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TOOL 1

INDUSTRIAL PERFORMANCE

Structural change and productivity

EQuIP

Enhancing the Quality of Industrial Policies

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Name of tool	**Industrial Performance: Structural change and productivity**
Objective	This tool offers a general overview of the magnitude, strengths, productivity and performance of a country's industrial sector. It provides insights into the country's industrial capacity, its patterns of structural change and growth. The tool covers several dimensions of domestic production, with a focus on rigorous benchmarking and analysis to identify policy implications for enhancing industrial performance. Special attention is given to structural change and productivity.
Key questions	• Where does the country stand in terms of level of industrialization of its economy? • How has this changed over time? • What is the pace of the country's structural change? • What is the contribution of structural change to labour productivity? • How can the sources of labour productivity growth be measured? • How can the sources of differences in the levels of labour productivity across countries be measured? • What is the level of the country's capacity to produce productively – and how can this level be improved? • How does the country's capacity and growth performance compare to that of peer or benchmark countries? • What are the policy implications based on an analysis of structural change, productivity growth and capabilities?
Performance indicators	• MVA per capita • Share of manufacturing value added (MVA) in gross domestic product (GDP) • Share of employment in manufacturing • Labour productivity • Physical capital (fixed assets)* • Total factor productivity (TFP)*
Capacity indicators	• Distance to world technology frontier*

* Indicator that represents a relatively complex concept, is based on a more complex calculation, or requires more or detailed da

1 Introduction

In many developing countries, the manufacturing sector[1] has not yet reached its full potential, and there is scope for increasing the capacity to produce manufactured goods. Accordingly, the oft-observed strong and positive correlation between manufacturing growth and that of gross domestic product (GDP) can be interpreted as a case for industrial policy and for expanding the manufacturing sector's size and growth. This is often couched as structural change.

Successful episodes of industrialization are characterized by sustained industrial growth over long periods of time. This growth generates income for various actors, including firms and workers, thereby contributing to an improvement in material well-being and acting as a key driver for poverty alleviation. At the same time, industrial growth also indicates an expansion of a country's productive capacity. This reflects an increase in the productive sector's ability to meet the material needs and demands of the country's population. By increasing productive capacity, the country may reduce its dependence on imports for the supply of final goods and services, which in turn results in self-sufficiency and reduces dependency risks, thus increasing the country's likelihood of producing goods and services that are in demand in international markets.

Globalization and decades of trade liberalization have led to increased interlinkages between national economies. Consequently, local producers are now more exposed to foreign competitors, requiring them and the industrial systems within which they operate to possess a certain level of competitiveness. In turn, competitiveness depends to a large extent on firms' level of productivity. Simultaneously, global economic integration, at least in theory, has made it easier to access foreign markets.

This tool focuses on providing a methodology analysing national industrial and manufacturing capacity as well as performance, primarily in the form of productivity growth. It explores the contribution of structural change to labour productivity and how sources of labour productivity growth can be measured. It also discusses how the sources of differences in levels of labour productivity across countries can be measured.

This tool provides methodologies for analysing a country's future potential for growth in manufacturing value added. By using the measures presented here, analysts can gain insights into the magnitude and strength of the country's industrial system. Ultimately, this analysis will inform the discussion on the implications for industrial policy.

One reason why EQuIP focuses mainly on the manufacturing sector is that industrial policy in most low-income countries is primarily concerned with promoting structural change, whereby the economy shifts away from the (dominant) agriculture sector and towards (an expanding) manufacturing and services sector. Moreover, empirical evidence and history have demonstrated that the manufacturing sector plays a strategic role in countries' development process. Manufacturing has historically been the primary source of innovation and productivity growth in modern economies, with manufacturing firms' research and development (R&D) activities serving as major drivers of technological progress.

Manufacturing also plays a crucial role in diffusing new technologies to other sectors of the economy. Additionally, manufacturing activities typically have strong linkage and positive spillover effects on

[1] An economy consists of three economic sectors: agriculture, industry and services. The manufacturing sector is a subsector of industry. The remaining industrial subsectors are electricity and gas, water supply, mining and construction.

other industries. That is, the manufacturing sector, as an important consumer of financial, transport and communication services but also of raw materials and agricultural products, is a critical source of demand for products and services provided by other sectors. Consequently, manufacturing has strong forward and backward linkages to other sectors, thereby contributing to improvements in productivity, domestic investment, employment, and economic growth in countries' development process.

As per capita income rises, the share of agricultural products in total household expenditure falls, while that of manufactured products increases. That is, many manufactured goods are characterized by a higher income elasticity of demand, offering significant opportunities for future demand, market expansion, output growth and exports. Industrial manufacturing also has the potential to generate high-quality jobs with higher wages relative to agriculture and traditional manufacturing processes. As a country's population grows and becomes more urbanized, there is a need for manufacturing employment to grow to absorb the displaced agricultural labour.

Despite the critical role manufacturing plays in countries' development process, policymakers should not prioritize industrial development at the expense of other sectors. In fact, the manufacturing sector's productivity and competitiveness are also influenced by the availability of producer services and supply of resources and agricultural inputs. Sustainable industrial development should therefore also be understood through the lens of its complementarity with other sectors such as agriculture and services. In this context, the challenge for policymakers is how to create mutually supportive linkages between the industrial and non-industrial sectors of the economy.

The purpose of this tool is to provide a means to analyse, measure and understand the scale and performance of a country's economy, with a particular focus on manufacturing. It outlines how an analysis of a country's manufacturing capacity and growth can be conducted. To provide a comprehensive analysis of a country's industrial development trajectory, this tool suggests a set of indicators to monitor the country's economic structure, how it has changed over time, and its capacity to produce.

But what is manufacturing performance and how should it be measured? Measuring performance in absolute terms poses numerous challenges. Simply stating that Country A's manufacturing value added was x dollars could lead to different interpretations. In the context of this tool, performance can be understood as something that increases ("more is better"), but as we will see below, it can also be viewed in terms of efficiency, e.g. using fewer inputs per output. Another way to assess performance is by comparing, say, the production level of country A with that of country B. Performance can also be evaluated over time, e.g. by comparing a country's current value added relative to that of last year, or the amount of value added produced relative to the country's potential amount given its endowments.

What is sometimes lost in the discussion is that industrial performance is not an end in itself—it is a contributor to the overall economy and, consequently, to the welfare of a country's citizens. Therefore, it could be argued that industrial performance is best understood by its *contribution* to the overall economy, which implies that the decomposition of an aggregate (e.g. GDP) into its different parts (e.g. primary, secondary and tertiary sectors) must account for changes in the aggregate's structure. Separating such changes from sectoral contributions gives a misleading picture and risks leading to weak or, in the worst case, erroneous policy design.

One indicator often used is the share of manufacturing value added in GDP. This share rises in most developing countries as the country develops. However, for those developing countries that have started to transition into the tertiary sector, this indicator may actually decline. But does this decline automatically imply a decline in industrial performance? The answer is no – it simply means that other economic activities contribute higher shares to GDP. This highlights the importance of not relying on only one indicator to measure [industrial] performance and instead to measure performance based on a *set* of indicators or more comprehensive (or composite) indicators.

For example, sectoral labour productivity is generally recognized as an important and comprehensive indicator, as it contains richer information on economic performance than simple sector shares.[2] Interestingly, if the manufacturing value added-GDP ratio decreases, manufacturing labour productivity could increase. In the former case, it could be assumed that [one type of] performance has decreased, while in the latter case, that it has improved—which one is correct?

Tool 1 provides tractable ways to answer this question correctly and with reliable accuracy. We offer a battery of performance indicators and clearly explain <u>what</u> they measure (and what they do not measure!) and <u>how</u> these indicators are measured. Ample examples are provided of how these indicators can be combined, contrasting them with the alternative of using a single indicator.

Moreover, the issue of benchmarking is explored in depth. As mentioned above, it is important to compare the performance of a country or subsector with that of another to assess performance. However, it is not insignificant who this "other" is. Our goal is to understand how far a country's industry is from reaching its full potential – that is one of the key purposes of performance benchmarking. Using the example of labour productivity, we want to know whether Country A's level of productivity is the highest attainable given its capabilities. By identifying countries with similar characteristics, such as a comparable capital per worker ratio, we can measure the distance from Country A to the best performer, or to a given technological frontier. This gap indicates how much room for improvement there is for Country A and can be used to inform the design of industrial policies aimed at catching up with the frontier.[3]

Country A can also be compared with other countries that are more dissimilar. For instance, how far away is Country A from the best performers in the world or from the OECD average? Country A may want to compare its performance with that of its neighbours, with a regional average or even a trade area such as Mercosur. It is important to note, however, that this comparison is not intended to measure industrial performance and determine how much better Country A *should* be able to perform, but serves a different purpose.

Apart from catering to a large set of developing countries and introducing new indicators and a more solid approach to benchmarking, one issue that has often been raised by users of EQuIP tools is: "We now know the position of our manufacturing sector and how it is performing, but what should I [as a

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[2] Another common performance indicator is competitiveness. While it is an attractive concept, competitiveness is not easily quantified. Labor productivity, on the other hand, is a straightforward measure. Incidentally, the most important source of competitiveness is productivity, especially in terms of price competitiveness. The only way to reduce the price of a product or service, apart from dumping and similar shady activities, is to reduce the cost of production (the flipside of productivity and more akin to efficiency). In a competitive market, higher productivity allows for production at lower marginal cost; in a non-competitive market, the average cost can be reduced. However, in the latter case, there might be other reasons apart from productivity per se behind the lower average cost, such as scale economies. Competitiveness plays a central role in the probability of being able to start exporting. Research has shown that firms able to overcome the fixed (or sunk) costs associated with entering international trade are those that will export. The main predictor for such competitiveness is productivity (Clerides, Lach and Tybout (1998) made a seminal contribution in this regard. See also Granér and Isaksson (2002) and Foster-McGregor and Isaksson (2014; 2016).

[3] Importantly, this is not about comparing, say, Cambodia with the United States or Germany, but rather with countries such as Viet Nam and Bangladesh, which have capabilities that are more comparable with those of Cambodia.

policymaker] do about it?". One way to address this question is to discuss policy in terms of capabilities, along with the different measures of performance. Once the position of a country's industry has been determined, Tool 1 includes a section that discusses capabilities and policies that can help improve that country's position within the scope of existing resources. The policy often involves expanding on those resources.

The key questions analysts will learn to address with this tool include: What is the country's position in terms of its economy's level of industrialization? What can be said about its capacity to produce competitively? How has this capacity changed over time? What is the impact of a country's manufacturing sector on the performance of the country's total economy? How does its capacity and growth performance compare with that of peer or benchmark countries? And what is the potential of its future growth?

This tool does not explicitly show calculations on the subsector level, but the basic ideas remain the same. Where necessary, it refers to different data sources and to possible differences from the calculations at the country level. This tool emphasizes the rigour of the analysis. We hope that this does not compromise one of EQuIP's main advantages, namely its accessibility for a non-technical audience of policymakers. However, accessibility should not come at the expense of a proper analysis. This tool aims to strike a balance between these two goals: accessibility and rigour. After all, what good is an analysis if it is fraught with errors, especially if the ultimate goal is evidence-based industrial policy?

Indicators and analyses that are considered technically challenging or have significant data limitations are denoted with one asterisk "*". Of course, all users, technical and non-technical, are encouraged to explore the material in its entirety.

2 Relevance for the industrial policymaking process

Tool 1 focuses on diagnosing the performance of manufacturing by determining whether the country's manufacturing sector is able to achieve its potential, both in relation to its "own" limits and in an international context. This can be considered the first step towards defining *policy areas*, that is, areas that require attention. For example, if a country with similar characteristics or endowments is able to produce twice as much as the country under analysis, it suggests that implementing a well-designed industrial policy could enhance performance.

This tool also analyses data over time to assess significant structural shifts, such as a structural change between primary, secondary and tertiary sectors as well as between sub-sectors within manufacturing.[4] The goal is to achieve shifts from the primary sector/low-tech sector to the secondary and tertiary/medium- and high-tech sectors over time. If such shifts do not take place, it may indicate a need for policy interventions that address bottlenecks and other obstacles. The issue of structural change is addressed from both the output and input perspectives.

A third policy-relevant area that is related to the aforementioned one is policy evaluation. While delving deeper into policy evaluation is beyond the scope of this tool, it can provide an initial indication of whether a policy is achieving the desired outcome. For example, by analysing time series data, past policy interventions can be correlated with changes in performance. For instance, it is expected that a policy that promotes the adoption of advanced technology will be reflected in enhanced productivity, an increased rate of structural change, and a narrowing of the technology gap compared to the global technology frontier. If this is not the case, policymakers have to investigate the reasons why these changes have not taken place.

Finally, while EQuIP does not aim to provide a comprehensive solution to the question of what policymakers can do to address a given policy challenge, it provide some guidance. Specifically, this tool uses a production framework that considers the input side of production and the economic environment to suggest which "policy buttons" need to be pressed to improve output performance.

[4] Structural change refers to the shift of activities and resources between sectors and subsectors.

3 Methodology and indicators

This section provides a guide on how to calculate a selection of basic indicators for measuring manufacturing performance in terms of domestic production. While acknowledging the multiple possible interpretations of these indicators, the section then explores approaches that offer a better understanding of manufacturing performance by considering its contribution to aggregate performance indicators, such as GDP growth. This approach significantly reduces the uncertainty associated with measuring performance using basic indicators.

The section addresses questions such as: Which indicators can be used to measure manufacturing performance, impact and growth? How are they calculated? Which data are needed, and where can the appropriate data to answer these questions be found? How do the data need to be manipulated?

We begin with simple, yet somewhat ambiguous, indicators such as manufacturing value added per capita, manufacturing value added in GDP and manufacturing employment shares in total employment, and then move to more robust indicators such as manufacturing productivity. These indicators are relatively informative when dealing with economies in the process of industrializing, typically low-income countries. However, when including countries that may have already peaked in terms of industrialization and where structural change is more advanced, these simple indicators become increasingly misleading. This is because they start to decrease even when the changing composition of manufacturing results in a larger contribution of manufacturing to overall growth. For instance, all else being equal, a smaller share of high-tech production in the manufacturing sector's contribution to GDP is likely to contribute more to overall productivity growth than a large share of low-tech manufacturing. Therefore, it is argued that for this class of indicators, manufacturing performance is best assessed in terms of manufacturing's contribution to GDP growth and aggregate productivity growth.

3.1 Manufacturing performance

To illustrate how the methodology presented in this tool can be applied, methodological discussions are accompanied by concrete examples, using data from different countries around the globe. In principle, all calculations can be conducted at any level of aggregation, that is, the level of aggregation has no bearing on the methodology *per se*.[5] However, in reality, data availability dictates which calculations can actually be conducted in which context. The analyst will need to carefully explore the available data.

Indicator 1: Manufacturing value added per capita

We begin by examining a broad indicator that provides an initial overview of the manufacturing sector's performance: manufacturing per capita. While closely related to manufacturing per worker (see below), these two indicators should not be confused. They often offer different insights into manufacturing performance because they measure different types of performance. However, there

[5] It is important to note that the concept of MVA only applies to manufacturing as a whole. As soon as the analyst moves to subsector analyses (2-digit, 3-digit or 4-digit ISIC subsector), the sum of value added is not necessarily equal to MVA. This is because the data for the different levels of aggregation are derived from different sources with slightly different meanings.

are instances where they convey a similar story if their components move in a similar direction. The difference between the two indicators lies in the fact that employment (i.e. workers) is calculated as a percentage of the population, and the two indicators may thus diverge based on factors such as labour force participation. For example, if the size of the population increases between two years while the number of workers decreases during the same period, manufacturing per capita will decrease while manufacturing per worker will increase. This shows why the analyst must exercise caution when interpreting the two indicators as measures of manufacturing performance.

Production capacity is the maximum amount a country can produce when all production factors are fully utilized. MVA per capita is sometimes used as a capacity indicator. This is erroneous, however, because manufacturing per capita could only be used as a capacity indicator if production factors are *fully* employed. However, it is known that unemployment and underemployment are widespread in many developing countries, rendering this an inappropriate capacity indicator because the full employment condition is not met. Such underutilization also extends to other production factors such as equipment and machinery, which often operate at less than full capacity. **Table 1** presents the variables and possible data sources (Error! Reference source not found.) used for creating this simple indicator.

Table 1: Manufacturing per capita

Indicator	Variable	Source
MVA per capita	Manufacturing value added (MVA)[6]	NSO, UNIDO or WDI
	Population	NSO, WDI, UN Statistics
Change in MVA per capita	Change in MVA	NSO, UNIDO or WDI
	Change in population	NSO, WDI, UN Statistics

Note: All in constant 2010 US dollars.

