International Labour Organization

Modelling Through towards a Just Transition Planning

A discussion paper

About

This discussion paper explores the use of economic models, specifically Input-Output Tables (IOTs), to analyse and forecast the impacts of a just transition. It explains how IOTs map sectoral interdependencies within an economy using monetary flows, while also acknowledging their limitations, such as high aggregation and data lag.

The paper then presents a practical application which uses IOTs and modelling to develop decarbonisation scenarios for Central Asian countries and Azerbaijan. These scenarios range from a current policies baseline to a comprehensive just transition pathway incorporating gender equality and climate resilience.

The analysis underscores that while such modelling is a powerful tool for illustrating potential economic, employment, and emission outcomes, its results are highly dependent on underlying assumptions. The paper concludes that model outputs should inform structured debate and adaptive planning rather than be treated as precise predictions, emphasizing the need for local expert input to enhance the realism of the scenarios.

Models

Models are efforts to represent realities. As children, we frequently encounter models as toys, models that are physical artefacts (e.g. model railways, scale models of aircraft, boats, buildings or engines). Sometimes these are realistic, and even use the same materials as the object models, sometimes they are far from reality (e.g. trains and planes with human faces). We still encounter physical models as adults, for example in scale models of buildings or townscapes, in museum displays, and so on.

But many models are less tangible - they may be paper- or screen-based, with diagrams, words, mathematical formulae and numbers. They can be a combination of these different media. They may be displayed on screens for users to interact with – as in the case of computer and videogames. These model a whole world within which the player can interact with various elements of that world (and perhaps with other players of the game).

Some models are made by hobbyists or educators to demonstrate the workings of some device or system. Some are created purely for entertainment or fun. A major practical use of models is to make the realities they represent easier to understand. This is commonly encountered in the work of architects, educators and in museum exhibits. Models are employed to show how different parts of the object or system which we are looking at work together, and they can bring some of these elements to greater prominence, so we can look at them in more detail, and in some cases we can adjust these elements to see what effect this might have. Often, models allow designers and users to experiment with how the reality might be manipulated. What, for example, would be the effect of increasing or decreasing one or other feature of the real system? (Take the case of speeding up a train in a model railway. This should mean that the train completes circuits in less time – but it may run off the rails, or collide with other trains.)

It is possible to build a physical model of an economy. One model, developed in the nineteenth century featured volumes of liquid that moved along pipes between vessels that represented different industries, for example. Since the development of electronics and then computers, this sort of physical model has become obsolete. Almost all current economic models are more abstract and mathematical. There may be a diagrammatic representation of the linkages in the model, with arrows linking together different elements. But most often models work with mathematical formulae that link these different elements – outputs from one industry and inputs into another, for example. Statistical data are used to estimate the stocks and flows that are involved. Most often, the data is represented in terms of, monetary values; the formulae compute relationships in terms of such values. Thus industry A could have an output of, say, $10,000; it could have sales worth $5,000 to industry B, and so on. In the real world, money may be changing hands, as in payments for goods and services, and volumes of goods (and of services performed) are also being transferred. The model typically just expresses relationships between various components (industries, products, etc) in monetary terms. For instance, the trade between country X and country Y might involve X exporting $2m worth of goods and services to X and importing $1.5m from Y (in this case, giving X a positive, and Y a negative, balance of trade). In work with a more environmental focus, some volumes may be considered. For example, quite a number of studies estimate the amount of CO2 that is released when the activities that produce a certain economic output are performed.

At any one point in time, the statistical data from a real-life economy will tell us about the monetary value of goods and services being traded in an economy, and how these exchanges result in the expenditures that constitute final demand. If nothing else changed, a particular increase or decrease in exchanges across the board would result in a similar level of increase/decrease in final expenditure. Life is rarely that simple, however, and the work of econometrics often involves constructing more dynamic economic models, which depict more complicated relationships. For example, the typical relationship between supply and demand is one in which the prices of goods and services will tend to go down when demand for them drops, and to rise when demand increases. Economists theorise that in a perfect market, prices will stabilise at an "equilibrium" level, when supply and demand match. The precise formula governing this will be estimated by examining actual statistics for the market in question. Or, to take a different example, increasing volumes of production of a product are frequently accompanied by decreasing prices of each item of this product (for instance, as a result of economies of scale in production processes). This implies that a particular expenditure will purchase more units of the product - or that consumers can pay less (a lower amount of expenditure) for the amount of product they want (leaving them with more disposable money, other things being equal).

Different sets of statistical data are required to create different types of economic model, and to "calibrate" these to fit real-world situations. Economic forecasting models are built around such variables as GDP, inflation, employment levels, government spending, and interest rates. These variables are linked together by equations derived from economic theories and calibrated via examination of historical data concerning these variables. These models can be used to generate forecasts of the performance of these key variables under various circumstances (including different government policies).

Now, any real-world economy features numerous sectors that interact together, and the flows of goods and services between different sectors are recorded in Input-Output Tables. These provide a framework which can be linked to forecasting models, to give more precise views of how different sectors may fare in the forecasts; and when policies or other interventions may impact specific sectors, the implications of such variations can be estimated. The next section of this note gives a little more explanation of Input-Output Tables and their roles.

Inputs and Outputs

Economic Activities involve the production, supply and use of goods and services. In market economies, goods and services are exchanged - bought and sold – between suppliers and users. Suppliers make their products (goods or services) using **inputs** (such as machinery and tools; raw materials; and the labour of human beings). Their **outputs** are then the goods and services they produce. (For the time being, assume that there are no "externalities", such as unwanted outputs like pollution and waste material, or consequences for the well-being of workers or communities.)

