the IPD for total olive production.
Hint, just divide the current price series by the constant price series and multiply by 100.

ii) Calculate the arithmetic mean of the IPD in 2014. *What do you notice?*

iii) Calculate the harmonic mean IPD in 2014.

Hint: the formula for the harmonic mean is: $\dfrac{1}{\sum_{t \in Y} \frac{1}{P_t} w_t}$

where P_t is the IPD for time t (i.e. each quarter), and summation takes place over all four quarters of the year (Y), and w_t is the current price weight in each period t, calculated as $w_t = \dfrac{V_t}{\sum_{t \in Y} V_t}$, where V_t is the current price value at time t.

One other thing to note is that it is possible to also use a *weighted arithmetic mean* of the IPDs in each the year to calculate the same average, where the weights *are based on quantities* (or volumes) rather than current price values. This follows because the deflator for year (Y) is just the ratio of total current price turnover to total constant price turnover, i.e.:

$P_Y = \frac{\sum_{t \in Y} V_t}{\sum_{t \in Y} Q_t}$. But this can be re-written, simply by multiplying and dividing the term inside the summation in the numerator by $\frac{Q_t}{Q_t}$ (i.e. multiplying by '1'), i.e.

$$P_Y = \frac{\sum_{t \in Y} V_t \frac{Q_t}{Q_t}}{\sum_{t \in Y} Q_t} = \frac{\sum_{t \in Y} \frac{V_t}{Q_t} Q_t}{\sum_{t \in Y} Q_t} = \sum_{t \in Y} \frac{V_t}{Q_t} \frac{Q_t}{\sum_{t \in Y} Q_t} = \sum_{t \in Y} P_t \frac{Q_t}{\sum_{t \in Y} Q_t}$$

which follows because $\frac{V_t}{Q_t} = P_Y$

i.e. $P_Y = \sum_{t \in Y} P_t \frac{Q_t}{\sum_{t \in Y} Q_t}$

or, in words*, the average deflator in any year is the arithmetic weighted average of the deflators in each period, where the weights are given by the quantity (or volume) shares in each period.*