NSO = National Statistics Office; WDI = World Development Indicators (World Bank)

Box 1. Choosing data sources

Some of the indicators used in this tool are drawn from several data sources, because several data sources contain the same information. For example, UNIDO provides the World Bank (World Development Indicators, WDI) with data on MVA. Hence, the same information can be obtained from either UNIDO or the World Bank, except in cases where the World Bank (in this case) makes independent adjustments to the data. Another example is data on population, which is compiled by UN Statistics in New York and shared with WDI. In nearly all cases, National Statistics Offices (NSOs) serve as the original data sources. Disaggregated data are often only available from NSOs. Yet which data source is best? One advantage of using primary sources, such as NSOs, is that the data often have not been manipulated, e.g. no inter- or extrapolation, smoothing or any other adjustments have been undertaken, meaning the analyst can work on the raw data. Moreover, WDI does not always cover all countries for all data required and it might therefore be useful to "add" data from primary sources (take note of the point on data inconsistency below). One possible disadvantage could be that the analyst does not have the

[6] Manufacturing value added is the manufacturing sector's net output after adding up all outputs and subtracting intermediate inputs. It is calculated without any deductions for depreciation of fabricated assets or depletion and degradation of natural resources.

wherewithal to make meaningful adjustments to the data series drawn from NSOs, which secondary data sources may do in some cases. A secondary source such as the WDI might be preferable to combining primary sources because data across time and countries, as well as means of data revisions, ought to be consistent. Sometimes the analyst has no other choice but to combine different data sources (Table 8 in this document is such an example). On the other hand, combining data from several primary sources could introduce errors that lead to data inconsistencies. It is generally always useful to compare primary and secondary data sources for differences, especially when there are large shifts in data series, and to understand what has caused these shifts and whether they are justified. In cases where the primary or secondary data source introduces what seems to be an error, the analyst is advised to research the data and then choose the data source that is deemed more credible (and not the one that produces the most convenient result!).

It is important to scale manufacturing (in this case) with population because large economies will automatically have higher absolute levels of manufacturing value added based on sheer country size irrespective of performance. Scaling by population moves us closer to the notion of performance: what is the volume of manufacturing production when country size has been accounted for? Error! Reference source not found. discusses different ways of measuring monetary values.

Box 2. Prices

The description of the indicator specifies whether monetary values are measured in current or constant prices. When studying values over time, in particular, it is advised to use values in constant prices as they are corrected for inflation. Otherwise, an increase in a value may in part be attributable to inflation instead of a real increase (in quantities). Technically speaking, the conversion of a current price series to a constant prices series is called deflation, and the price index used is called the deflator.

Strategic questions:

- What is the country's volume of manufacturing production per person, i.e. when differences in terms of country size have been accounted for?

Calculation: MVA per capita is calculated as:

$$MVApc_A = \frac{MVA_A}{POP_A}$$

MVA_A *= Manufacturing value added of Country A*
POP_A *= Population of Country A*

Variables required	Data source	Notes
MVA and population by country	World Development Indicators (link) UNIDO INDSTAT (link)	The indicator is readily available in WDI without the need for calculation. In case the analyst wants to calculate the share of value added in GDP for a given subsector, UNIDO's INDSTAT database should be used.

Table 2 presents 12 countries that are used as examples for all of this tool's indicators. Four of them represent the most (technologically) advanced economies, while the others were chosen based on their geographic location.

Table 2: MVA per capita, level and change, 1970–2018

	MVA per capita (constant 2010 US$)			Change in %		
	1970	**2000**	**2018**	**1970–2018**	**1970–1999**	**2000–2018**
AZE	535	93	302	–2.42	–17.08	6.40
CHI	859	1,877	1,761	1.48	2.45	–0.34
CHN	64	561	2,254	7.53	7.21	7.60
CZE	4,455	3,839	5,984	1.02	–2.22	2.36
EGY	159	356	485	2.31	2.78	1.64
GER	6,767	8,658	10,761	0.97	0.67	1.15
JPN	6,632	9,498	9,980	0.84	1.10	0.26
KEN	91	116	100	0.18	0.70	–0.77
KOR	349	4,427	7,804	6.54	8.43	3.03
MOR	203	410	607	2.26	2.36	2.09
URU	1,202	1,207	1,873	0.91	0.33	2.34
ZAM	238	96	107	–1.62	2.75	0.53

Data Source: World Bank (2020).

Note: Change calculated as compound annual growth rate (CAGR). Years for AZE and CZE = 1990–2018. AZE=Azerbaijan, CHI=Chile, CHN=China, CZE=Czechia, EGY=Egypt, GER=Germany, JPN=Japan, KEN=Kenya, KOR=Republic of Korea, MOR= Morocco, URU=Uruguay and ZAM=Zambia.

A discussion covering all countries and regions in the world can be found in A. Isaksson (forthcoming), "Industrial Policy, Productivity and Structural Change".

Box 3. Calculating indicators at more disaggregated levels

While the concepts also hold when calculating this indicator at the subsector level (e.g. for the food and beverages industry), the data sources are different and the analyst must be aware of some practical issues. Sectors and subsectors are organized according to the International Standard Industrial Classification (ISIC). The broadest sectors (ISIC 1-digit) are agriculture, industry and services. Data on manufacturing subsectors (ISIC 2-digit, 3-digit or 4-digit) are provided by UNIDO INDSTAT. The analyst should take note that MVA (as shown above) and total value added in INDSTAT are not necessarily the same, as different data sources are used based on different methods of calculation.

Two revisions of ISIC are currently in use, 3.1. and 4. Some international databases use one or the other revision, while others use both. In revision 3.1, manufacturing subsectors are 15–37; in revision 4, they are 10–33. The list of subsectors is available in the Annex.

Table 2 presents the MVA per capita levels for 1970, 2000 and 2018 and three periods of annual average growth rates – the full-time period and two sub-periods: up to the year 2000 and after 2000.

MVA per capita serves as a preliminary measure of manufacturing performance, the indicator's main advantage being its simplicity. The major drawback is the denominator. A relatively large share of the population in many developing countries is not engaged in productive activities. This may be due to high levels of unemployment and under-employment and due to the large and growing share of young people in the population. As such, the indicator says more about how much MVA is available to citizens rather than about manufacturing performance—the latter requires a measure of labour input. If we had used labour input here, the indicator would have been manufacturing labour productivity, which is a much better and accurate performance indicator than MVA per capita. That indicator is addressed later in the tool.

As expected, most of the countries included in **Table 2** have seen increases in MVA per capita over time. The exceptions are Azerbaijan—which experienced a major structural reconstruction after the fall of the Soviet Union—and Kenya and Zambia, whose manufacturing performance appears to have already peaked based on this indicator.

Another important observation is the phenomenal growth of China and the Republic of Korea, although the latter is showing early signs of stagnation and convergence with its OECD partners, Germany and Japan. Chile's performance in terms of manufacturing per capita seems to have also already peaked. Finally, both Egypt and Morocco are showing encouraging signs of ongoing industrial development. Do these results hold once indicators that are closer to true performance such as labour productivity are used?

Indicator 2: Share of manufacturing in GDP

Another crude indicator that sheds light on the significance and strength of a country's manufacturing sector is share of MVA in GDP, which can be interpreted as a measure of the manufacturing sector's contribution to GDP. Its primary advantage lies in its simplicity of computation. Another advantage is that we can gain insights into the output side of structural change by studying its development over time. This comes with a major caveat, however, since that share tends to decrease for advanced economies without necessarily suggesting that manufacturing is less of a *contributor* to the overall economy. For example, the content of manufacturing matters in this regard and, everything else being equal, manufacturing with a higher content of medium- and high-tech is likely to generate a larger contribution in terms of productivity than labour-intensive manufacturing. In addition, manufacturing with strong domestic and foreign backward and forward linkages, including to the non-manufacturing sector, is likely to contribute more to spillover effects, other positive externalities and aggregate productivity than an enclave type of manufacturing.[7] The inability of this indicator to capture such contributions is a major drawback.

With this caveat in mind, **Table 3** lists the necessary variables to calculate this indicator.

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[7] Spillovers refer to the impacts subsectors can have on other subsectors because of their linkages to them either on the input or output side. These can be positive (reinforcing positive developments such as increased demand) or negative.

Table 3: Manufacturing's contribution to GDP

Indicator	Variable	Source
Share of MVA in GDP	Manufacturing value added (MVA)	NSO, UNIDO or WDI
	Gross domestic product (GDP)	NSO, WDI
Change in share of MVA in GDP	Change in MVA	NSO, UNIDO or WDI
	Change in GDP	NSO, WDI

Note: Evaluated as MVA in current prices divided by GDP in current prices.
NSO = National Statistics Office; WDI = World Development Indicators (World Bank)

This indicator sheds light on the level of national industrialization and can be compared with the contribution of other sectors (such as agriculture or services, which are not shown here) to total output as well as to the share of manufacturing in GDP in comparator countries. In this context, it is also interesting to study the evolution of the share of manufacturing in GDP over time, which represents one aspect of structural change. This can either be measured as percentage changes or as changes in percentage points – we have opted for the former.

Strategic questions:

- What is the level of manufacturing's contribution to the domestic economy? What is the share of MVA in GDP?

Calculation: The share of MVA in GDP is calculated as:

$$MVAinGDP_A = \frac{MVA_A}{GDP_A}$$

MVA_A = Manufacturing value added of Country A

GDP_A = Gross domestic product of Country A

Variables required	Data source	Notes
MVA and GDP by country	World Development Indicators (link) UNIDO INDSTAT (link)	The indicator is readily available without the need for calculation in WDI. In case the analyst wants to calculate the share of value added in GDP for a subsector, they should use UNIDO's INDSTAT database.

Table 4 presents the indicator and its evolution over time for the same 12 countries as above.[8]

[8] As in the case of manufacturing per capita, the calculation here can be easily conducted at any level of aggregation or for any subsector (not shown here). For example, the analyst can calculate a subsector's value added as a share of GDP or as a share of all manufacturing subsectors' value added. The latter shows the subsector's significance relative to all manufacturing subsectors.

Table 4: Share of MVA in GDP, level and change, 1970–2018

	Share of MVA in GDP (%)			Change in %		
	1970	2000	2018	1970–2018	1970–1999	2000–2018
AZE	19.37	5.60	5.23	–4.41	–10.68	–0.36
CHI	18.87	19.93	11.64	–0.98	0.13	–2.79
CHN	28.06	31.72	29.07	0.07	0.40	–0.46
CZE	31.85	25.93	25.63	–0.75	–2.34	–0.06
EGY	21.73	17.96	16.67	–0.54	–0.44	–0.39
GER	34.18	22.79	22.65	–0.84	–1.43	–0.03
JPN	35.46	22.52	20.40	–1.12	–1.52	–0.52
KEN	15.28	14.10	8.30	–1.24	–0.42	–2.75
KOR	19.25	29.31	29.16	0.85	1.29	–0.03
MOR	19.81	20.52	17.80	–0.22	0.13	–0.75
URU	21.20	14.40	12.82	–1.02	–1.28	–0.24
ZAM	15.04	10.17	6.38	–1.74	–1.04	–2.42

Data Source: World Bank (2020).

Note: Change is calculated as compound annual growth rate (CAGR). Years for AZE and CZE = 1990–2018. AZE=Azerbaijan, CHI=Chile, CHN=China, CZE=Czechia, EGY=Egypt, GER=Germany, JPN=Japan, KEN=Kenya, KOR=Republic of Korea, MOR= Morocco, URU=Uruguay and ZAM=Zambia.

A discussion covering all countries and regions in the world can be found in A. Isaksson (forthcoming), "Industrial Policy, Productivity and Structural Change".

Two sub-Saharan African countries, Kenya and Zambia, together with Azerbaijan are the only counties with single-digit MVA shares in GDP in 2018. The two OECD countries included have a high and stable MVA share in GDP, but China and the Republic of Korea achieved the highest shares of MVA in GDP at nearly 30 per cent.

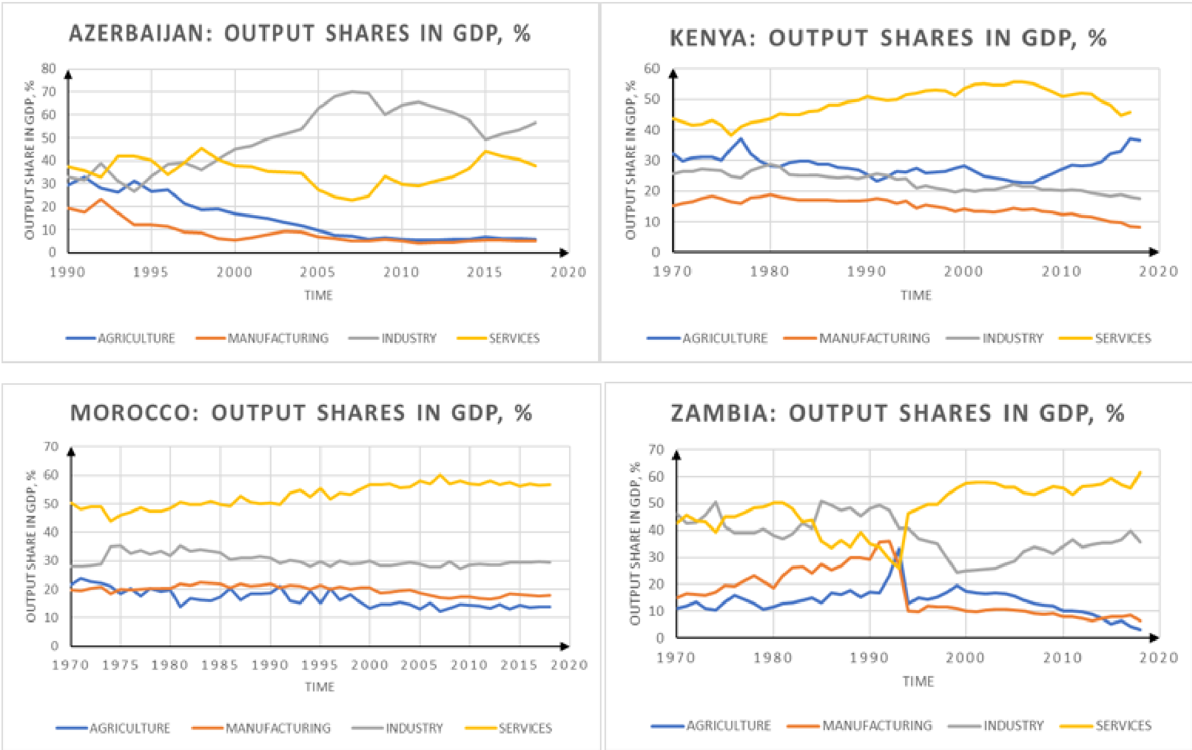
Secondly, the share of MVA in GDP fell in all countries over the entire time period with the exception of China and the Republic of Korea, while it declined for all countries during 2000–2018.[9] In other words, according to this measure, all countries included recorded a reduction in the contribution of MVA to GDP. Some scholars (e.g. Rodrik, 2023) refer to this phenomenon as [premature] deindustrialization. Caution should be exercised when drawing such drastic conclusions, as the indicator is a ratio and can decrease without any change in the share of MVA in GDP. For example, an increase in GDP could result from an increase in the contribution of the construction industry or service sector and thus be the reason behind a decrease in the output share of MVA. It is not clear whether this is necessarily associated with (premature) deindustrialization. While Azerbaijan has seen

[9] While it is common to calculate sectoral shares using current prices for both the numerator and denominator, primarily due to data availability, it is important to be mindful when the prices of two distinct aggregates develop in different directions or at significantly different speeds. For example, the recent commodity boom has influenced the results from 2000–2018 (i.e. with commodity prices rising faster than prices of manufactured goods), resulting in decreasing shares, all else being equal.

a plunge in the share of MVA in GDP following the collapse of the Soviet Union, the developments in Kenya and Zambia are particularly concerning. One would have expected to see increasing shares in these two countries, but they actually experienced decreasing shares even before the turn of the millennium.

For a comprehensive analysis of the evolution of structural change (shifting contributions of sectors to GDP), a graphical approach is more effective. **Figure 1**[10] provides such an illustration, depicting the corresponding shares of value added by sectors in GDP.[11]

Figure 1: Contribution of manufacturing to GDP (%)



Data Source: World Bank (2020).

Note: A discussion covering all countries and regions in the world can be found in A. Isaksson (forthcoming), “Industrial Policy, Productivity and Structural Change”.

One important observation is that the share of agriculture in GDP is sharply declining in all countries, indicating an ongoing industrialization (and/or servicification) process. Some of the countries, for example Kenya and Morocco, still have sizeable agricultural sectors, while it has already played a negligible role in OECD countries for a long time.

A second observation is that the contribution of all non-agricultural sectors is on the rise everywhere, albeit at different speeds. While the share of manufacturing in GDP seems to have peaked in several of the countries included, it still plays a prominent role in many economies. It is important to note,

[10] For brevity, not all countries included in the tables are shown here. The remaining country graphs are available in Annex A8.