Inputs and outputs can be very varied. Statisticians cope with this by dividing up the economy into different sectors, in their System of National Accounts. Thus we have primary, secondary and tertiary sectors. The first grand sector involves mainly "extractive" industries (these get things from nature by mining, agriculture, etc). The second grand sector is mainly comprised of industries that make things, physical products (like manufacturing and construction) often using inputs from the primary sector. The third of these great sectors supplies services: it does things that change the state of people or things (such as transporting people and goods, facilitating trade, producing and communicating information, and providing public services). Statisticians disaggregate each of these great sectors into numerous smaller industrial sectors, so that the primary sector, for instance, includes various categories of mining and oil extraction, agriculture, forestry and fisheries. The secondary sector includes numerous manufacturing industries, ranging from food and clothing to heavy machinery and electronic goods. It also contains the construction industries, and activities such as electricity, gas and water supply infrastructure. The tertiary sector is highly diverse – it includes business and consumer services, personal and public services, services that change the state of goods and environments and those focused more on people, and activities ranging from education and entertainment to security and software maintenance.

In the System of National Accounts, the inputs and outputs of industries are described in terms of prices: the sums of money that suppliers and purchasers pay and receive for the products. (There are also transfers of money that take place through taxation, government subsidies, and the like. As already noted, some other outputs are often not paid for, priced or measured, notably pollution. For simplicity, let us leave these things on one side to begin with. We begin with a focus on transactions in the market.)

We can see profit as simply being the difference between the overall expenditure on inputs, and the overall sales value of outputs. Over any period in time, a functioning business will need to spend a certain amount of money on inputs to achieve a certain number of outputs. If it has spent $1000 on inputs to achieve sales worth $2000, then each dollar received for output will have cost on average $0.5 of inputs. Value-added in this case is $1000 overall, or $1 per dollar of input.

A very simple economic model would assume that these ratios remain constant. All other things being equal – which is a very unrealistic assumption – a doubling of inputs would result in a doubling of outputs. In real life, it would take a very unusual sort of firm for it to be able to double its labour force, equipment and plant practically instantaneously. Few firms can simply double their purchases and sales at short notice (though many might like to). Smaller changes in activity might, however, be feasible, even in relatively short periods of time. A 10% increase in inputs and outputs is far more likely to be achievable in a short period.

Reality is rather more complicated, however: it is fairly uncommon for input and outputs to expand or contract to precisely the same degree. Econometric models do try to take account of this. For example, they may build in the supply-demand relationships that were mentioned earlier. Prices of inputs would be likely to change if there is a sudden increase in demand for them, for example – over time this market signal should result in more supply being made available, but this can take time. However, the point is clear enough: changes in one sector of the economy are liable to have impacts on other sectors. It is the relationship between sectors that Input-Output Tables and models deal with.

One other point needs to be made before we proceed. Remember that the economists are typically focusing on inputs and outputs in terms of values: the amount of money that is involved in the purchase of these goods or services. But what is used, by suppliers or consumers, is not the money, but the goods and services themselves. It is the volume of the product that determines how much use can be got from purchases of the product. When prices change, the volume of goods that can be purchased for a particular sum will increase or decrease (according to whether prices are going down or up, respectively). One source of change in economic relationships is not actual volumes of particular inputs, but their values – the prices that have to be paid for them, some of which can be very volatile. In the example featured above, prices of inputs may go up (due to scarcity or sudden increases in demand, for instance). The business may then find itself needing to pay for not $1000, but for $1500 worth of inputs, in order to achieve the volume of outputs that it has been selling for $2000. It may be able to raise its prices of the outputs – their "value" (as measured in the accounts) would then go up, especially if users continue to buy the same volume of the goods or services. Value might then increase, while volume decreased. In reality, there is liable to be a drop in demand as the prices go up. The supplier's ability to increase prices may be limited by its consumers choosing to spend their money elsewhere.

Input-Output Tables

The discussion above largely considered individual firms. Firms are critical actors in economic development and in past and future transitions. Firm-level analysis is important, and individual firms need to develop their own strategies. But there are huge numbers of individual firms. A table that took account of every single firm would be immensely large (and would expose much of the workings of businesses to their competitors. In any case, policymakers and statisticians want to examine the aggregate situation – while being aware of the variety of experience across different firms as far as is possible.

Input-Output Tables (IOTs) depict the exchanges of products across different **sectors** in an economy. Sectors are categories that encompass individual firms engaged in the same areas of economic activity; statisticians aggregate the data for these individual firms. Working with the three grand sectors (primary, secondary and tertiary) would be of limited use, and IOTs usually present much more detail than these provide. The economy is usually disaggregated into dozens (and in a few countries, into hundreds) of individual sectors. Commonly 20-100 sectors are featured. The numbers vary according to the intended purposes of the data, and the statistical capabilities of the country in question. We get to see data about what inputs are used by each sector, and which sectors use the outputs of each sector. It can be very interesting to see which sectors are the main suppliers to, or markets of, other sectors.

It is important to be aware that IOTs, and the models that are based upon them, only tell us about whole sectors. IOTs are very powerful tools, but give little insight into the variety of experiences across firms within a sector. For example, a manufacturing sectors might consist of a few very large firms, and a large number of smaller firms doing specialised tasks (such as making specific components for the larger firms to integrate into their products). As well as size differences, there can be striking variety of experience across different regions of a country; the national IOT will have nothing to say about this. Finally, it is quite common for a sector to combine together several subsectors that are in reality very distinctive – e.g. livestock farming and arable farming are often put together, though they are very different (even if some farms combine the two); and they may well be further combined with forestry and even fishing in IOT and other statistical uses. Simplification is necessary for us to gain a sense of major features of economic circumstances and changes; but interpretation of what these features mean on the ground requires going beyond the highly aggregated data.

One further potential source of difficulty is that international organisations and individual countries are liable to update their sector classifications over time. While there are usually good reasons for this, it can render comparisons of data across time periods problematic. In such cases, fairly high levels of sectoral aggregation are usually relatively stable, but more detailed disaggregation may involve different groupings of industries, so care is needed when we use these data to track changes over time.

An IOT provides the overall picture of the sectors' inputs and outputs as expressed in monetary (value) terms. IOTs will not tell us whether a sector is comprised of numerous small firms, a few very large firms, or something in between these extremes. The main products of the sector will be treated as being uniform, but individual firms may specialise in different goods or services that fall into the broad product category. (Just as the producers of goods and services are classified into broad sectors, so the goods and services themselves are classified by statisticians into different product categories.) IOT data treats the sector, and its products, as if they were homogeneous; in reality, of course, different user sectors may actually be using different types of output from a supplier sector, but our models have to simplify things, as discussed above. Also, firms are located in different places, but national IOT data tell us nothing about where activities are located. in practice the locations of economic actors may have great impact on their transport costs and other factors that influence the relationships formed among them.

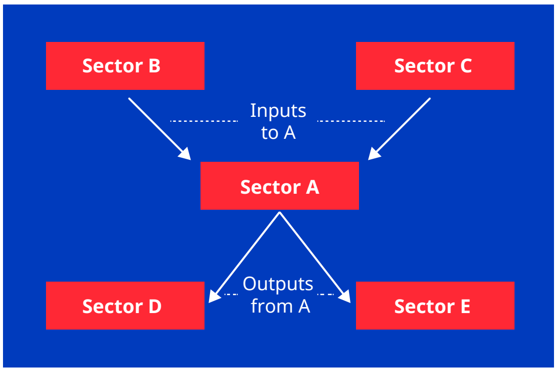
One particular example of how sectoral aggregation can limit understanding of what is taking place in an industry involves productivity. Productivity levels are liable to vary from firm to firm, but the IOT deals with averages here, and fails to acknowledge these differences. When a sector shows a growth in productivity (increased outputs for a given level of inputs), we cannot conclude that all firms in the sector are improving their performance. Quite possibly, some are improving their performance while others change little. Or it may be that new entrants may be appearing in the sector with superior performance. It could even simply be that some poorly performing firms are going out of business… The IOT will not tell us how far each of these possibilities may apply. The IOT approach is particularly helpful for giving a view of the whole economy, but other sources of statistics may do a better job of giving us firm-level insights.[1]

Statisticians create the IOT by totalling up data on inputs (expenditures) and outputs (revenues) for all of the firms classified as belonging to each sector. The sums of the inputs and the outputs, provide us with input-output figures for the whole sector. The statistical information tells us about which sectors inputs come from, and which sectors purchase products.

Let us outline a simple example. Here, the agriculture sector (A) buys fertiliser from chemicals industry B and machinery industry C. It also buys labour (L).[2] It sells its outputs to the food manufacturing industry D, and some directly to the retail trade (F), Ultimately businesses (mainly those in sector F) sell the final goods to Households (who we might treat as sector H, but that will typically be labelled as "final consumption" or something similar.

We can draw a neat little flow chart describing this flow of value from sectors B and C to A and then on to D and E (Figure 1). Other inputs and outputs will also exist, including, labour inputs and, for some sectors, outputs that go into final consumption in H.

Figure 1: Sector A's Inputs and Outputs



Households, of course, underpin the labour force whose economic contributions are inputs to all other sectors, the cost of which (wages) may be labelled "compensation of employees" or something similar. Household activities may be described as final consumption, though these are certainly not only leisure activities. Much work is performed in households – cleaning, child-rearing, meal preparation, and much else. This is largely unpaid labour, though employment of domestic servants should be captured in data on compensation of employees. But unpaid housework has typically been completely neglected in statistics, and is invisible in the IOT. The following discussion will focus on exchanges between industrial sectors.

Typically, economies are more complicated than represented in Figure 1. The complexity comes from several factors. First, many sectors in fact are simultaneously both suppliers to, and purchasers from, many other sectors. For example, the Chemicals industry B both buys from, and sells to the Machinery sector C. The goods and services that one industry purchases from, or sells to, another described an intermediate goods and services. Final products are those that go for household consumption. (Again, to simplify things we will put to one side, for now, the question of things like food bought by the military services, or products that are exported for sale in other countries. [3])

A second complicating factor is that many industries are (intermediate) consumers of some of their own products. For example, some firms in Machinery sector C may well purchase machines from other firms in that sector, for their own use; they will not manufacture all of the equipment they use in their own production processes. Even within the Agriculture sector we may find some farms buying animal feed from other farms, and so on Our flow diagram, then, will start to feature two-way flows and loops between sectors Figure 2 takes these points into account. It still focuses on Sector A, and shows that there can be two-way exchange between this and sectors B to E. The

1 For example, the firm-level studies by the World Bank Enterprise Survey – though note that these are limited in sectoral coverage, and deal only with firms that are in business at the time of the study. See [https://www.enterprisesurveys.org/en/reports .](https://www.enterprisesurveys.org/en/reports)

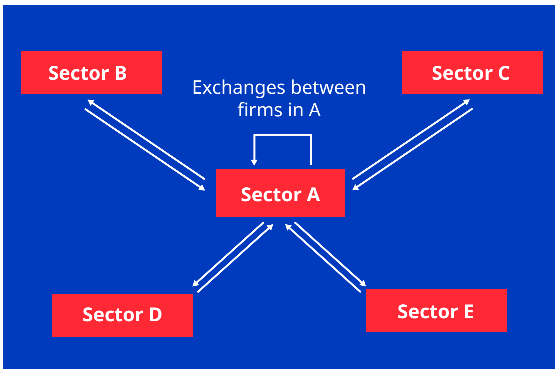
2 Of course, in reality there are very likely to be other input purchases, such as energy supplies, equipment repair services, and much else. In a typical IOT, most sectors are themselves acquiring inputs from many other sectors. Of course, the scale of these inputs varies considerably – some sectors make very little use of products that some other sectors are heavily reliant upon.

3 International transactions – imports and exports – are often represented as if international trade was a sector in its own right. We may then capture the exports from a sector, and imports it consumes, as if this were transactions with another sector. (Trade data typically tell us about what is traded (the product, or rather the monetary value of imports or exports of a particular class of products), but not about what sector it came from.)

diagram would become far more complicated if we also depicted the exchanges between Sectors B and E to each other, together with the exchanges in which each sector acts as an intermediate consumer of some of its own products, with transactions taking place between different firms within the sector.

While the three grand sectors of primary, secondary and tertiary industries are often used to capture data on, say, employment, this is too broad-brush to examine economic activities in any detail. Typically we work with a great deal more detail than this, and when this involves many more sectors than the four discussed in the example above, any diagram along the lines of Figure 2 rapidly becomes extremely complicated.