[11] The shares of agriculture, industry and services add up to 100 per cent (manufacturing is a subsector of industry). The analyst can calculate these shares the same way as MVA in GDP. For most countries, the data are available in WDI.

however, that the share of manufacturing in GDP only provides a first glimpse of the significance of manufacturing; the size of this share alone can sometimes be misleading. One case deserves special attention. Zambia has witnessed a sharp drop in its share of manufacturing in GDP, which can likely be attributed to a period of political turmoil and high inflation, followed by the implementation of harsh monetary policies, with high real interest rates making domestic investment expensive. This coincided with a severe drought, which severely impacted the agricultural sector.

Industry's share in GDP has remained relatively stable in most cases, and has reached significant levels. The share of industry has been expanding, particularly in Azerbaijan, even more than the services sector. The trend in all other countries illustrates a steady increase in the share of services in GDP.

Indicator 3: Share of manufacturing in total employment

Structural change and manufacturing's contribution to the country's economic structure can also be measured in terms of input by way of share of employment. Structural change not only implies that the relative importance of various sectors' output changes, but inputs to production such as labour also shift from one activity to another. Shifts in employment shares are another way to gauge the contribution or performance of manufacturing. Compared to output shares, one advantage of considering labour shares is that it limits concerns about the impact of price effects, such as during commodity booms. However, an indirect impact could be possible due to changing relative wages and relative labour demand (a typical case being relative wage changes in relation to Dutch Disease in favour of the non-tradeables sector).[12] A favourable labour shift (i.e. from agriculture to manufacturing) generally indicates an increase in the contribution of manufacturing to GDP and is usually associated with improved manufacturing performance.

The theory of structural change is largely based on the economic structure of low-income countries, characterized by a predominant, relatively unproductive agricultural sector with surplus labour, and a small but relatively productive and relatively capital-intensive manufacturing sector. Structural change and economic growth are driven by a shift of activities and labour from agriculture to manufacturing (see, for example, Lewis, 1954; Chenery, 1960, 1979; Syrquin, 1988). The underlying economic concept is referred to as production function, which describes how the production of output is related to production factors such as labour, capital, land and technology. Labour input is not the only production factor that can shift, however, while land is in principle fixed[13] and capital input is quasi-fixed (fixed in the short term, but flexible otherwise), workers are highly mobile. Extending the production function further, other inputs can also be considered (e.g. capital, land and intermediate inputs) as can the sectoral allocation of these inputs. Here, we only consider labour shifts (**Table 5)**.

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[12] One typical example of Dutch Disease is the discovery in a country of a natural resource which is then exploited and exported. This results in high inflows of foreign currency, leading to an appreciation of the exchange rate, which in turn decreases the attractiveness of manufacturing exports as a result of price increases and often leads to job losses. Additionally, the windfall gains from the resource discovery often increase demand for non-tradeables such as services, driving up labour demand and relative wages in that sector. The term "Dutch Disease" originated from the effects on the Dutch economy of the discovery of natural gas in the North Sea in 1959.

[13] In the long run, one may consider the measure letting land to industry instead of to agricultural activities.

Table 5: Manufacturing's contribution to total employment

Indicator	Variable	Source
Share of manufacturing employment in total employment	Manufacturing employment	NSO or WDI
	Total employment	NSO, WDI
Change of manufacturing employment in total employment	Change in manufacturing employment	NSO or WDI
	Change in total employment	NSO, WDI

NSO = National Statistics Office; WDI = World Development Indicators (World Bank)

Box 4. Employment vs. employees

As will be discussed below, there are different measures for labour inputs. One major distinction is employment, which includes the self-employed, vs. employees, which does not include them. Ideally, when choosing between the two, employment is the more correct variable, because the self-employed account for an important share of the working population in many countries. However, when the analyst calculates this indicator for the subsector level, data on employment become scarcer. UNIDO's INDSTAT database provides data on employees at the 2-digit subsector level, ILOSTAT reports employment at the subsector level for some countries. The analyst must select comparator countries and use the measure that is available for all or at least most of them to ensure that the numbers are comparable.

Strategic questions:

- What is the share of manufacturing employment (employees) in total employment (employees)?

Calculation: The share of manufacturing employment is calculated as:

$$Empl_A^{share} = \frac{Empl_{A,mnf}}{Empl_A}$$

$Empl_{A,mnf}$ *= Employment (or employees) of all manufacturing (mnf) subsectors in Country A*

$Empl_A$ *= Total employment (employees) in the economy*

Variables required	Data source	Notes
Employment or employees by economic sector	World Development Indicators (link) UNIDO INDSTAT (link) ILOSTAT (link)	The indicator is readily available for manufacturing without the need for calculation in WDI. In case the analyst wants to calculate a subsector's employment share, they should use UNIDO's INDSTAT database or ILO's ILOSTAT database.

Table 6: Manufacturing employment in total employment, level and change, 1970–2018

	Manufacturing employment in total employment (%)			Change in %		
	1970	**2000**	**2018**	**1970-2018**	**1970-1999**	**2000-2018**
AZE	5.86	4.57	5.22	–0.40	–1.81	0.70
CHI	16.56	14.01	10.35	–0.96	–0.48	–1.58
CHN	19.66	19.41	20.34	0.07	0.05	0.24
CZE	31.40	27.40	27.55	–0.45	–1.24	0.03
EGY	13.97	11.91	12.22	–0.27	–0.19	0.14
GER	25.90	23.76	19.07	–0.62	–0.29	–1.15
JPN	23.89	20.61	16.25	–0.78	–0.44	–1.25
KEN	13.90	8.95	2.66	–3.32	–0.88	–6.18
KOR	25.92	20.29	16.81	–0.88	–0.89	–0.98
MOR	12.98	12.52	10.49	–0.43	–0.09	–0.93
URU	16.78	15.14	10.41	–0.97	–0.26	–1.95
ZAM	4.28	3.94	4.29	0.01	–0.25	0.46

Data Source: World Bank (2020).

Note: Change calculated as compound annual growth rate (CAGR). Years for AZE and CZE = 1990–2018. AZE=Azerbaijan, CHI=Chile, CHN=China, CZE=Czechia, EGY=Egypt, GER=Germany, JPN=Japan, KEN=Kenya, KOR=Republic of Korea, MOR= Morocco, URU=Uruguay and ZAM=Zambia.

Note: A discussion covering all countries and regions in the world can be found in A. Isaksson (forthcoming), "Industrial Policy, Productivity and Structural Change".

Table 6 is to a large extent in line with the picture that emerges when examining output shares. However, manufacturing employment shares are generally lower. For example, in 2018, China's employment share in manufacturing was around 20 per cent, while the sector's output share was 30 per cent. An interesting contrast emerges between the two transition economies, Azerbaijan and Czechia, where the former country's industry is dominated by extraction and the manufacturing sector's employment share is as low as 5 per cent, while manufacturing is still a significant activity in the latter country with a share of manufacturing employment close to 30 per cent.[14]

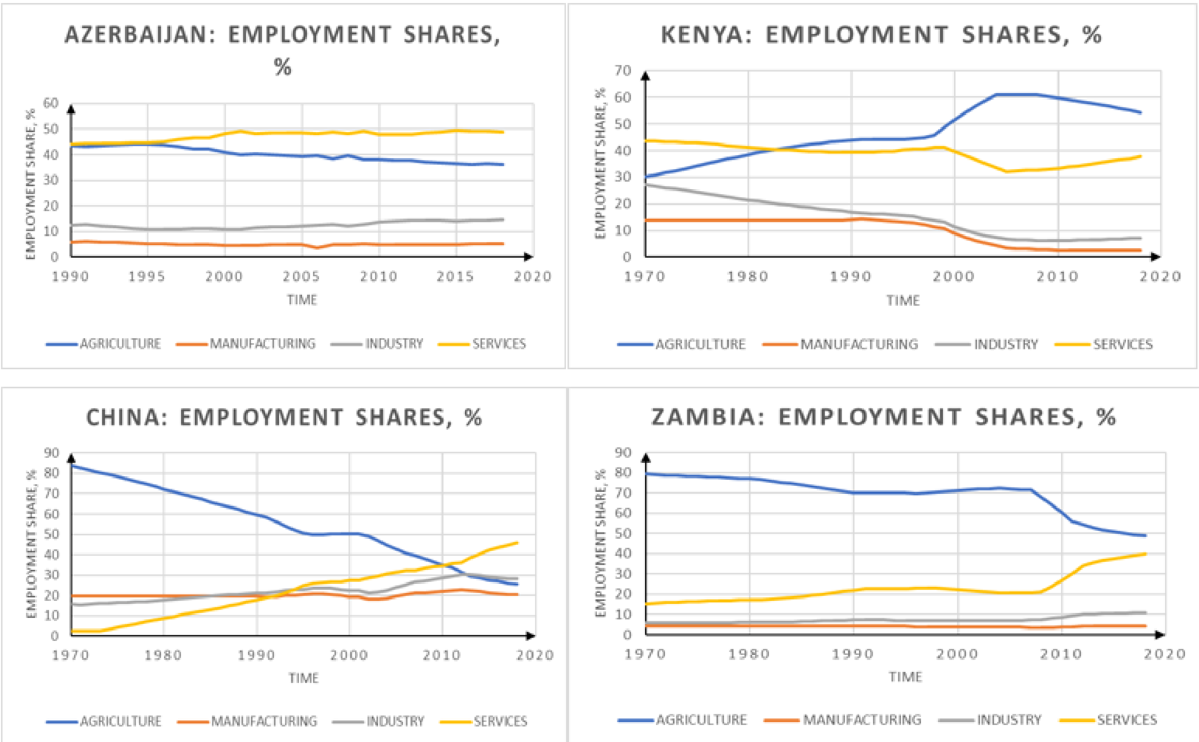
Interestingly, both Germany and Japan continue to have a relatively large share of employment in manufacturing activities. A far more concerning picture emerges when we look at developing countries outside of Asia, where manufacturing has absorbed around 10 per cent of the workforce or less. The shares of manufacturing employment in sub-Saharan Africa indicate low manufacturing activity, with Zambia primarily focusing on extractive industries, with a corresponding industry employment share of slightly over 10 per cent. What is also concerning are the overall declining trends, with China being the only exception. The period leading up to the turn of the millennium seems

[14] One important distinction between manufacturing and industry is that the latter is a broader concept that also encompasses extractive industries such as mining.

to have witnessed falling employment shares in manufacturing and there are some weak signs of reversal in some countries thereafter, albeit often starting from low levels.

As in the case of output shares, Figure 2[15] illustrates the overall structure of the economy (in terms of employment) and its development (structural change) over time. All developing and transitioning countries with the exception of Kenya exhibited a sharp decline in agricultural employment shares, with Azerbaijan, Kenya and Zambia maintaining a high level of agricultural employment. Kenya's agricultural employment share is *increasing*, a trend that was weakly visible in terms of output shares as well.

Figure 2: Manufacturing's contribution to total employment (%)



Data Source: World Bank (2020).

Note: A discussion covering all countries and regions in the world can be found in A. Isaksson (forthcoming), "Industrial Policy, Productivity and Structural Change".

Manufacturing employment seems to have been stable throughout the period under investigation, although a gradual decline is evident in most cases, which aligns with the trend seen for output shares: manufacturing seems to have also peaked in many developing countries. As expected, workers are increasingly transitioning to the tertiary sector, i.e. services. This shift has taken place worldwide, albeit at different rates. In most cases, industry seems to, by and large, be reflecting the patterns seen in manufacturing. Any discrepancies that arise tend to be the result of variations in level rather than in slopes.

[15] For brevity, not all 12 countries are shown here; the remaining ones are available in the Annex.

Indicator 4: Labour productivity

We have argued that the previous indicators only offer a partial picture of manufacturing's contribution to GDP. These indicators allow for multiple interpretations, and sometimes even convey contradictory messages. This in part is due to the fact that they either only consider the output (value added) or the input (employment) side, or because changes in demography are taking place without any corresponding changes in manufacturing production, resulting in a change in the indicator that is unrelated to manufacturing output.

One indicator of manufacturing performance that provides information on both production and employment is manufacturing labour productivity. Although productivity can be measured for all production factors as well (an indicator called total factor productivity, also referred to as multi-factor productivity), we use labour productivity here (for a discussion on other productivity measures that elaborate on various productivity indicators and their relative merits, see, for example OECD, 2009; Hulten, 2001).

Labour productivity equals an output measure, e.g. GDP or MVA, divided by a measure of labour input (L), resulting in GDP/L or MVA/L. The data sources are the same as before (**Table 7)**.

Table 7: Manufacturing labour productivity

Indicator	Variable	Source
Labour productivity	Manufacturing value added (MVA)	NSO, UNIDO or WDI
	Labour input	NSO, WDI
Change in labour productivity	Change in MVA	NSO, UNIDO or WDI
	Change in labour input	NSO, WDI

Note: MVA series in constant 2010 US dollars.

NSO = National Statistics Office; WDI = World Development Indicators (World Bank)

Whereas the numerator in the case of manufacturing, MVA, is a straightforward variable, the denominator, labour input, is slightly less obvious.[16] The most common measure is labour force, which measures the number of available workers. However, some of them might be unemployed and the labour force may therefore overestimate labour input and underestimate labour productivity. Employment, which is the sum of people employed by firms and the self-employed, e.g. owners of small firms, is a better measure. One issue is that some of the employed persons might not actually be working full time (another source of overestimation of labour input). Hence, what is in fact needed is a measure that fully accounts for the utilization rate of labour, namely hours worked.

A ranking of the most desirable labour input measures, starting with the best one, is:

1. Hours worked

2. Employment

[16] Please note that MVA in official statistics tends to cover the formal sector only. There is a sizeable informal sector in developing countries, especially in low-income ones. This reality significantly affects the data on labor input as well.

3. Employees

4. Labour force.

The best labour input measure is unfortunately also the most difficult to obtain for developing countries and we therefore use employment (or employees) from hereon.

Strategic questions:

- How productive on average is the manufacturing worker in the country? How has this changed over time and how does it compare to that of average manufacturing workers in other countries?

Calculation: Labour productivity is calculated as:

$$Lab\ prod_A = \frac{MVA_A}{L_A}$$

MVA_A = Manufacturing value added in Country A

L_A = Labour input in Country A

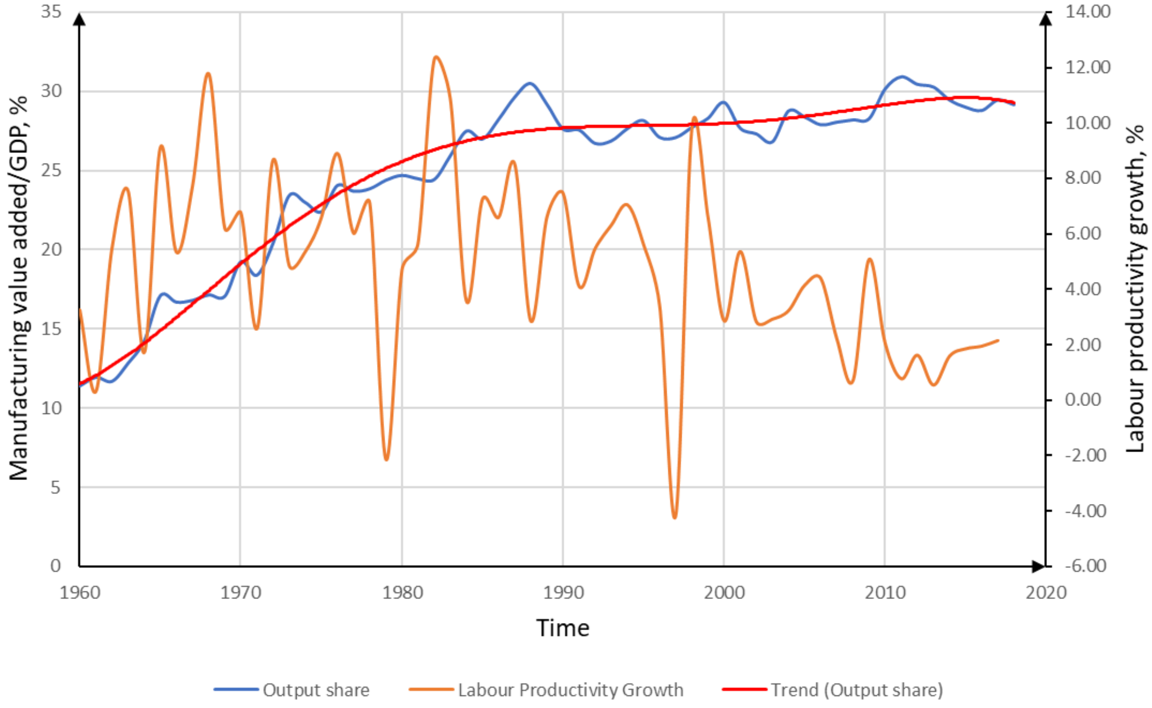
Variables required	Data source	Notes
MVA or value added by subsector Employment, employees or other labour input for the economy or by subsector	World Development Indicators (link) UNIDO INDSTAT (link) ILOSTAT (link)	In case the analyst wants to calculate labour productivity by subsector, they should use UNIDO's INDSTAT database for value added and employees or ILO's ILOSTAT database for employment or other labour inputs.