Figure 2: Sector A's Inputs and Outputs



The solution that econometricians have developed to deal with this complexity is the **Input-Output Table.** There is quite a range of such tables, though they have similar basic structures and underpinning ideas. The sort of IOT that represents the processes discussed above is one in which the transactions between sectors are represented as cells, as the rows in a set of columns. Thus, we could represent the input flows into sector A as represented in Figure 3, and the output flows from sector A, as in Figure 4.

There are various types of IOT, though the most familiar ones are Industry-by-Industry tables. These feature the same set of industries in their rows and columns: sectors A, B, C, etc. Imports and exports will then usually be treated as if these involved purchases from and sales to another sector.

However, it is worth noting that some other types of IOTs deal with products as well as industries. There are Industry-by-Product and Product-by-Product tables, for example. Thus, what is called a "Supply Table" outlines which industries provide which products: firms are attributed to specific industrial sectors on the basis of what their main products are, so sectors are composed of the firms that are the main specialists in producing these products. Not surprisingly, the industries that specialise in producing one sort of product will usually be the biggest supplier of that product in the economy: they will appear as the dominant supplier, unless this is a product which is mostly imported. But many sectors produce more than one type of product. A retail store may offer cafeteria services, a computer manufacturer may provide software, and so on. So we could have a table that tells us what products sectors are generating, using a product classification that maps closely onto the industrial classification – this will show that most sectors overwhelmingly output their own main product, of course, but that other sectors may contribute significant amounts of some other products, We can also look at "Use Tables" to examine how much of the intermediate products various sectors are consuming; again, purchasers may sometimes acquire more from imports than from the national sectors that specialise in providing these products. Other types of IOT can be constructed to examine exchanges between countries or regions of a country; and IOTs can be extended to explore, for example, the purchases by households of different types.

Figure 3: Inputs to Sector A

Sector	A: Inputs
A	Sector A's firms' purchases from each other
B	Sector A's firms' purchases from Sector B
C	Sector A's firms' purchases from Sector C
D	Sector A's firms' purchases from Sector D
E	Sector A's firms' purchases from Sector E
Total	**Total purchases by sector A firms**

Figure 4: Outputs from Sector A

Sector	A: Outputs
A	Sector A's firms' purchases from each other
B	Sector B's firms' purchases from Sector A
C	Sector C's firms' purchases from Sector A
D	Sector D's firms' purchases from Sector A
E	Sector E's firms' purchases from Sector A
Total	**Total sales from sector A firms**

Probably the most common, and straightforward, IOTs are the Industry-by-Industry tables. These feature the same set of industries in its rows and columns– sectors A, B, C, etc – and do not differentiate between different products. We will continue to refer to the sectors as A, B, C etc. In practice, different sectors and subsectors are given numerical codes, e.g. sector 1, subsector 1.2, sub subsector 1.1.1 and so on. Different parts of the world have slightly different accounting systems, and may use different terminology and numbering systems, but the basic ideas are as sketched in above.

The next step is to assemble the information for all sectors, into a table – or, to use a more technical terminology, a matrix. As mentioned, there can be different sorts of matrix. For example, many firms produce several sorts of product – a farm may produce livestock and grain, sold on to butchers or mill operators, but it may also produce cheese sold directly to consumers. A garage may retail petroleum, but it may also wash cars and repair them. Industry-by-Product tables capture such data.

Typically, in an IOT, the inputs to a sector (as in Figure 3) are arranged horizontally, and the outputs vertically. Figure 5 captures a simple version of this: in reality the table would be considerably larger. The final column would capture the total outputs of the horizontal sector, and the final row the total inputs to the vertical sectors, as expressed in monetary terms.

Figure 5 Part of an Industry-by-Industry IOT (the top left-hand corner of the table)

Sector	A	B	C	... and so on
A	Outputs from Sector A consumed by Sector A	Outputs from Sector B purchased by Sector A	Outputs from Sector C purchased by Sector A	...
B	Outputs from Sector A purchased by Sector B	Outputs from Sector B consumed by Sector B	Outputs from Sector C purchased by Sector B	...
C	Outputs from Sector A purchased by Sector C	Outputs from Sector B purchased by Sector C	Outputs from Sector C consumed by Sector C	...
... and so on	...	...	...	...

These data capture the activity in an economy over a period of time (typically a particular year)- as represented at sectoral, not at firm level. While some countries issue their IOTs on an annual basis, most do so less often – 5 years between tables is quite common among industrialised countries, less frequently in many other cases. In some countries they can be further disaggregated, for example an IOT could be produced for specific regions, though this is not standard practice in most countries. They can be related to other data, for example the information on labour costs (wages) can be related to data concerning hours worked, or to numbers of people employed, or even to numbers of employees at particular skill levels. Data on energy expenditures can be converted into estimate of actual energy consumption, and, potentially, to estimates of carbon dioxide emissions.

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The basic IOT material can be related to other data, For example, the data on amounts paid for labour in different sectors can be related to other statistics, such as the number of jobs that the sector employs. On that basis, it should be possible to examine the likely number of jobs created or lost as a sector expands or reduces its output – or manages to increase labour productivity in one way or another. The information on labour costs can be linked to data concerning hours worked, or to numbers of people employed, or even to numbers of employees at particular skill levels. Such information may be very important went it comes to assessing labour productivity: in many ways value-added per hour worked is at least as important as value-added per person employed. While precise information on hours worked is often not available, there may be statistics distinguishing between full-time and part-time workers that can be used to approximate this. In countries with sufficient occupational data, it is even possible to consider the numbers of jobs of different occupational types – most often as represented in terms of low-, medium- and high-skilled jobs. This can be helpful, in that there are quite often shifts in the composition of employment within sectors over time – for example, a decline in the number of manual labourers as compared to the number of office workers (though such changes are by no means inevitable).

Another type of data that is often linked to IOTs is data on energy use and/or on emissions of greenhouse gases. Data on energy expenditures can be converted into estimate of actual consumption of different forms of energy, and, potentially, to estimates of carbon dioxide emissions. Prospects for job creation and reduced carbon dioxide emissions are both extremely relevant to a Just Transition, and IOT analysis can be a valuable contribution to examination of how this can be achieved.

The information contained in an IOT is rather difficult to assemble, so IOTs are typically somewhat out of date – they represent the state of affairs in an economy some months, or more often several years, ago. It is possible to make some estimates of how the real situation may have changed; this is really a matter of forecasting (or, technically, "nowcasting"!) using IOTs, which is discussed in the following section. At times of rapid change, the reliance on data that become rapidly out of date, can be a real limitation.

Two other limitations of the data should be mentioned. As with all economic statistics, there can be problems with the quality of data in IOTs. Not all transactions are captured (informal activities are usually missing, likewise much criminal and also much corrupt activity); mistakes can be made (for example, firms may be allocated to the wrong sector); important variations across different regions are hidden (for example, inputs to agriculture may vary dramatically across a country). Changes in the quality of goods and services may not be well-reflected in data expressed in monetary terms; for example, the computing power that can be purchased for $1,000 today would have cost many times this amount ten or twenty years ago (as well as requiring a bigger device). These problems are encountered with many economic statistics, but should not be taken to mean that the data are irrelevant – simply that they need to be interpreted alongside other evidence concerning the state of the country, in particular if this has involved major disruptions of economic activity.

Forecasting Using IOTs

The IOTs tell us about the flows of goods and services across the economy, and the interdependencies of different sectors. An IOT can be integrated into an economic forecasting model for an economy, to provide detailed estimates of how the different parts of the economy might develop. Furthermore, different scenarios can be explored which can inform policymaking and businesses' strategic planning. The macroeconomic forecasting model will be initialised with the available data on the main component parts of the economy; their performance will be projected forward in time, and this ultimately allows for estimation (forecasting) of the GDP level (which is constituted by their aggregate activity). The econometric modelling may take into account dynamic relationships indicating, for instance, how demand might be affected by shifts in prices (typically increasing with reduced prices, decreasing with higher prices.) Forecasters may also be working with projections based on assumptions about such things as the rate of technological change, and the impact of such change on productivity, resource use, or other topics of interest. The Cambridge Econometrics (CE) forecasts for Central Asian countries employ a sophisticated economic forecasting model labelled E3ME. [4]

Often such models are brought into play in order to forecast medium- or long-term trends, or, in contrast, the possible effects of various “shocks” – such as increases in prices of imports, or of locally sourced inputs. The forecasting model tells us about macroeconomic changes, but the relationships between sectors mapped by IOTs are based on the most recent current data. (Thus, in the example sketched out earlier, everything in the economy increased by the same amount). This can still be useful for rapidly estimating the possible consequences of changes in a sector’s activity, especially when we are looking into fairly short-term developments. We can look at the consequences of change in the levels of activity of a sector (increases or decreases in its output). But some developments in products, processes, policies and markets – including technological innovation - may well mean changes in sector A’s requirements for inputs from other sectors. Taking this into account means making assumptions about these shifts.

The relationship between the intermediate inputs required, and the outputs produced through the use of these inputs, is expressed arithmetically by what are known as “Technical Coefficients”. For example, a specific technical coefficient will be used to capture the ratio between the $1000 of output from sector A and the $50 of input from sector C required to manufacture it. In this case, the technical coefficient will be 0.05. To forecast the effects of technological changes, for example, modellers will need to do two things. First, they should adjust the coefficients associated with the purchases that user sector A requires from the technology supplier (capturing the acquisition of the new technology). The technology supplier may even belong to a sector that has not been sourced from before – as when an industry begins purchasing computers and software, in addition to its usual purchases of machinery and raw materials. The technical coefficient is then liable to be a matter of guesswork about rates of adoption. Second, modellers must estimate the effects that using the new technology means for the technical coefficients of other intermediate inputs being used by sector A. In the case of major technological change many inputs, and thus many technical coefficients, could be affected. For more routine change, it is likely that only a few intermediate inputs would be affected.

One of the major challenges for forecasting the effects of technological change is using realistic estimates of the extent to which these changes will affect the production process. Technology suppliers often claim that massive increases in efficiency and productivity will be obtained from using their equipment or software - but will this really be the case? how rapidly can these improvements be made in any case? will they be maintained (they may be increased as production scales up – or decreased if later adopters have difficulty in realising the gains from technology)? what other issues may arise? These are topics where inputs from local experts and practitioners may be particularly valuable in bringing realism to bear on estimates; modelling is able to show the complexity of impacts of change as they reverberate across the economy, but it has its own limits.

In order to inform estimates of technical coefficients and the pace of change, evidence may be drawn upon from other economies or even from pilot studies, which can provide some guidance. But, even if the suppliers are not being selective in reporting such data, how far are such performance gains transferable to a different economy (with, for example, different infrastructure, workforce skills, climate…)? how far are results from pilot studies liable to apply when scaled up (will small firms, later adopters, newcomers be able to use the technology or the new work practices more or less effectively than the pioneers?). Even if good-quality evidence is available, past experience and expert judgement about the speed and effects of technological change will often be invoked. Such expert judgements are embedded into the process of envisioning the characteristics of different scenarios. It will then be critical to take into account how far the experts’ knowledge applies to the sectors and economic dynamics in the country of concern. Users of such analyses need to know the basis on which experts are making judgements about the implications of use of, and capabilities for using, the new technology.

The IOT Approach applied to Central Asia and Azerbaijan Scenarios

Cambridge Econometrics (CE) has used IOTs in its analyses and forecasts of technological and policy change in a wide range of countries. Their model covers Central Asia and Azerbaijan (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan) and can be run for the region as a whole, or for individual countries. It is available

4 https://www.e3me.com/what/ (The name derives from “Energy-Environment-Economy Model for Europe”, reflecting its early development.)

(along with the underlying IOTs) via Excel spreadsheets. The model is set up so as to work to 2050. Note that the authors caution that "Long-term forecasts may be more sensitive to scenario assumptions than to the internal mechanisms of the model itself. Users should consider this when designing and interpreting results."[5]

A baseline of growth estimates for each country and for the whole region is drawn from the IMF's World Economic Outlook; the E3ME forecasting model provides overall forecasts of macroeconomic developments. It can be applied to the region as a whole, and for each of 6 countries Population trends are based on the medium scenarios in UN Population Projections and other data sources for information on such factors as emissions of greenhouse gases (carbon dioxide and methane. IOT and employment/household data are linked to the basic model.