The *level* of labour productivity alone is not very useful for assessing performance, as it is difficult to determine whether the number obtained suggests good or poor performance. The limitation lies in the fact that we do not know at this stage whether the country could or should have performed better given its capabilities and resources. Despite the said limitation, comparing the level of labour productivity of two similar countries is interesting, and the analyst can conduct a benchmark analysis, which allows for a better understanding of the relative performance of labour productivity. We provide an example of such an analysis below.

The growth of labour productivity is also interesting because it indicates whether performance has improved or deteriorated over time. However, as in the case of level of labour productivity, the indicator is silent on whether the performance of productivity growth is as good as one would expect. To assess this, we must compare labour productivity with that of a similar country.

Another useful way of analysing labour productivity is to combine it with another indicator. Above, we have highlighted the importance of exercising caution when interpreting MVA/GDP. To exemplify this point, let us take a closer look at the case of the Republic of Korea and compare the country's MVA/GDP with its productivity growth. Figure 3 shows that once the contribution of MVA/GDP stabilized at around 30 per cent, the Republic of Korea's productivity growth started to decline. If we had only looked at the level of MVA/GDP, we would have concluded that the country's performance was very good (since 30 per cent represents a high MVA/GDP share) when in fact it is not sufficient to maintain previous levels of productivity growth. While deindustrialization in the Republic of Korea is not yet in full force, it seems that manufacturing has already reached its peak and that other less efficient growth engines are at play, in particular the services sector.

Figure 3: MVA/GDP and productivity



Source: World Bank (2020).

Decomposition of GDP and (labour) productivity growth

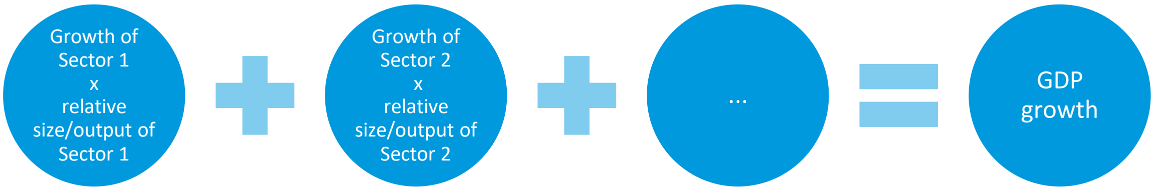
Combining labour productivity and the share of MVA in GDP significantly enhances the analysis and reduces uncertainty when interpreting the data. However, with a bit of effort, we can delve even deeper, specifically by conducting various types of "sources of growth" analyses (i.e. where did growth come from?). For example, by examining how much manufacturing growth has contributed to GDP growth, or how much manufacturing labour productivity growth has contributed to aggregate (GDP) labour productivity growth, we can gain a more powerful indicator of manufacturing performance. We refer to these as sectoral decompositions of GDP growth and aggregate labour productivity growth. We will discuss a second useful decomposition that illustrates the relative contribution of adding more skilled workers, capital, such as equipment and machinery, and technology to the production process.

Understanding performance in this manner provides valuable policy insights that we could not have based on basic indicators alone. Inter alia, the policymaker will learn how resource allocation to different sectors affects GDP growth and aggregate labour productivity growth. The policymaker will also gain insights into the advantages of allocating resources to investment promotion (for capital accumulation), skill development (for increasing the number of skilled workers), and innovation activities (to support technological progress). This understanding puts the policymaker in a better position to arrive at the most profitable policy mix.

Sectoral decomposition of GDP growth

We start with the simplest type of decomposition to demonstrate how "one should think". All the other decompositions are variations of this simple version, albeit with a few important extensions to gain additional policy insights. The extended decompositions are slightly more technically complicated to carry out, but the Annex includes all the formulas.

First, we decompose GDP growth into its sectoral growth sources. The simplest approach is to calculate each sector's growth rate and add them up to determine the GDP growth rate. Unfortunately, such an approach would be misleading, as every sector's contribution depends on its relative importance. Therefore, each sector's growth rate must be multiplied by its relative importance, measured by its share in GDP (for example, the growth of MVA times its share of 20 per cent (MVA/GDP)). GDP growth is the sum of the weighted sectors' growth (see Annex A1 for the formula used). This decomposition is illustrated below.



The result of this exercise is illustrated in the left part of **Table 8**. It presents the weighted growth rates (by relative size) of the three primary sectors for a selection of countries. A discussion of the results can be found below after the next decomposition is explained.

This type of analysis can also be conducted for more disaggregate data, e.g. decomposing value-added growth at the sector or subsector level. At the manufacturing sector level, this would tell us whether the growth in overall MVA came from growth in different subsectors or also (or primarily) from an increasing importance of certain subsectors over others.

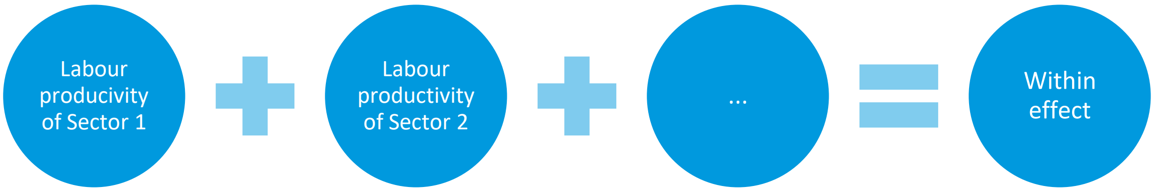
Decomposing GDP growth or MVA growth in this way is relatively straightforward because the output measure only has one component (i.e. GDP growth or MVA growth).

Sectoral decomposition of labour productivity growth

After performing a decomposition exercise involving a basic indicator, we can now turn to the decomposition of indicators with multiple components (e.g. we have already seen that manufacturing labour productivity consists of two components, MVA and labour input). These indicators provide far more insight into the contribution and performance of sectors such as manufacturing. Such a decomposition is slightly more complicated because we are dealing with indicators that consist of more than one variable. Instead of simply measuring aggregate and sectoral output indicators, we have to also consider how input evolves in each sector *and* how it shifts between sectors. This gives rise to so-called within and between effects. Moreover, unlike the case of GDP growth, where output shares were used as weights, labour shares are used in the case of aggregate labour productivity growth.[17] Analogously, we would use capital shares as weights for capital productivity.

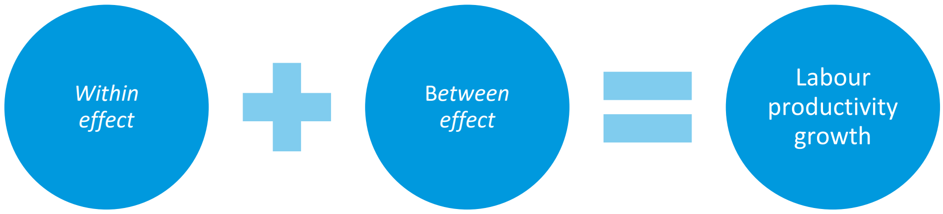
[17] For example, the manufacturing sector's weight would be the share of total employment allocated to manufacturing, analogously for agriculture, services, etc.

To facilitate understanding of this decomposition, we will divide it into two major parts. The main components of the decomposition are presented in the first part. The labour productivity of different sectors of the economy (agriculture, manufacturing, industry—which includes manufacturing—and services) can grow or shrink based on changes in their output and labour input (in economic terms, this is known as the *within effect*, i.e. the effect within each sector).



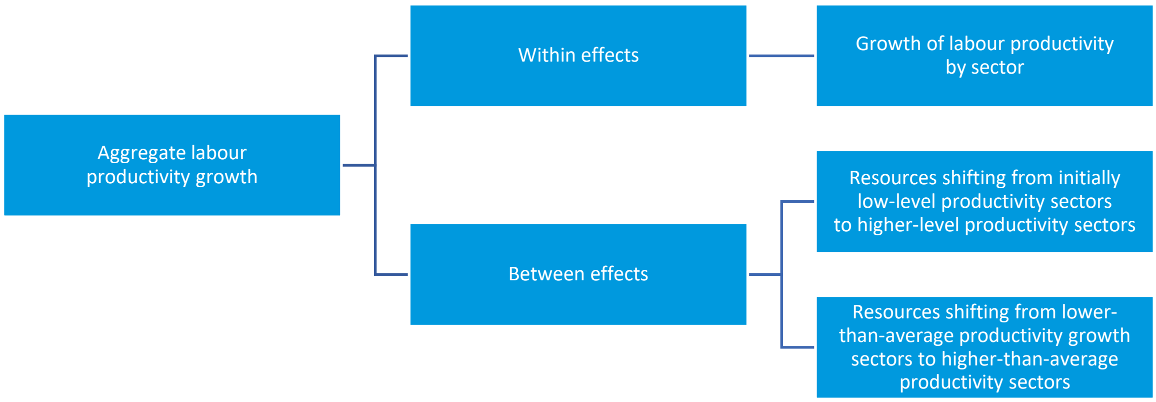
Labour productivity growth can also be affected by the reallocation of activities and resources such as labour shifts between sectors, i.e. structural change (in economic terms, this is known as the *between effect*, i.e. the effect between sectors). The combination of sectoral labour productivity growth (within effect) and structural change (between effect) sums up to aggregate labour productivity growth. As in the previous case, we must also consider the sectors' relative importance, that is, we must calculate and apply sectoral weights.

This allows the analyst to determine whether successful countries' GDP growth increased more because of within effects or between effects. This is important because if within effects outweigh between effects (structural change) as the main driver of labour productivity growth, different policy measures will be necessary. Usually, policy responses are based on a mix of within and between effects, where the "optimal" mix depends on the relative significance of the within and between effects.



In the second part, we must acknowledge that there are two types of structural change, i.e. that the reallocation of labour input can occur in two different ways. Firstly, labour can shift from relatively low productivity sectors to those that initially have a higher-than-average level of productivity. This sets sectoral shares at their initial levels, thereby eliminating the effect of structural change and considers the change in labour productivity that would have occurred had the sectoral structure remained *un*changed. If labour were to move from textiles to computers, for example, it would probably increase overall labour productivity because the computer industry has a higher level of productivity to begin with. The opposite shift would have the opposite effect.

Secondly, labour may also shift to industries with a higher-than-average productivity growth, which would increase the growth of aggregate labour productivity. Conversely, resources may shift to activities with *slower* productivity growth, which would *reduce* the growth of aggregate labour productivity. In contrast to the first structural change effect, the second term sets labour productivity at its initial level to isolate the effect of changes in economic structure (i.e. changes in employment shares) on aggregate labour productivity growth. The figure below depicts the different components. Annex A2 provides the formula for decomposing aggregate labour productivity into its sectoral contributions (middle part of **Table 8**), while Annex A3 illustrates how to assign the respective contributions of the within and between effects (right part of **Table 8**).



Having discussed the measurement of different useful decompositions, we now turn to the results of these decompositions **(Table 8**). Beginning with the decomposition of GDP growth, the most obvious observation is the relatively rapid growth of developing countries compared to Germany (2.1 per cent average GDP growth) and Japan (2.5 per cent average GDP growth). This indicates that a process of catching up was underway in developing countries. However, the sectoral sources of this process differed widely across countries. Manufacturing played a significant role as a source of growth in the fastest growing economies (China, Rep. of Korea). Industry more generally was an even stronger growth contributor. Agriculture was by and large a weak or even negative contributor (Kenya being the main exception), while the services sector appeared to have been a solid source of GDP growth.

Table 8: Sectoral contributions to GDP and aggregate labour productivity growth (%), 1970–2018

	Sectoral value-added growth (weighted)					Sectoral productivity growth (weighted)					Contribution (weighted)		
CNTY	**ΔY**	**ΔA**	**ΔM**	**ΔI**	**ΔS**	**ΔLP**	**ΔA**	**ΔM**	**ΔI**	**ΔS**	Within (%)	Between (%)	Total
AZE	**4.2**	-0.9	-0.5	4.0	1.1	**1.8**	-1.3	-0.7	2.8	0.3	87.3	12.7	100
CHI	**4.1**	0.2	0.6	1.4	2.4	**1.6**	0.1	0.2	0.8	0.7	88.1	11.9	100
CHN	**8.9**	1.2	2.8	4.0	3.7	**5.0**	1.1	2.2	2.6	1.3	71.6	28.4	100
CZE	**2.2**	-0.1	0.6	0.6	1.7	**1.5**	-0.0	0.3	0.4	1.2	83.3	16.9	100

EGY	**5.2**	0.6	0.8	1.8	2.8	**2.6**	0.4	0.4	0.9	1.2	77.0	23.0	100
GER	**2.1**	-0.0	0.3	0.4	1.7	**1.8**	0.0	0.4	0.7	1.0	85.0	15.0	100
JPN	**2.5**	-0.0	0.4	0.6	1.9	**2.1**	0.0	0.4	0.9	1.2	84.2	15.8	100
KEN	**5.0**	1.5	0.6	1.0	2.5	**2.1**	0.2	0.5	0.8	1.0	77.1	22.9	100
KOR	**6.9**	0.3	2.0	2.7	3.9	**4.5**	0.3	1.7	2.5	1.8	83.6	16.4	100
MOR	**4.5**	0.7	0.8	1.4	2.4	**1.4**	0.3	0.4	0.5	0.6	97.4	2.6	100
URU	**2.6**	0.0	0.3	0.7	1.9	**1.5**	0.0	0.2	0.6	0.9	97.6	2.4	100
ZAM	**3.6**	0.2	0.1	1.2	2.3	**-1.0**	-0.1	-0.3	-0.6	-0.4	79.5	20.5	100

Data source: FAO (2020), OECD (2020), UNIDO (2020), United Nations (2020) and the World Bank (2020).

Note: Δ denotes compound annual growth rate (CAGR). ΔA (agriculture/primary sector) = ISIC 01-03; ΔM = manufacturing ISIC 10-33; ΔI (industry/secondary sector) = M + ISIC 05-09, 35, 36-39, 41-43, and ΔS (services/tertiary sector) = ISIC 45-96 (United Nations, 2008). The first set of calculations is based on the Laspeyres index, while the right-hand side panel involving structural change is based on the Törnqvist index (see Annex). The data run from 1970 to 2018 and thus encompass nearly five decades, except for economies in transition (TRAN), where data run from 1990 to 2018. Aggregate GDP and labour productivity growth are the sum of the growth of agriculture, industry (manufacturing included) and services.

All figures are simple averages over the entire time period.

AZE=Azerbaijan, CHI=Chile, CHN=China, CZE=Czechia, EGY=Egypt, GER=Germany, JPN=Japan, KEN=Kenya, KOR=Republic of Korea, MOR= Morocco, URU=Uruguay and ZAM=Zambia.

Note: A discussion covering all countries and regions in the world can be found in A. Isaksson (forthcoming), "Industrial Policy, Productivity and Structural Change".

Next, we focus on the middle part of **Table 8** and the decomposition of aggregate labour productivity growth into its sectoral sources. It should not come as a surprise that Asia has the highest aggregate labour productivity growth rates, considering the region's rapid catching-up process, i.e. the East Asian Miracle (Hong Kong (SAR of China), the Republic of Korea, Singapore and Taiwan (Province of China) and later countries such as India, Indonesia, Malaysia, Thailand and Viet Nam), but several other countries, including OECD economies, show solid labour productivity growth figures as well. It is worth noting that catching up to the world technology frontier is generally easier than driving it forward, a challenge many OECD countries are facing. One particular concern in this respect is Zambia, where labour productivity growth has, on average, been negative on an annual basis.

Interestingly, manufacturing labour productivity growth is a major contributor to aggregate labour productivity growth only in Asia. For countries with strong extractive industries, such as Azerbaijan and Egypt, industry labour productivity more generally is a positive contributor. Overall, it seems that the tertiary sector drives aggregate labour productivity, which is in line with the notion that most of the economies included in this comparison have already reached their peak industrialization.[18] This, however, is not the case for most low- and lower middle-income economies that have not yet undergone a significant industrialization process.

Finally, on the right side of **Table 8**, the within effect (sectoral growth effect) overwhelmingly dominates any structural change effect. As we will soon argue, this [overwhelming] effect can be considered a slight overestimation. Nonetheless, when taken at face value, policymakers should design policies that allocate resources *mainly* towards enhancing sectoral productivity.

[18] This might not be completely true. With the advent of the so-called Fourth Industrial Revolution (or Industry 4.0), there are indications that advanced economies are bringing back manufacturing production to the countries of origin. One reason for this is that the introduction of advanced technologies allows for labour-saving to such an extent that the initial rationale for moving production abroad (relatively low labour cost) is lost.

We have demonstrated how to perform sectoral decompositions using the most aggregated levels, i.e. a decomposition of the economy's aggregate performance into its sectoral components at the level of agriculture, manufacturing, industry and services. We have observed significant differences between sectors' contributions even at this aggregate level.

At this stage, a note on the effect of aggregation on the decomposition is in order. At every level of aggregation, starting at the plant-level, aggregating data points will tend to "hide" structural change effects in favour of the within effect, that is, aggregation leads to a measured underestimation of the contribution of the between effect. The more we aggregate the data, the more of the between effect will remain obscured. In other words, our level of analysis has maximized/minimized the contribution of the within/between effect.

The implication here is that in **Table 8**, which presents highly aggregated data, some of the between effects in agriculture, manufacturing, industry and services appear as within effects. More concretely, any change within manufacturing from, say, low-tech food production to, say, high-tech chemicals production would show up as a withing effect in **Table 8** rather than as a between effect. In other words, **Table 8** *underestimates* the power of structural change as a source of growth in favour of sectoral productivity effects which are consequently overestimated.

The level of aggregation has significant implications for policymaking. When using highly aggregated evidence, the policymaker will be more likely to design policies that prioritize sectoral productivity growth, while disaggregated data sources would reduce this likelihood and increase the priority of policies that support structural change. Policymakers should therefore aim to use data that is as disaggregated as possible for a more balanced and credible source of information. Notwithstanding this shift in focus, empirical studies demonstrate that the importance of sectoral growth tends to outweigh that of shifts between sectors as a source of growth.

In short, we can now gauge the manufacturing sector's contribution, which is able to account for the "net effect" of the development of output *and* labour input in one single indicator.

As Table 8 has established that the sectoral labour productivity growth effect (within effect) tends to show up as the main contributor to aggregate labour productivity growth, the policymaker will contemplate the allocation of resources to further such growth. Put differently, is there a way to determine how resources should be allocated between the factors that generate sectoral labour productivity growth? This leads us to the next decomposition, namely understanding the sources of aggregate labour productivity growth: the relative importance of capital per worker growth and technological progress.

For this, we first need to identify the relevant components and how to measure them.

Indicators 5 and 6: Capital intensity and Total factor productivity: level and growth*

Previously, we decomposed GDP growth into its components within-sector productivity growth and reallocation between sectors (structural change). Decomposition analysis is important from a policymaking perspective because the policymaker needs to understand what is generating the growth and thus how to allocate resources accordingly. To this end, another useful and important decomposition of GDP growth, namely sectoral growth such as MVA growth and aggregate labour productivity growth focuses on the relative importance of factor accumulation (i.e. growth of production inputs such as capital and labour) and total factor productivity (TFP) growth. In economics, TFP growth is often interpreted as technological progress, and going forward, we will use these concepts interchangeably.

Both components are crucial for understanding economic development and growth. Consequently, the policy implications are profound. Conceptually, this section will consider both capital intensity (level of capital per worker) and capital deepening (growth of capital intensity), on the one hand, and TFP (level of output per capital intensity, i.e. technology) and technological progress (TFP growth), on the other.

Productivity measurement at the total economy level—implicitly or explicitly—starts from the notion of a relationship between output and production factors (or inputs). This relationship is known in economics as production function. Adding more inputs, such as capital, labour or technology, results in more output. What is unknown is how much output will increase when capital, labour or technology increases by, say, 10 per cent. In other words, what combination of capital, labour or technology increases will generate the largest change in output? This information is crucial for the policymaker to be able to optimally allocate resources to investment in these production factors. For example, the optimal allocation may be 20 per cent to higher capital, 10 per cent to more workers and 70 per cent to more technology, or some other combination. Ignoring these percentages can result in a significantly suboptimal allocation and result in less output than what could have been in fact achieved. This ultimately means less welfare for citizens. The decomposition that is introduced below is therefore of utmost importance for policymaking.

The use of a production function is almost inevitable when measuring TFP, but it is important to remember that it is only a metaphor, since it is unlikely that the actual shape and properties of such a function can be accurately deciphered.[19] However, its use is justified as an effective means to organize the data in a way that it is economically meaningful, and as a framework for interpreting empirical results for policymaking.

A general form of the production function is Y = TFP*F(K, L), where F denotes the relationship between output *Y* and the production factors capital *K*, labour *L* and technology *TFP*. It is convenient to express production function in such a general way for now because we do not know the exact form of the relationship. Adding more capital (*K*), workers (*L*) and technology (*TFP*) will increase the amount of output (*Y*; products and services) produced in the economy.

Economists prefer to express this relationship in a so-called intense form, that is, per worker, resulting in aggregate labour productivity Y/L = TFP*F(K/L). This is even more convenient because we now only have to figure out how aggregate labour productivity relates to two components, namely technology (TFP) and capital intensity (capital per worker).

Before turning to the decomposition, we must acknowledge the importance and information contained in capital intensity and TFP, not only as inputs to output. Both are powerful indicators that will help us better understand economic development, that is, to analyse these indicators and their development. This holds true for both a country's economic development over time as well as for differences in the *level* of economic development across countries. Put differently, economic development is closely related to the amount of capital intensity and technology (TFP). Higher levels of these implies a higher stage of economic development. Rich countries have plenty

[19] In fact, the technical conditions for consistent aggregation may be too restrictive to be intuitively implausible.

of both capital intensity and technology, while low-income countries typically have low levels of both.

Before we perform the decomposition, we will explain these concepts and their measurement in more detail. What is capital intensity (K/L) and capital deepening? Capital stock (*K*) is the accumulated total amount of equipment and machinery and other fixed assets in the economy. The more capital a worker has at their disposal, the more productive the worker becomes. For example, compare a farmer who works several hectares of land using only a shovel compared with a farmer who uses a tractor or similar equipment. Clearly, the latter will be more productive. Another example is comparing two office workers: one uses a pencil and a hand calculator, whereas the other uses a PC with standard software: the latter office worker will undoubtedly be more productive. Hence, increasing capital per worker (capital intensity) will usually also increase output per worker (labour productivity). Likewise, one of the sources of aggregate labour productivity *growth* is the change in capital intensity, commonly referred to as capital deepening. In general, the faster a policymaker can increase capital per worker, the faster labour productivity will grow.

While the total amount of labour is simply the sum of all workers, calculating capital stock is much more complicated because we need to sum up very different types of capital assets (e.g. 100 shovels + 200 tractors + 500 robots, etc.). There is no official data source for capital input at disaggregated levels. However, we have domestic data and based on fairly simple assumptions, the investment series can be transformed into a capital stock series.[20] Luckily, national accounts provide information on total investment in fixed assets (gross fixed capital formation, GFCF) each year, which can be summarized for the entire time period, with a deduction made for wear and tear of shovels, tractors and robots (the reduced economic efficiency of capital over time is called depreciation).[21]

Annex A4 provides a simple formula for calculating capital stock[22], while Annex A5 shows how to calculate the contribution of capital intensity and capital deepening to country differences in aggregate labour productivity and aggregate labour productivity growth, respectively. **Table 10** summarizes the indicators and variables used in the calculation. **Table 12** below presents the results for the same set of countries we analysed earlier. The results are discussed below next to **Table** 12.

Strategic questions:

- What is the level and growth of capital intensity (K/L) in the country?

[20] See Annex A4, which shows how capital stock can be calculated.

[21] This assumes that capital stock is proportional to the flow of capital services, which, if available, would be the superior measure of the flow of capital input services. UNIDO has a dedicated training programme on productivity and innovation that covers different ways of calculating capital input, *inter alia*.

[22] This is not the only way of calculating capital stock, but it is the most common approach. Isaksson (2015) and OECD (2009) discuss alternative approaches and assumptions for the calculation.

Calculation: Capital intensity is calculated as:

$$(\frac{K}{L})_A = \frac{K_A}{L_A}$$

K_A = Capital stock in Country A

L_A= Number of workers in Country A

Variables required	Data source	Notes
Capital Employment or other labour input to the economy	World Development Indicators (link)	Capital is the accumulation of all previous streams of gross fixed capital formation (investment). Annex A4 demonstrates how this can be calculated. If the analyst wants to calculate capital intensity at the level of total manufacturing or its subsectors, they should use UNIDO's INDSTAT database for gross fixed capital formation and employees or ILO's ILOSTAT database for employment or other labour inputs.

Table 9: Capital intensity*

Indicator	Variable	Source
Capital intensity*	Capital (K)	NSO, UNIDO, UN statistics or WDI
	Labour (L)	NSO, UNIDO, UN statistics or WDI
Capital deepening*	Growth of capital intensity (K/L)	NSO, UNIDO, UN statistics or WDI

NSO = National Statistics Office; WDI = World Development Indicators (World Bank)

What is TFP[23]? In Solow's *theoretical* model (1956, 1957), TFP represents technology, while TFP growth denotes technological progress. It is possible to increase labour productivity without changing capital intensity by introducing more or improved technology (TFP). In other words, technological progress increases output per worker (labour productivity) without any change in capital intensity. In Solow's model—and as has been empirically demonstrated multiple times—labour productivity growth in the short- to medium term derives from a *mix* of capital deepening (capital intensity growth) and technological progress. In the long-run, technological progress is responsible for *all* growth. Why?

Consider once again the case of the farmer and his land. Adding one more farmer to work the land would increase labour productivity. However, as more farmers are added, the land becomes congested and the farmers start getting in each other's ways, thus slowing down labour productivity. Labour productivity might even decrease if too many farmers are added. Let us also consider the office workers. Adding a computer increases the office worker's labour productivity, but what happens when two or three additional workers are added? Clearly, one worker will not be able to work on several computers at the same time, hence adding more computers will most likely *decrease* the worker's labour productivity. There is therefore a maximum limit to the number of farmers or computers that can be added. Beyond that point, the marginal return of adding more farmers or computers

[23] As mentioned above, another common concept is multi-factor productivity (MFP), since there is no guarantee that all ("total") factors have been accounted for.

diminishes. Once the potential for increasing labour productivity by adding more workers and capital has been exhausted, the remaining driver of labour productivity is technology (TFP).

This insight reveals the power of technology in economic development and growth and explains the significant differences in economic development (e.g. Hulten and Isaksson, 2007). Similar to the relationship between labour productivity growth and capital deepening, the faster the rate of technological progress, the faster the growth of labour productivity. The distinction between technology and capital intensity unfortunately becomes less distinct in empirical work because we cannot accurately measure all components of the production function and their interrelationships. This introduces errors that are empirically measured as TFP, resulting in an overestimation of the role of technology (considering the previously discussed decomposition and how the contribution of sectoral growth tends to be overestimated at the expense of the contribution of structural change). While the magnitude of this error is ultimately an empirical question a significant amount of empirical literature has focused on reducing this error. Yet, TFP/technology consistently emerges as the primary contributor to both economic growth and economic development differences.

Annex A5 presents a common way of calculating TFP level and TFP growth and its relative contribution to country differences in aggregate labour productivity levels and growth, respectively. Table 10 summarizes the indicators and variables used in the calculation.

Strategic questions:

- What is the level and growth of total factor productivity (TFP) in the country?

Calculation: Total factor productivity (TFP) is calculated as:

$$TFP_A = \frac{Y_A}{F(K,L)_A}$$

Y_A = GDP in Country A

$F(K,L)_A$= Composite indicator summarizing all inputs to production in Country A

Variables required	**Data source**	**Notes**
GDP Capital Employment or other labour input to the economy Share of labour compensation in GDP	World Development Indicators (link) United Nations National Statistics Office (NSO)	If the analyst wants to calculate TFP at the level of total manufacturing or its subsectors, they should use UNIDO's INDSTAT database for value added and employees or ILO's ILOSTAT database for employment or other labour inputs.[24] The United Nations and NSOs provide data on the share of GDP being paid to workers in the form of a salary and other types of compensation. This share is used to calculate the relative importance of capital and labour in GDP, where the respective income shares sum up to 1.

[24] Note that this is the case for value-added based TFP indicators. An alternative is to base the TFP calculation on gross output instead of value added, where gross output = value added + intermediate inputs such as material, electricity, water and other intermediate inputs. In that case, F(K,L) must include intermediate inputs *M* and becomes F(K,L,M). Such an exercise adds a considerable amount of complexity and is therefore excluded here.

Table 10: Total factor productivity (TFP)*

Indicator	Variable	Source
Total factor productivity (TFP)*	Labour productivity (Y/L)	NSO, UNIDO, UN statistics or WDI
	Capital intensity (K/L)	NSO, UNIDO, UN statistics or WDI
TFP growth*	Change in labour productivity (Y/L)	NSO, UNIDO, UN statistics or WDI
	Change in capital intensity (K/L)	NSO, UNIDO, UN statistics or WDI
Income share	Income shares	NSO or UN statistics

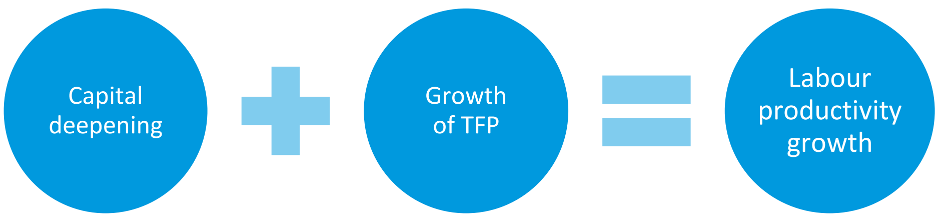
NSO = National Statistics Office; WDI = World Development Indicators (World Bank)

Decomposition of labour productivity growth into capital deepening and TFP growth

In this section, we present two useful decompositions. The first concerns labour productivity *growth* decomposed into its capital deepening and TFP growth components. This is commonly referred to as a sources-of-growth analysis. This decomposition can be linked to the previous decomposition, in which labour productivity growth was decomposed into its sectoral contribution (within effect) and the growth associated with shifts of activities between sectors (structural change or between effect). Next, we will demonstrate how these can be linked and the implications for the policymaker.

The second useful decomposition relates the *level* of labour productivity of two entities into its components, capital intensity and TFP level. This requires data for more than one country and as such, is more data intensive. We will perform the decomposition in the next sub-section.

In practice, TFP is "backed out" as a residual when all the production factors have been accounted for.[25] The intriguing part of this exercise is that TFP (technology) is not directly observable, but its production factors are. Since output is produced using observable production factors and technology, accounting for the observables gives us a measure of the unobservable input, technology. For example, if we find that 75 per cent of aggregate labour productivity growth is due to capital deepening (i.e. capital growth per worker), then the source of 100 - 75 = 25 per cent of aggregate labour productivity is TFP growth.



We cannot simply divide capital deepening (growth of capital intensity) by labour productivity growth to calculate the contribution of capital deepening, obtain a figure, subtract it from 100 and back out the contribution of TFP growth. As in the case above of decomposing GDP growth into its sectoral contributions, we must adjust the contribution of capital deepening to its significance in GDP. National accounts provide valuable information about the composition of a

[25] Isaksson (2009) provides a brief description of alternative approaches to measuring TFP growth, including parametric and non-parametric frontier approaches and various approaches based on regression analysis.

country's GDP and the share of labour compensation (roughly, salaries and benefits paid to workers), which typically amounts to around 60 per cent to 70 per cent. Economists refer to this as labour share. The remaining share of GDP is allocated to capital owners in the form of profit or capital share. Labour share plus capital share thus equal GDP.[26] The same holds at more disaggregated levels, with MVA divided into compensation for manufacturing workers and profit. This means that, if data allow, these decompositions can be performed at any level of aggregation.[27]

Capital share (1-labour share) is used to calculate the contribution of capital deepening to labour productivity growth. For example, if capital share is 30 per cent, capital deepening is 6 per cent, and labour productivity growth is 10 per cent, the contribution of capital deepening to labour productivity growth is calculated as (6*0.3)/10 = 1.8/10 = 18 per cent. In that case, the contribution of TFP growth to labour productivity growth would be the remaining 100 - 18 = 82 per cent, which suggests to the policymaker that the most important driver of growth is related to technological progress. In fact, these numbers can be used to calculate the relative allocation of the budget towards policies for factor accumulation and technologies progress. In this simple example, 82 per cent of the budget is allocated to investment in innovation activities, while 18 per cent is allocated to investment in fixed assets.

Note that the same type of adjustment to capital intensity is made when comparing cross-country levels of labour productivity (level) and the relative contribution of capital intensity, and TFP level to labour productivity (level) differences across countries (more about this below).

In what follows, the main purpose is to present the methodology. Hence, the objective is not to achieve a perfect measure. Nonetheless, the results shown are correct in terms of their direction, albeit not as "exact" point estimates. This means that the conclusion will not change *drastically* (e.g. be reversed) if we use a different measure of labour or capital input. However, what might change is the *relative* share of contributions of capital deepening and TFP growth. **Annex A5** presents the relevant calculations.

[26] For statistical and definitional reasons, the profit part is more complicated to calculate, which is why economists focus on the part that is accurate, namely labour compensation. Then, 1-labour compensation effectively becomes the capital's share. If labour compensation is 70 per cent of GDP, capital share becomes 1-0.70=0.30, or 30 per cent.