IOT data are derived from Asian Development Bank IOTs and Eora Global Supply Chain Database (EORA) and Supply-Use tables for 2022. These data represent the national economies in terms of a limited number of economic sectors. 27 sectors are included. Four of these are **Primary Sector** industries: Agriculture; Fishing; Oil & Gas Extraction; and (sector 4) Other Extraction. The **Manufacturing** sectors are: Food & Beverages; Textiles and Wearing Apparel; Wood and Paper; Petroleum; Chemical; Metal Products; Electrical and Machinery; Transport Equipment; and (sector 13) Other Manufacturing. Three other sectors are: Recycling (sector 14), followed by utilities – Electricity (15); Gas (16); and Water (17) – with sector 18 being Construction. The remaining nine sectors are service industries: Maintenance and Repair; Wholesale Trade; Retail Trade; Hotels and Restaurants; Transport; Post and Telecommunications; Finance and Business; Public Administration; and (sector 27) Education, Health and Other Services.[6] This is a fairly high-level

aggregation but captures much of the sectoral diversity needed to understand the Just Transition.

The model allows for the tracking of various indicators across different scenarios. The key indicators are:

- Output, Gross Value Added, (GVA)[7] , and employment by sector, at the regional and country level.
- Employment by gender, at the country level.
- Youth employment, at the country level (for selected countries).
- Employment by occupation, at the country level (for selected countries).
- Emissions by sector.

These indicators can also be related together to get measures such as productivity (in this approach, GVA divided by employment). The model is designed so that users can readily input new data and can explore the implications of policy instruments enacted at particular points in time. CE has provided details of the three scenarios it has developed using this model.

The Central Asia and Azerbaijan Scenarios

Using IOT analysis as a framework to augment macroeconomic modelling, Cambridge Econometrics examined a set of scenarios for Central Asia. Essentially, this examination involves using the existing data on relationships between sectors, and a set of assumptions about how sectoral activity and relationships might change. These are used to project activity forward into the future. Baseline projections are used to represent a business-as-usual reference case. The scenarios are developed by introducing changes to this baseline. The forecast consequences can be compared with the baseline to estimate the impacts of the sets of policies envisaged under each scenario.

The CE scenarios range from ones where change is relatively limited, to ones characterised by very substantial transformation. In order of the extent of change anticipated, the scenarios are:[8]

- **Baseline/ Current Policies –** This scenario incorporates all policies that had been announced and implemented in the Central Asia countries up to the end of 2023.

5 Cambridge Econometrics (2025) *"Decarbonisation scenarios for Central Asia and Azerbaijan - Draft scenario assumptions and results June 2025"* p27; and also *Cambridge Econometrics (2024) "Input-Output Tool for Central Asia and Azerbaijan – Model manual and specifications"* p8.

6 Private Households are treated as sector 28.

7 GVA is a measure of output (the value of goods and services produced in an economy) minus the value of intermediate consumption (the goods and services used up in producing that output); both are expressed in monetary terms. Depreciation of fixed capital is taken into account to produce the (lesser-known) indicator, Net Value-Added.

8 This discussion draws on CE (2024) *"Decarbonisation scenarios for Central Asia and Azerbaijan - Scenario design and assumptions – October 2024"* and CE (2025) *"Decarbonisation scenarios for Central Asia and Azerbaijan: Draft scenario assumptions and results June 2025".*

- **NDC –** This scenario goes beyond the *baseline* and assumes countries in the Central Asia region deliver their unconditional NDC (National Development Commitment (targets by 2030 (and conditional targets where no unconditional targets are announced).

- **Strong Industrial Policy –** This scenario assumes that the region delivers net zero emissions by 2050; this involves scaling up of the policies in the NDC scenario, and also adding stronger measures to facilitate the transition across the region.

- **Climate Resilience –** This scenario features, in addition to the steps taken in the *Strong Industrial Policy scenario,* the introduction of social policies to establish a climate-resilient economy. (Additional policies include: Improved water management systems and Reforestation and land management.)

- **Just Transition –** This scenario adds enhanced gender policies to the *Climate Resilience scenario*. These include enhanced education, and policies establishing quotas and employment schemes that promote improved gender equality (both in terms of representation and pay) in the labour market.

To operationalise each of these scenarios, and to estimate the effects that might be forthcoming from the various changes that they introduce, depends upon many assumptions. These assumptions are not arbitrary guesses. CE has made efforts to base them on the best available evidence. However, these assumptions are necessarily based on partial evidence – we cannot know definitively how close they are to the events that will ultimately evolve. Users must be aware that these are not authoritative predictions. They certainly do not come from an omniscient computer system that is able to use greater-than-human intelligence to assess all the facts and reach wise conclusions from its objective appraisal. They are "what-if?" forecasts, where all scenarios share some assumptions while scenarios differ in terms of additional assumptions, mainly concerning the details of policies and their implementation.

Users may fruitfully question how likely it is that the phenomena would take place in the particular way described: how plausible are the specific arithmetic figures involved, and the timings and evolution over time of the effects considered? Modelling forces those involved to be precise about all sorts of things that we only have partial knowledge about. While the particular policy components of different scenarios are enlightening, even since the analyses were performed events may lead users to reconsider their plausibility.

These forecasts associated with the various scenarios depend, then, on a great number of assumptions. It would take many words to examine each in detail. [9] A few examples will suffice to illustrate the sorts of issue that arises.

Some highly speculative assumptions in the CE scenarios, then, concern:

- **Carbon prices –** the assumptions here, with the baseline drawing on IEA formulations and Kazakhstan's plans, are that (1) carbon pricing is applied in the NDC scenario to those industrial sectors contributing more than 60% of CO2 emissions, and (2) in the "stronger" scenarios it is applied across the economy, (3) increasing over time (reaching \$90/tCO2 by 2030, \$160 by 2040 and \$200 by 2050) in line with IEA's estimates for requirements to meet net zero pledges. Collection of such revenue is vital for funding many of the policies outlined for the scenarios. But introduction and implementation of these measures may not be as smooth as hoped (though the prices could in principle be fixed at higher levels). One of the things that this revenue should finance is substantial economy-wide investment into such measures as building insulation, and productivity-enhancing process redesign, that improve efficiency. These are not measures that directly relate to switching fuel or technology.

- **Financing:** beyond the NDC scenario, it is assumed that international funding will be forthcoming to support retraining and social inclusion actions. 50% of the measures are assumed to feature only in the Just Transition scenario. Transition-related investments and policy costs that are to be borne by governments are funded through carbon revenues. Any shortfalls would be met by raising income tax. (Any excess from carbon revenue would be distributed to firms and households through reductions in income tax). It is assumed that in the two "strongest" scenarios (Climate Resilience and Just Transition), a new regional financing scheme has been put into place.

- **Green Hydrogen:** considerable attention is paid to this alternative to electrification/batteries as a substitute for fossil fuels, especially in the three "strongest" scenarios. This is indeed a very promising alternative, and well worth much more effort around the world. But it is also a

9 CE very helpfully outlines main assumptions and related sources of evidence in Tables 2.1 and 2.2 of the April 2025 *Decarbonisation scenarios for Central Asia and Azerbaijan: Draft scenario assumptions and results* report.

highly uncertain and somewhat controversial area. Current costs of producing green hydrogen via electrolysis are high (reflecting both capital and operational costs); it is energy-intensive, and the amount of electricity required implies very substantial and reliable renewable energy resources (for this to be "green" rather than what is variously known as "blue" or "grey" hydrogen, produced through the use of fossil fuels.[10] (However, promising new methods for hydrogen production are being explored actively, so this remains an area to watch closely.) Production, storage, and distribution of green hydrogen also requires investment in the necessary large-scale infrastructure (which takes time to construct); and development of skills at design and operational levels right across what is effectively a new energy system. Given that green hydrogen technology is still in developmental stages and not yet a mature technology, this strategy has risks. As the technology matures, and economies of scale and experience are established, the prospects should look brighter, and expectations will be better-grounded. At present, the assumptions used in this modelling – including those about the prospects for green hydrogen exports replacing fossil fuel exports – are liable to be seen as highly optimistic. This is not to argue against the need to develop capabilities to move rapidly as prospects (hopefully) improve. But it does suggest that not all eggs should be put into this one basket: other alternatives might need to be explored. Technology advances may be anticipated, too, in such alternatives as battery and related technologies.

- **Carbon Capture and Storage (CCS):** this is mentioned as one way in which the transition might be achieved despite ongoing use of fossil fuels in some sectors where they prove particularly difficult to displace. The aim is to capture carbon dioxide from the atmosphere (or in some cases, from emissions of power stations, etc., and to store it underground in geological formations (such as oil and gas reservoirs that have been exploited[11]). This also remains a technology that is still under development, albeit that some industrialised countries are currently investing heavily in it. If the technology can be established, it might be one that could be taken up by countries that have been engaged in oil and gas production at large scale, Again, this technology is a matter of controversy among experts, and as with green hydrogen, there is still a lack of large-scale application experience. Nature captures carbon through vegetation, and the scenarios do assume reforestation efforts across the region. (However, current thinking is that older trees are much more effective as stores of carbon than are newly planted ones.)

- **Renewables:** Fossil fuel production is to be phased out, along with coal power, in the three "stronger" scenarios. (How this is to be maintained in the NDC scenario, without successful implementation of CCS, is not altogether clear.) Financing of initiatives here is a source of much uncertainty.

  - Considerable increases in the amount of energy produced by wind, solar, and, in some cases, hydro power, are anticipated across all scenarios. Subsidies to support capital investment for wind and solar power are assumed.

  - Assumptions concerning solar energy, in particular, may be suspect – and for once may be rather pessimistic. Solar power is subject to rapid technology change and price reductions. Have these been sufficiently taken into account in the IEA data used? Is it likely that solar power will remain one of the two most expensive power sources in terms of the imputed MWpH price (which, surprisingly, is treated as staying constant over time). The other expensive source is wind power; both of these renewables are seen as substantially more expensive than fossil fuels, especially gas. Many commentators would disagree with this being generally true even now, though there could well be local exceptions (and the question of energy storage, when the source if intermittent, is a major issue – this could be where hydrogen comes into its own, though several other large-scale storage systems are being explored).

  - Geothermal energy is neglected. This is surprising, given that this is not an intermittent source of power, temperature differences between the surface and deep areas of the Earth's crust being persistent. Another reason for being puzzled by the

10 To further complicate matters, there is now interest in "white hydrogen", naturally occurring hydrogen gas found beneath the Earth's surface in fairly large quantities in some locations. Geological surveys are required to establish whether this resource may be available in regions of a specific country, and how far capabilities developed for oil and gas extraction can be refocused to making this economically viable.

11 There are also several ways in which old coal mines may be used for carbon storage.

neglect of this is that skills and technologies used in oil and gas extraction can be applied here. The CE study is not alone in its neglect of this source, but further investigation would seem to be in order.

- There is no mention of nuclear energy, which is being actively discussed in the region. The security issue alone would seem to mitigate against this controversial technology – nuclear sites have been sources of much concern in the Ukraine war. Furthermore, the time-scales required for construction and utilization of high-quality facilities can be lengthy. Still, nuclear power may be promoted by certain neighbouring countries, and there are numerous advocates of new generations of this technology.
- Another issue that might be considered in further scenario work is the scope for decentralised and robust local energy systems, on the one hand, and electricity exports on the other. There are assumptions in the study concerning new investments in grid capacity, but it has proved difficult to move planning for a regional grid forward.