[27] Note that our calculation is only permissible because it is assumed that the labour share and capital share are country- and time-invariant. Although Gollin (2002) strongly argues that this indeed is the case, Hulten and Isaksson (2007), for example, are less convinced of the validity of this assumption. If labour and capital shares vary across countries or time, these calculations are no longer immune to the choice of base-country, so the formula provided by Caves, Christensen and Diewert (CCD, 1982) is preferable. Since for the sake of simplicity we assume common income shares, we do not present the formula here but refer the reader to the reference provided. When using common income shares as we have here, CCD produces the same results.

Table 11: Sources of growth analysis, 1970–2018

	Average annual growth, % YL, KL and TFP						Average annual contribution, % KL and TFP %			
	1970–1999			2000–2018			1970–1999		2000–2018	
	YL	KL	TFP	YL	KL	TFP	KL	TFP	KL	TFP
AZE	–7.2	–2.4	–6.4	6.2	2.9	5.2	11.2	88.8	15.7	84.3
CHI	1.6	2.9	0.6	1.7	2.3	1.0	60.4	39.6	43.5	56.5
CHN	6.0	5.9	4.1	8.3	9.6	5.1	32.7	67.3	38.7	61.3
CZE	0.1	2.4	–0.7	2.6	2.1	1.9	1024.8	–924.8	27.4	72.6
EGY	3.5	4.4	2.0	1.7	0.7	1.5	42.5	57.5	13.0	87.0
GER	2.2	2.3	1.4	0.9	0.6	0.8	35.3	64.7	20.2	79.8
JPN	2.6	4.4	1.0	1.0	0.7	0.7	58.2	41.8	23.4	76.4
KEN	0.9	1.0	0.5	1.8	1.0	1.5	36.7	63.3	18.4	81.6
KOR	5.6	7.8	3.0	2.7	3.4	1.6	46.3	53.7	41.8	58.2
MOR	0.9	3.6	–0.3	2.9	3.9	1.6	132.3	-32.3	45.2	54.8
URU	0.7	0.0	0.7	2.0	2.6	1.2	1.4	98.6	42.3	57.7
ZAM	–1.6	1.0	–1.9	3.1	7.8	0.5	–22.1	122.1	82.6	17.4

Data source: World Bank (2020).

Note: Change calculated as compound annual growth rate (CAGR). Years for AZE and CZE = 1990-1999 and 2000-2018. AZE=Azerbaijan, CHI=Chile, CHN=China, CZE=Czechia, EGY=Egypt, GER=Germany, JPN=Japan, KEN=Kenya, KOR=Republic of Korea, MOR= Morocco, URU=Uruguay and ZAM=Zambia.

A discussion covering all countries and regions can be found in A. Isaksson (forthcoming), "Industrial Policy, Productivity and Structural Change".

Error! Reference source not found. presents actual calculations and demonstrates that the relative contributions vary by country and change over time. Policymakers should therefore exercise caution when selecting the time period used for practical policymaking. The table consists of two panels, each divided into two time periods: 1970–1999 and 2000–2018. The left panel displays the average annual growth of GDP per worker, capital per worker and TFP, while the right one shows the relative contributions of capital per worker and TFP growth to GDP per worker growth. Negative signs indicate a negative contribution, while values above 100 per cent indicate a contribution greater than GDP per worker growth. Such a result typically occurs in cases of very slow growth.

Starting with the left panel, we observe a bumpy transition in Azerbaijan and Czechia during the earlier period, and slow growth in the two sub-Saharan African countries as well as in Uruguay. Technological regress represented the biggest obstacle in Azerbaijan, Czechia and Zambia, while Kenya and Uruguay experienced little growth mainly due to TFP growth. Among the richest countries, Germany's growth was primarily driven by technological progress, while growth in Japan was mostly hinged on factor accumulation, which fuelled GDP per worker growth. China and the Republic of Korea stand out as interesting cases of rapid growth, with technology seemingly playing the most important role, especially in China.

In the 21st century, both transition economies experienced strong recoveries, especially Azerbaijan fuelled by its oil and gas industry. Kenya saw an increase in the role of TFP, while Zambia's growth recovery was primarily driven by capital per worker growth. Japan and Germany have both become predominantly technology-driven, while Kenya and Egypt benefitted from substantial TFP growth. In China and the Republic of Korea, technology as a source of growth has also increased. However, while China grew even faster during the second period, growth in the Republic of Korea slowed down as the country's economy matured and is very close to the world technology frontier. In Morocco, capital per worker growth was the main driver of growth during the first period, but during the second period, the country managed to achieve a balance between factor accumulation and TFP growth.

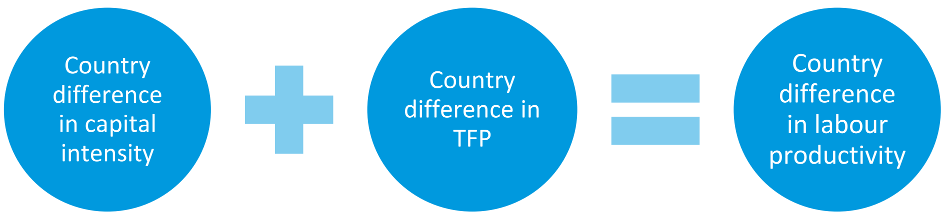
Decomposition of differences in labour productivity into differences in capital intensity and TFP

The level of labour productivity, capital intensity and TFP alone for a specific year may not be very meaningful metrics and therefore need to either be analysed in terms of their growth form, as we have just done, or need to be compared with those of another country. This brings us to the next powerful decomposition, which focuses on the sources of country differences in terms of *level* of labour productivity (at any level of aggregation, e.g. GDP or manufacturing). These sources reflect country differences in capital intensity and TFP level. Decomposition based on country comparison essentially takes the "long view" by analysing the sources of *level* of differences in labour productivity, which is similar to the result of accumulated capital deepening and technological progress. Annex A6 provides more details on how to compute the relative contributions of differences in capital intensity and TFP to the difference in labour productivity.

A country comparison is more data intensive as data for other countries are needed as well. In the productivity literature, it is common to compare countries with the United States ("best in class"), but for our purposes, we need to find a more suitable peer for a developing country. We have chosen the Republic of Korea,[28] a country whose level of development was similar to Ghana's in the 1960s and has since become an OECD economy. Many developing countries today look to the Republic of Korea as a model to learn from and emulate. Finally, despite being an OECD economy, the Republic of Korea is still fairly "close" to many developing countries, whereas the United States is far ahead, perhaps too distant to be attainable in the foreseeable future.

It is useful for policymakers to understand the respective contributions. Let us consider the following hypothetical example. If, for instance, 80 per cent of the difference in labour productivity results from differences in capital intensity (capital per worker) while only 20 per cent results from differences in technology, policymakers might consider allocating relatively more resources to capital investment because this is the main source of difference in labour productivity.

As in the case of sources of labour productivity growth, the role of difference in capital intensity needs to be weighted by its relative share in GDP. This is calculated the same way as above, i.e. 1- labour share.



[28] A comparison can, of course, be made between a country and the OECD average, for example, or between two country groups.

Next, we turn to some empirical results. The left panel of **Table 12** presents the level of GDP per worker, capital per worker and TFP of the 12 countries analysed above relative to the values of the Republic of Korea and the United States. The right panel shows the relative contribution of capital per worker and TFP to differences in GDP per worker for each country compared to the Republic of Korea and the United States. Since these are represented as levels, they may be interpreted as long-term differences.[29]

The most obvious observation is that all countries are closer to the Republic of Korea than they are to the United States since the Republic of Korea's GDP per worker is around 45 per cent of that of the United States. The difference between the two countries can largely be explained by differences in technology used in production.

Table 12: Level comparison between countries in %, 2018

	Differences in YL, KL and TFP, 2018, %						Contribution of differences in KL and TFP to differences in YL, 2018, %			
	KOR			USA			KOR		USA	
	YL	KL	TFP	YL	KL	TFP	KL	TFP	KL	TFP
AZE	23.1	18.4	40.7	10.5	10.5	22.2	26.5	73.5	33.4	66.6
CHI	61.8	46.8	79.7	28.0	26.7	43.5	25.2	74.8	31.9	68.2
CHN	27.9	29.0	42.2	12.6	16.6	23.0	34.6	65.4	43.7	66.3
CZE	93.5	94.9	95.2	42.3	54.2	51.9	33.8	66.2	42.6	57.4
EGY	18.5	10.0	39.9	8.4	5.7	21.8	18.0	82.0	22.6	77.4
GER	183.8	156.1	158.4	83.2	89.1	86.5	28.3	71.7	35.7	64.3
JPN	188.4	201.7	149.1	85.3	115.1	81.4	35.7	64.3	45.0	55.0
KEN	6.2	3.6	18.1	2.8	2.0	10.2	19.2	80.8	24.2	75.8
KOR	100.0	100.0	100.0	45.3	57.1	54.6	100.0	100.0	42.0	58.0
MOR	21.0	21.7	35.0	9.5	12.4	19.1	34.3	65.7	43.3	56.7
URU	58.6	37.8	81.0	26.5	21.6	44.2	21.5	78.5	27.1	72.9
ZAM	8.2	7.2	19.6	3.7	4.1	10.7	29.5	70.5	37.2	70.5

Data source: World Bank (2020).

Note: AZE=Azerbaijan, CHI=Chile, CHN=China, CZE=Czechia, EGY=Egypt, GER=Germany, JPN=Japan, KEN=Kenya, KOR=Republic of Korea, MOR= Morocco, URU=Uruguay and ZAM=Zambia.

A discussion covering all countries and regions can be found in A. Isaksson (forthcoming), "Industrial Policy, Productivity and Structural Change".

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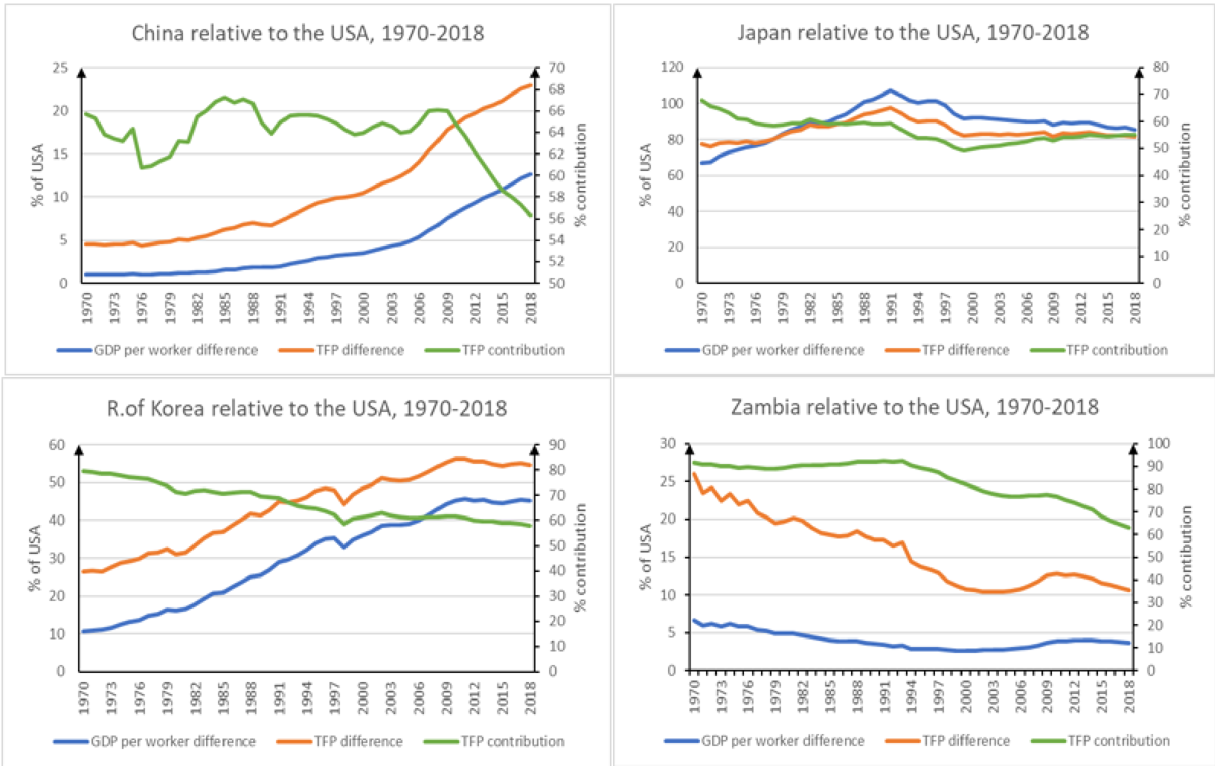
[29] Because we do not have data on human capital for Azerbaijan, these results have been calculated without human capital. This is likely to overestimate the role of technology relative to capital per worker. A cross-check accounting for human capital demonstrates that this indeed is the case, but since it does not change the overall direction of the results and the main purpose is to illustrate the methodology, we will proceed without human capital.

Germany and Japan have GDP per worker levels almost on par with the United States. Once again, technology is the main source of difference. Czechia and the Republic of Korea have GDP per worker levels at a similar level, with the small differences largely explained by technology. In the long-run, differences in technology outweigh differences in capital intensity. Next, we examine the development of GDP per worker in these countries and determine whether it results from the accumulation of capital per worker of TFP growth — we know that the latter is the source of GDP differences and that it therefore might be advisable to invest in technological progress, for example, by strengthening innovation systems and supporting invention activities such as R&D and the protection of intellectual property rights.

As a last exercise, it is useful to graphically examine how relative levels have developed between 1970 and 2018 to better understand which countries are catching up with the frontier (i.e. the United States) and what is driving the closing of the gap.

Figure 4: GDP per worker and TFP difference and TFP contribution, %, 1970–2018



Data source: World Bank (2020)

Figure 4 illustrates the evolution of differences in GDP per worker and TFP between four countries—China, Japan, the Republic of Korea and Zambia—and the United States. The differences in per cent are gauged on the left vertical axis. The green line represents the relative contribution of TFP differences as a source of differences in GDP per worker, while the secondary vertical axis is used to illustrate that contribution.

Both China and the Republic of Korea display clear catching-up scenarios, with both countries starting from very low levels of relative GDP per worker in 1970. The Republic of Korea ceased catching-up after the financial crisis in 2008 and has since maintained a constant level relative to the United States. An interesting negative trend in terms of source of GDP per worker difference is evident, where differences in technology continue to be the dominant source but to a lesser extent. On the other hand, China's catching-up in terms of both GDP per worker and TFP has been exponential. Similar to the Republic of Korea, the financial crisis had a significant impact on China, albeit a different one. After the crisis, the difference in TFP as a source of GDP per worker started to decline. However, the drop was not as drastic as the illustration appears to show, since the secondary vertical axis has small steps. In reality, the decline went from 66 per cent to 56 per cent over a span of 10 years.

Contrary to the two preceding cases, Zambia serves as an example of an economy that is losing ground. This is in line with the inward shifting of the world technology frontier among the low-income countries shown above. Starting from a very low level, Zambia has lost ground relative to the United States, both in terms of GDP per worker and TFP. The main reason behind the gap between these two countries is level of technology, although the gap has become less pronounced since the mid-1990s.

Our last example is Japan, a mature economy. Japan's story of surpassing the United States in the decadal shift from the 1980s to the 1990s, spurred by a technological catch-up, is a familiar one. However, instead of maintaining its leading position in the world, as clearly illustrated in **Figure 5**, Japan was hit by a long recession. At the turn of the millennium, the decline in GDP per worker difference seems to have stabilized at a level similar to that of the early 1980s. Catching-up in terms of technology stagnated as well and the difference now lies at around 80 per cent. Finally, since the two oil crises in the 1970s, the contribution of technology differences to differences in GDP per worker has been gradually decreasing. Since the turn of the millennium, when this contribution dropped below 50 per cent for a few years, it recovered to its current level of 55 per cent.

To conclude, we have observed that technology differences have had a significant impact on the differences in GDP per worker in the 12 countries analysed. This does not by any means imply that capital investment is irrelevant. In fact, in several cases, differences in capital per worker are a significant source of differences in GDP per worker. Moreover, the crucial complementarities that exist between capital investment and level of technology should not be disregarded.

Nonetheless, policymakers in developing countries should focus on designing policies that promote invention and innovation to drive technological progress in their countries. That having been said, it is likely that the relative contribution of manufacturing would have increased manifold if we had avoided confounding the effects of capital deepening with that of technological progress. We will discuss this further below in the section on extensions.

What all of the above indicators have in common is that they are silent on whether the displayed performance is the best attainable, that is, whether economies are operating at their maximum capacity. In the next section, we discuss how the policymaker can determine how much more/better an economy could have or should be able to perform.

3.2 Benchmarking production capacity

We have measured an economy's performance along various dimensions, with particular emphasis on the contribution of manufacturing performance to aggregates such as GDP, GDP growth or aggregate labour productivity. While this is a good initial step, it does not address whether the economy or manufacturing sector have reached their full potential. This can be determined if, for example, a reasonable comparator country has successfully achieved larger within and/or between (structural change) effects or managed to achieve faster capital deepening and TFP growth. This means that an alternative or complementary way of assessing performance is to compare it with a potential or capacity. This type of analysis is known as benchmarking.

Interestingly, benchmarking performance to better understand production capacity is another way to measure performance. The utility of benchmarking hinges to a large extent, if not fully, on the *purpose* of the exercise. For example, in the productivity literature, it is common to compare productivity levels of countries with the best performance. The purpose of such a comparison is to measure how far behind a country is from the frontier. In this case, the interest is not necessarily whether the best performance is attainable or not; most countries have fewer capabilities than the best performer and will therefore not be able to achieve frontier performance within a reasonably short period of time. If the purpose is to use benchmarking to better understand either the country's current performance or the distance to something achievable, or both, the time and capabilities dimensions matter. This is precisely what we are interested in here.

Different benchmarking approaches have different advantages and disadvantages. As regards achievable targets, the approaches share the commonality that they compare against something that should be comparable. Although we do not recommend it, one could in principle compare the country of interest with any other country, for example a neighbouring country even if it possesses far more capabilities. However, it is questionable what kind of *useful* intelligence for policymaking can be obtained through this method.

Unfortunately, all benchmarking approaches share another feature: the upper bound might not indicate an objective measure of the highest attainable output—the "true" capacity output in fact is unknown—but "only" the highest actual output attained given a set of capabilities.

Keeping this mind, we use an approach that only benchmarks against the actual best performance. That is, we are not keen to benchmark against countries that are either less productive (exhibit weaker performance) or have capabilities that differ considerably from the country of interest.

If the goal is to assess a country's potential performance within a reasonable time frame, a reliable and robust benchmarking approach is to compare the country of interest with other countries that have similar capabilities. However, if the purpose of benchmarking is different, the analyst may choose to benchmark the country of interest against countries with differing capabilities. In this case, examples can include a low-income country benchmarking against the best in the world, arbitrary role models, neighbours or simply even for reasons of vanity.[30]

This means that the choice of comparator country not only depends on the set of available capabilities, but also on the time horizon. What is unattainable in the short term could become attainable in the medium- to long term through persistent and smart investment in capabilities based on properly

[30] One common strand of economic literature uses an economy's *own* performance as the benchmark. This approach is based on the notion of *potential output* (Okun, 1962). In this case, "capacity" can be interpreted as the maximum output attainable given all available production factors (or capabilities) to the producing unit. For this interpretation to be valid, it relies on the crucial assumption that the calculated upper bound reflects the full employment of production factors. This assumption could be problematic for developing countries, where unemployment or underemployment of resources tends to be endemic. If the upper bound does not reflect full utilization, then the benchmark is not the actual (full) capacity and the ensuing gap from "capacity" would not be accurate. As such, this approach has a major disadvantage. In addition, it is technically difficult to compute, as it relies on econometric methods. However, the major advantage of this benchmark approach compared with most others is that it only requires data for one's own country (since it only compares with one's own performance).

designed industrial policy; even the world technology frontier will eventually become attainable. The so-called East Asian Miracle proves this point (World Bank, 1993).

Therefore, it is important for the analyst to be clear about the purpose of benchmarking, that is, are we benchmarking with a view to understanding the country's current performance or with a view to understanding what is needed to reach a given level of performance in, say, 25 years?

Benchmarking against countries with a similar level of internal capabilities

Country comparisons are not as straightforward as decomposition exercises (e.g. accounting for the relative weights of within and between effects) because we now need data for multiple countries. More importantly, we need data that describe similarities in endowments between countries. We will call these endowments *internal* capabilities because they represent the capabilities firms have control over in their plants. Examples of internal capabilities include capital assets such as equipment and machinery, workers, human capital and technology. With the exception of human capital, we have already come across these concepts and measured them. On the other hand, *external* capabilities, such as physical infrastructure and innovation systems, are part of the economic capability environment but are not controlled by firms.

Combining internal and external capabilities into an overall capabilities index is ideal because firms' performance is influenced by both. One example of this is UNCTAD's Productive Capacity Index (UNCTAD, 2020). Unfortunately, combining "all" the factors that influence production and productivity is not straightforward. Composite indices, i.e. indices which have multiple components, often involve double counting because the components are correlated. As a result, the same phenomenon could be measured several times using certain components. For that reason, we recommend using single variables, or at least composites with (very) few variables.

One major advantage of our approach is that it is objective, robust and theoretically well-founded. In other words, the analyst will let the data speak and the resulting industrial policy is truly evidence-based. Another advantage of our approach is that it does not require any specific software. For example, the entire illustration we introduce below was created using Microsoft Excel (including Figure 5). A third advantage of our approach is that it is fairly simple to understand and perform. It involves simple mathematics but has profound implications for industrial policy.

However, our approach also has several disadvantages. For example, it does not suffice to only have data for the country of interest — we also need data for comparator countries. This raises the issue of data requirements. It would not be so difficult if we only focused on output or labour productivity. However, these indicators reflect outcomes rather than internal capabilities. Countries with considerably different internal capabilities could achieve the same output or labour productivity for a host of reasons, many of which may be unrelated to policy. In other words, one could question whether the comparison is objectively valid, i.e. are we really comparing countries with *sufficiently* similar capabilities?[31] To ascertain the comparison's validity, we argue that possessing data on internal

[31] For example, going beyond internal capabilities, it could be argued that an island economy should only be compared with another island economy, a landlocked country with another, and so forth. However, if we move too far in that direction, the sample of possible comparators becomes so small that the validity of the entire benchmarking exercise could be in jeopardy. Nonetheless, we leave it up to the user to decide how many restrictions should be imposed. The principle of our approach does not change with the number of restrictions imposed.

capabilities allows us to establish benchmarking rooted in country similarities central to driving structural change and productivity, which is the primary focus of this tool.

The level of aggregation is another potential restrictive requirement. While cross-country macro and aggregate manufacturing data are readily available for many countries, obtaining data beyond aggregate manufacturing quickly becomes a challenge. For example, no official data are available at a disaggregated level for capital input.[32] Obtaining sufficiently long time series of constant price investment data based on appropriate deflators (i.e. a price index specifically for investment, as discussed in Box 2) is particularly difficult. In the absence of investment-specific prices, using a producer price index is recommended. In case such an index is not available, the price index for MVA (the so-called MVA deflator) should be used for investment data.

Dividing current price investment by, for example the price index for MVA (a common approach) introduces errors, i.e. we would be dividing current price investment with prices that are unrelated with investment. Is this such a big problem? Unfortunately, it is. Over time, these errors accumulate, and we might end up with an investment series that is too noisy and with data that send out wrong information, thus leading to erroneous policy conclusions. Another solution is to choose comparator countries based on fairly aggregate data and hope or assume that this is also valid at a more disaggregated level. That is, the labour productivity of two countries' garment sector could be compared based on macro capital intensity data. Yet, we must conclude that data requirement is the main disadvantage of the approach we describe below.

When considering domestic production, the production function in some generic form is a useful framework for capturing the relationship between production and internal capabilities is — we have already come across the notion of the production function above.[33] For the benchmarking approach we are about to present, it suffices to know the content of the production function, i.e. labour productivity (as previously, output per worker, Y/L) and capital intensity (as previously, capital per worker, K/L). It is not necessary to know the precise form of the relationship between output and inputs. We will compare the performance of labour productivity between countries with similar levels of capital intensity (internal capabilities). For illustration purposes, we use macro data, but this type of benchmarking could also be performed at disaggregated levels, e.g. for the manufacturing sector.[34]

Since we have already discussed the concepts and calculation of countries' labour productivity and capital intensity and performed decomposition exercises in a previous section, we will not repeat that discussion here. However, since we are illustrating those concepts using macro data, we have chosen human capital as an additional production input (human capital is challenging to account for at disaggregated levels, since the data are only available at the macro level[35]). The idea is that the more

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[32] Any composite capabilities index would face the same problem, and some analysts try to solve this by focusing on investment-output ratio instead. However, there is little relation between the flow of capital services and the investment ratio, and the issue therefore remains unresolved.

[33] To reiterate, the production function relates output to inputs such as capital, labour and technology. For the interested user, UNIDO provides separate training courses on the measurement of production functions, productivity and technology.

[34] In a more advanced version, different dimensions of human capital (e.g. schooling and health), as well as agricultural land, at least at the macro level, could be used. As stated above, for every level of aggregation with the exception of macro, labour productivity would be measured based on the gross output production function, not the value-added version.

[35] Incidentally, when conducting micro-level surveys at the firm level, a rich measure of human capital can be obtained. The challenge is to measure human capital between the most aggregate and most disaggregated levels such as ISIC-1 and 2. If the analyst has access to a census (i.e. all firms), it might be possible to aggregate the micro data to more aggregate levels, e.g. human capital for the textile sector.

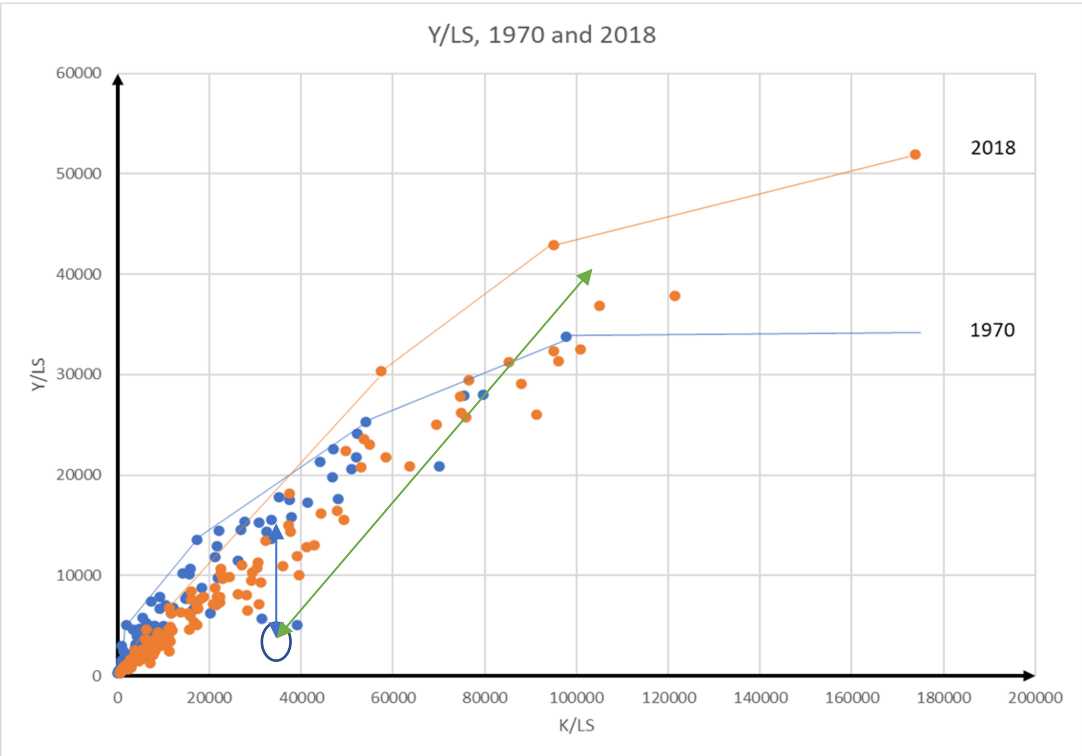
educated and experienced a worker is, the more productive she is. Human capital can be measured in several different ways. In our example, we use the average number of years of schooling. Human capital has been included by adjusting labour input *L* for years of schooling.[36] In what follows, we refer to human capital-adjusted labour input *LS*, instead of simply *L*.

Labour productivity is therefore calculated as output per human capital-adjusted labour, Y/LS, and capital intensity as capital per human capital-adjusted labour, K/LS. It is important to note that K/LS summarizes the level of internal capabilities. In other words, we are interested in comparing countries that are similar in terms of level of K/LS, and to determine the highest level of labour productivity (Y/LS) of the best performing country (we can call this 'potential performance'), and how far the other countries are from the best performance.

Based on these data, we can produce a scatter plot such as in **Figure 5** for a sample of 145 countries (all countries with complete sets of required data). By connecting the outermost combinations of Y/LS and K/LS, we can draw a line that represents the *highest* level of Y/LS given any level of K/LS. We call this the *world technology frontier*.

The vertical axis measures labour productivity (Y/LS), while the horizontal one measures capital intensity (K/LS). As shown in the figure, there are data points for 1970 (blue) and 2018 (orange), and we thus have two world technology frontiers, one for 1970 and another for 2018. The upward shift of the world technology frontier (from blue to orange) represents technological progress in the world.

Figure 5: World technology frontier, 1970 and 2018



Data source: World Bank (2020).

[36] Labour input (*L*) has been adjusted for schooling (*S*) following Hall and Jones (1999) and using educational attainment to proxy for schooling (Barro and Lee, 2013).

For a given year (in this case, either 1970 or 2018), the distance between the dots and the frontier is a measure of technical (in)efficiency, an indicator that denotes how much more a unit should be able to produce given its internal capabilities (K/LS). Put differently, it is the benchmark value that we are looking for, the gap between a country's labour productivity and how high it could be. If we measure the distance between two years, we can also calculate the change in this gap (technical inefficiency), that is, we can determine whether the country's gap has decreased (increased) over time. In other words, has the country become more (or less) efficient in its use of resources over time?

With this in mind, it is worth observing that the 2018 technology frontier up to K/LS = 40,000 lies *within* the 1970 technology frontier. That is, several developing countries have experienced technological *regress* in the past 50 years, which implies a widening technology gap vis-à-vis the most advanced economies.

For benchmarking purposes, we must identify the country of interest. Assume that we are interested in the country at the intersection of K/LS=40,000 and Y/LS = 10,000 (encircled). We immediately see that several countries have a similar level of internal capabilities (capital intensity, K/LS)[37], which have attained a higher level of labour productivity (Y/LS). This means that the country of interest, for various reasons, is operating below its maximum capacity and that there is scope for improvement, i.e. there is a significant degree of technical inefficiency in the country's production.[38] How high is the technical inefficiency? The percentage of technical *efficiency* is the vertical distance from the encircled point to the frontier, as shown by the blue arrow, while the percentage of technical *inefficiency* is the inversion of this percentage, 1/x. In other words, this is how much more productive the country could or should be given its level of internal capabilities.

To generate the quantitative difference vis-à-vis the frontier, we need to identify the country or countries (vertically) above the country we want to benchmark against. In fact, what we actually want to do is calculate the distance to the frontier, which is the correct benchmark, and not to a specific country. Once we have succeeded and determine that country's labour productivity y^*—or the labour productivity at the frontier—we can divide our country's labour productivity y by y^*. We thereby obtain a measure for the level of y^* of the country of interest, for example 60 per cent. Again, 100 - 60 = 40 is the gap (and our country's performance) and how much more our country should be able to produce given its capabilities.

Strategic questions:

- What is the country's labour productivity capacity and what is the gap between its actual labour productivity to its potential level of labour productivity, given a set of internal capabilities?

[37] The notion of "similar" in this case is somewhat arbitrary and could, for example refer to capital intensity +/- 10 per cent of the capital intensity of Country A.

[38] Extensive literature, starting with Farrell (1957), is available on technical efficiency. The literature is broadly divided between parametric (typically Stochastic Frontier Analysis, SFA) and non-parametric (typically Data Envelopment Analysis, DEA) approaches. Two useful references that cover the frontier literature include Coelli, Prasada Rao, O'Donnell and Battese (2005) and Sickles and Zelenyuk (2019).

Calculation: The "simple" version[39]

1 Calculate labour productivity (Y/L) and capital intensity (K/L).
2 Select all countries with a similar K/L. This, for example, could be K/L +/- 10 per cent.
3 Identify the corresponding Y/L to the selected K/L.
4 Rank Y/L.
5 Normalize so that the highest ranked Y/L = 100 by dividing each Y/L by the highest ranked Y/L and multiplying it by 100. Assume the country of interest obtains a value of 60. This means that its performance is 60 per cent of that of the highest ranked country given similar capabilities.
6 Calculate the gap to the highest ranked country, 100 – 60 = 40. This means that the country of interest's performance is 40 per cent behind the highest ranked country given similar capabilities. In other words, the country of interest should be able to attain a 40 percentage point higher labour productivity given its capabilities (which equals a productivity performance increase of 67 per cent).
7 If several years of data are being used, the change in technical efficiency should be calculated to determine whether the country's performance has improved.

The "extended" version:

8 Calculate labour productivity (Y/L) and capital intensity (K/L).
9 Select all countries with a similar K/L. This, for example could be K/L +/- 10 per cent.
10 Identify the world technology frontier, which could either be the highest ranked country, or above, and select the corresponding Y/L as the benchmark value and rank the countries accordingly.
11 Repeat points 5 to 7, but this time, normalize the frontier Y/L value to 100, just like in point 5 above.