- **Training** for new jobs associated with the transition. This includes projections of workers in fossil fuel supply industries receiving training for new jobs in low-carbon industries, at a cost of $11000 per worker. Another item is training of some 10% of the workforce in other sectors, to adapt to a low-carbon environment. (The associated costs are $1650 per worker in manufacturing and $550 per worker in other sectors. These costs are in part offset by a forecast of 1% increase in productivity in non-fossil sectors due to additional training.) In addition, 20% of all 15–24-year-olds receive higher education or vocational training, costing $1475 per person. These estimated productivity gains from training are estimated from relevant data (from EU countries) of impacts of training, and from World Bank work on training and education in Azerbaijan. How far these projections might apply to the sort of transition anticipated in the scenarios is highly uncertain. The rolling out of training programmes is liable to be complex and involve delays of various kinds. On a more optimistic note, it could be feasible to reduce some training costs with use of new technology, and deliver programmes that are more customised to specific groups of worker. But in any case, there are substantial uncertainties here.
- **Gender equality:** assumptions as to the success of regulations requiring 30% female participation in "governments" are also uncertain. (Furthermore the precise meaning of this formulation needs further clarification: it may extend beyond the public administration sector, but does it involve all public services?). Other regulations would be aimed at reducing gender pay gaps to 10% by 2050. These targets are reflected in the goals that have been set in some countries in the region. But how far these goals are achievable without further efforts, and the nature of those efforts in specific circumstances, requires attention. Prospects here are, again, highly uncertain: deep-rooted cultural and structural barriers may impede progress.
- **Additional points:** Many assumptions are made concerning the stability and decarbonisation of the global economy, and within the region it is assumed that there are no barriers to trade and migration between countries, and that actions are undertaken in a coordinated way. Both global and regional factors may facilitate such features - or render them harder to achieve. The timing of the policy agenda in different countries may also vary, making coordination difficult.

The list above represents only a partial review of the CE assumptions that enter into their modelling work. The relative simplicity of the model should mean that it is possible to modify many of these assumptions. Some revisions are liable to be necessary even in the fairly near future (for example, it is unlikely that the policies that are assumed to be already in place in 2025 will all have been implemented).

This is not to discount the effort taken by CE in elaborating the scenarios, nor to undermine their conclusions. CE has undertaken considerable work in designing and in explicating their modelling, and setting the assumptions employed for forecasting purposes.

The point is clear that business-as-usual is not an option, and that alternative pathways could provide major movement toward more sustainability together with growth. However, the detailed figures provided for the alternative futures are very much the product of assumptions, many of these assumptions will inevitably prove to be inaccurate. Whatever future is eventually achieved, it will never exactly correspond to any specific forecast.

The point of scenario analysis is to provide guidance as to possibilities, to present the spectrum of plausible futures, not to make precisely accurate predictions. Hopefully, as events unfold and more data become available, some assumptions may be revised in directions that result in more optimistic outcomes. Unfortunately, this cannot be taken for granted, and in some cases, expectations may need to be downgraded.

One fruitful activity might well be for the region, or countries belonging to it, to convene expert meetings to discuss model assumptions. They might even be able to explore the effects of varying certain assumptions in real time, taking into account the scope for reworking the spreadsheets used in the modelling (CE, 2025, p29).

CE Scenario Analysis

The discussion below draws on the draft report from CE on its scenario analyses (CE, 2025). At this moment, only a few of the many results of the analysis can be outlined. Sensitivity analyses suggest that trends in the global economy would have a major influence on the region's performance across the different scenarios. The uncertainties about the global trading environment mean that any forecast will need to be seen in the light of possible – probable? - disruptions.

The scenarios are very much differentiated by assumptions concerning such issues as decarbonisation (associated with this being carbon pricing regimes and targets for renewable energy substitution for fossil fuel use). All scenarios share some problematic assumptions about the effectiveness and immediacy of policy implementation and impacts, and the extent to which the historic sectoral linkages captured I IOTs from 2022 will continue to apply into the future.

In terms of **net zero** achievements, the bottom line is that net zero is not going to be obtained by 2050 in any of the scenarios. However, substantial reductions in greenhouse gas emissions are achieved in the "stronger", more ambitious decarbonisation scenarios. The NDC scenario features negative **employment impacts,** especially for men, while both male and female employment grow in the other scenarios. All countries benefit from these more ambitious scenarios, while Kazakhstan fares poorly in terms of output in the NDC scenario. The shift from fossil fuel industries tends to benefit female and youth employment more than other employment. The extent of employment impacts depends very much upon the economic structures of the particular countries. Productivity gains from training, and the extent to which there can be smooth reskilling and reallocation of fossil fuel workers to new sectors may also prove optimistic: historical transitions from coal to other industries in western countries have often been slow and painful, with social resistance and community costs.

In general, the more ambitious scenarios bring greater benefits. A combination of policies is liable to be more impactful than would be the addition of single policies without such synergy. Coordination between the countries should pay off, with cross-national supply chains, and migration to meet skill shortages, among the features mentioned in the presentation. Economic diversification, and appropriate training programmes, will be very important. Notably, the modelling results (especially short- and medium-term ones) are strongly affected by assumptions about green hydrogen success. It would be prudent to consider a range of options here, and to examine what might make for successful scaling up of hydrogen technologies.

Again, *it could be valuable for expert panels to be convened locally to discuss the realism of these scenarios and consider what may be missing in these analyses.* Precise figures for the impacts of specific policies, even (and perhaps especially) when provided by sophisticated computer modelling, can give a misleading sense of accuracy. Still, the results of such modelling can be useful. At the very least such modelling can both spur expert analysis, and act to show the complexity of the economy and prevent the "double counting" that may otherwise occur. Hopefully it can inform, and be one source of guidance for, discussion. It can enable debate and exchange of knowledge about the critical topics that are embedded in assumptions such as those discussed above. This could be a valuable way of structuring discussions that might otherwise just circulate a series of more or less ideological opinions. But users should be aware that there may be other options - including policy measures – that should be further examined (for example, geothermal power sources, new technologies applied to training, perhaps use of Artificial Intelligence and new approaches to data capture and analysis). Models are always imperfect accounts of the real world; and the complexity of the real world always has the capacity to generate unanticipated phenomena.

The future will certainly continue to feature challenges and opportunities. Planning processes will need to be adaptive enough to deal with these.

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