Alternatively, one could ask: if the country of interest has a K/LS=100,000, how much higher should its labour productivity [ideally] be? This is a forward looking question aims to understand "the rate of return" on investment in capabilities K/LS. The relevant arrow for this question is depicted in green in Figure 5. The value of posing such a question hinges on the time horizon of interest. In the case of "our country of interest" in the above example, the time horizon would have to be very long.

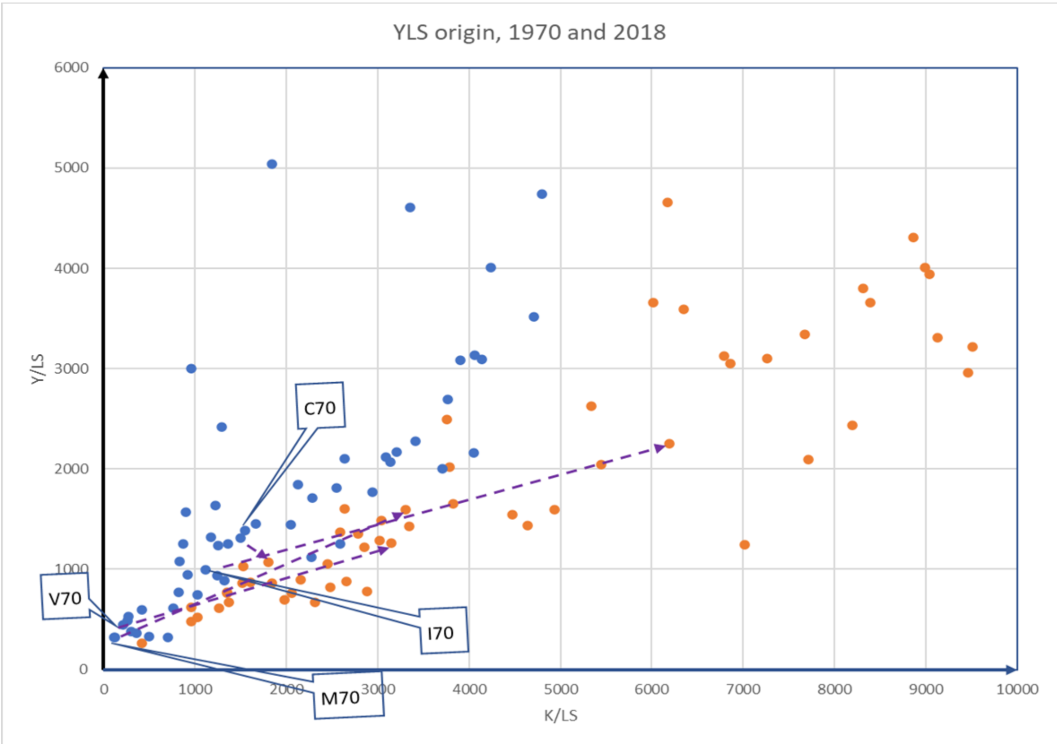
The main advantages of this type of benchmarking are its objectivity and simplicity. It does not require a comparison with a neighbouring country or any other arbitrary country with a different level of internal capabilities (capital intensity). Comparing countries with different levels of internal capabilities is akin to comparing apples with oranges and does not provide meaningful insights into a country's performance.

However, this approach also has disadvantages. One of the main disadvantages is the need to obtain data for a sufficient number of other countries. Additionally, the frontier is sample-specific, which means that the frontier might only show the best in the world based on actual data, but it is possible that the best performer could achieve even better results, indicating that the true frontier actually lies beyond the actual data points.

[39] For simplicity, we ignore human capital here.

Development is multi-faceted and many other factors aside from capital intensity may influence what is truly attainable. For example, a landlocked country with a similar K/LS as a country adjacent to the sea might never be able to achieve the same level of labour productivity due to its geographic position. However, it is up to the analyst to determine the sample and decide whether landlockedness or other factors, such as different climates, should be considered a constraint, in which case the analyst may want to restrict the sample.[40]

Figure 6: Different paths of development



Data source: World Bank (2020)

Before closing this section, we want to demonstrate that this approach can also be used to illustrate development paths. **Figure 6** presents four countries, all of which are located relatively close to the origin, both in 1970 and 2018. In the past 50 years, they have developed both similarly and differently. Their similarity is an increase in capital per labour input, although to varying degrees. Three out of the four countries have also improved their productivity performance, with Myanmar (M70) showing the most improvement. Cambodia (C70), despite its capital deepening, has experienced a *decrease* in the level of labour productivity, which is a disappointing outcome. It is likely that these differences among countries can be attributed to variations in technology levels and adoption, as demonstrated by Hulten and Isaksson (2007). This is also a probable explanation for the gap in the previous example, since we had fixed K/LS (same for all comparators), leaving technology as the only variable factor.

[40] This might not be the best example, since Switzerland is one of the world leading countries and obviously there are ways and means to circumvent geographic divergences.

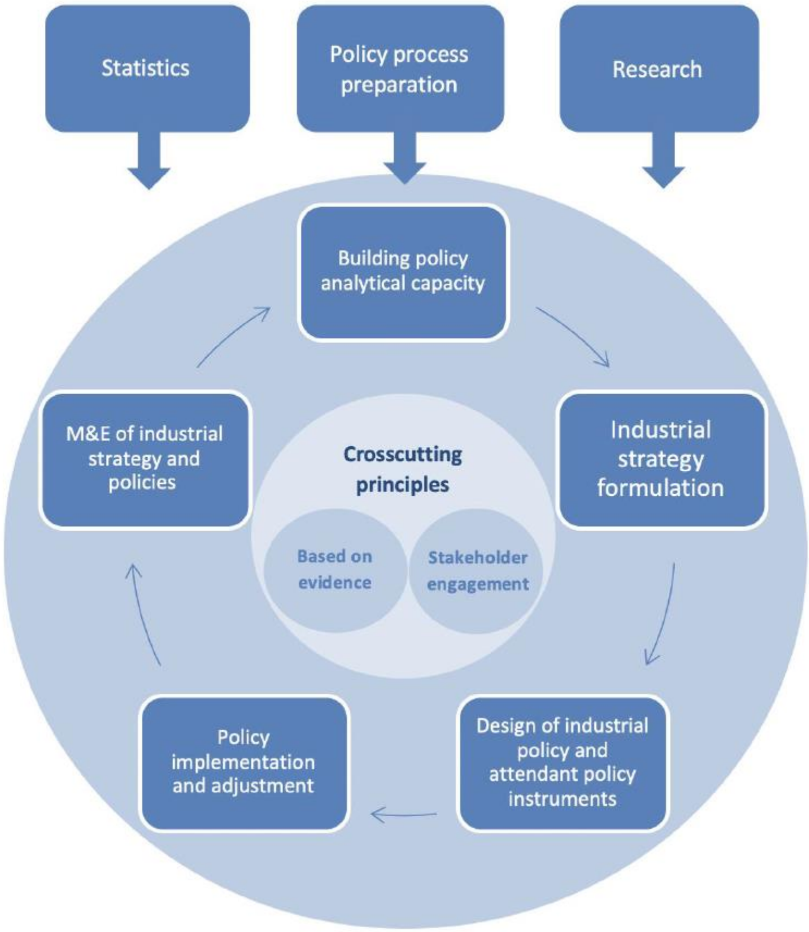
4 Policy options

4.1 How to use EQuIP for industrial strategy and policy design

The following section provides a brief overview of how to use EQuIP in strategy and policy design. A full discussion is available in *EQuIP Tool 0: Evidence for industrial policymaking*.

Industrial policymaking can be described as a cyclical or iterative process (**Figure 7**).

Figure 7. Industrial policy cycle



In the diagnostic phase, which requires analytical capacities, evidence (e.g. based on quantitative and qualitative data) is collected, systematically processed and used to identify policy challenges. Industrial strategies and related industrial policies are then defined to address these challenges. Industrial policy goals determine the choice of intervention areas and the formulation of suitable policy instruments. The implementation of these instruments is monitored and evaluated, with the results feeding back into diagnostics and evidence collection on progress made towards the intended industrial development targets, which completes the policymaking cycle. The cycle's iterative nature implies that industrial strategies and policies align with the progress achieved in the country’s industrial development trajectory. In this dynamic process of accumulation and adjustment of industrial capabilities, emerging industrial development challenges and opportunities are continuously addressed.

EQuIP diagnostic tools are designed to support the policymaking process. By implementing training programmes, they aim to increase policymakers’ analytical capacities and address the following three components of the policy cycle:

- Building policy analytical capacity – diagnostics
- Industrial strategy and policy formulation
- Monitoring and evaluation.

Building policy analytical capacity – diagnostics

Conducting a comprehensive, multidimensional assessment of the present situation and performance of the industrial sector is the first step in the policymaking cycle. The EQuIP diagnostic tools provide a solid foundation for such an assessment, covering a range of economic, environmental and social aspects. Each tool uses data-driven methodologies that serve as a reliable starting point for identifying areas that require further investigation. Additional in-depth examinations can take the form of additional quantitative research, such as using nationally available data, or qualitative research, such as reviewing existing reports, conducting interviews or consulting national stakeholders and experts. Such comprehensive assessments of the country’s industrial sector on different economic, environmental and social aspects establish a minimum evidence base from which (evidence-based) strategies and policies can be formulated.

Industrial strategy and policy formulation

The process of strategy and policy design should be goal-oriented, evidence-based and involves decision-making at five stages.

The first step is to determine which **national development goals** industrial strategy and policy can best contribute to.

The second step in the process is to design the **industrial development strategy**, which provides a general long-term view. This strategy outlines how inclusive and sustainable industrial development (ISID) contributes to national development goals.

Based on the objectives embedded in the industrial development strategy, the associated **industrial policy** specifies the roadmap towards achieving the strategic goals in greater detail. Industrial policy often narrows the scope of interventions, either by establishing general framework conditions for all economic activities (horizontal policy), or by providing targeted support to selected industries (vertical). The industry-related **objectives** outlined in the policy reflect its explicit goals for achieving ISID. These goals must be detailed, measurable, achievable, relevant and time-bound (SMART), taking the country’s capabilities and limitations into account.

To achieve these objectives, concrete changes in the behaviour of economic actors or the overall business environment are necessary. The **intervention areas** are derived from the objectives and specify the required changes.

The evidence derived from applying the EQuIP diagnostic tools can contribute to all of the steps described above, as the tools help identify the strengths and weaknesses of a country's industrial sector and its subsectors, and provide insights into the country's past developments and offer comparisons with other countries.

Once the intervention areas have been defined, policymakers must select **policy instruments**, i.e. develop specific government interventions that drive the necessary changes. Policy instruments are tools used to shape public- and private sector activities to achieve the specific goals set by the policy. Typically, several instruments are needed to achieve the intended outcome, hence necessitating the creation of a **mix of policy instruments** or a policy portfolio.

Designing a policy instrument entails determining the objective it pursues, the type of intervention to implement, expected outputs, the strategy to achieve the predefined results, the beneficiaries or target groups, access regulations (competitive or accessible to all beneficiaries), the source and amount of funding, and the time frame.

Monitoring and evaluation

The EQuIP diagnostic tools provide indicators and a logical sequence of decisions for designing strategies and policies for industrial development and serve as a starting point for establishing a monitoring and evaluation (M&E) system. An M&E system is essential for monitoring and evaluating not only policies, but also all types of interventions and instruments. Monitoring is a continuous process that provides regular feedback on progress towards achieving milestones and intended results. It focuses primarily on tracking spending in relation to an intervention, and whether the activities are being implemented according to the roadmap. Evaluation, on the other hand, involves regular reviews of the intervention's results and its impact on the intended outcomes. The purpose of evaluation is to determine whether an intervention has the anticipated effects and whether it contributes to the continuous policy learning process that makes industrial policymaking inherently cyclical and iterative in nature (Figure 7).

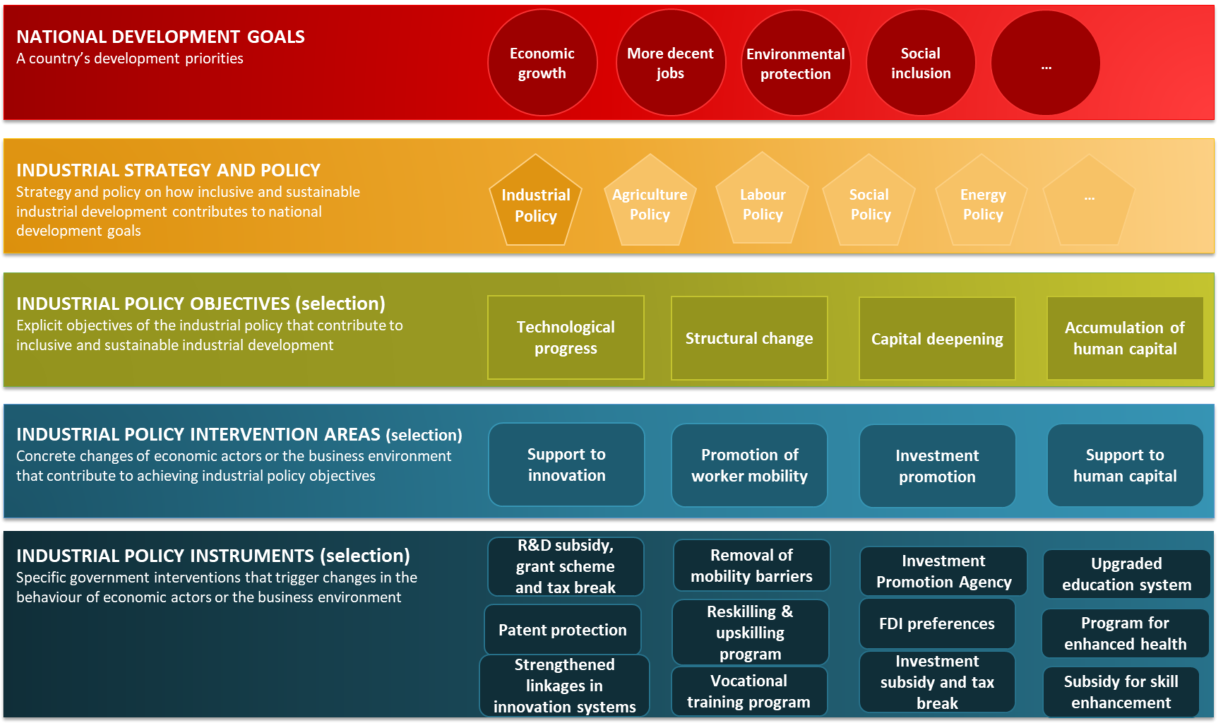
4.2 Productivity objectives and the use of indicators

In the following section, we will provide examples and discuss policy options specific to the policy areas addressed in Tool 1.

Several of the indicators in this tool relate in one way or other to a production framework or production function. We know from economic theory that policies that increase the volume of production factors and their quality, as well as the level of technology, will increase output and productivity. The introduction of better technologies, either disembodied or embodied in capital input, helps raise productivity and induces structural change. That is, a focus on these capabilities will take us a long way in answering the question, "what shall I, as a policymaker, do to improve my country's industrial performance?".

Error! Reference source not found. summarizes some of the policy options and responses available to policymakers. Three areas in line with the preceding discussion appear most pertinent, namely, (i) structural change, (ii) capital deepening (physical and human), and (iii) technological progress, which all contribute to enhanced productivity performance.

Figure 8. Decision tree of industrial strategy and policy design



Starting from labour input, equipping raw labour with human capital is transformative (e.g. Hanuschek and Woessmann, 2010; Caselli and Ciccone, 2011; Nelson and Phelps, 1966). Although economists continue to debate what is the most effective way to measure human capital, it is widely acknowledged that the higher the level and quality of a worker's education, the higher his or her level of productivity. Although this result varies across sectors, human capital plays a key role in manufacturing. It is not only about the workers themselves, but also their ability to handle ever more sophisticated machinery and equipment and new technologies.

Human capital in a broad sense is not only about educational attainment levels (years of schooling), but also about the quality of education, years of experience and health. One example of an instrument in this regard is to upgrade the education system. In the current era of Industry 4.0 and to meet its requirements, several countries are upgrading their science, technology, engineering and mathematics (STEM) curriculum.[41] Another example of an instrument is subsidies to encourage skill development, for example for firms to offer worker trainings, but also to give workers incentives for continuous enhancement of skills.

Human capital is entails more than just schooling; the health of workers also plays a crucial role. A dedicated programme that reaches a large share of the population and provides high-quality medical

[41] Acemoglu and Restrepo (2019) discuss the impact of Industry 4.0 on work and workers.

services is an example of a concrete instrument. The positive impact of improved health on labour productivity is especially evident in low-income countries. When students' health improves, they derive greater benefits from education, an effect that is evident in their future work life, as the worker's productivity is closely tied to his or her health both in the present and during his or her time as a student (e.g. Weil, 2014; Knowles and Owen, 1995; Strauss and Thomas, 1998; and Deaton, 2003).

Capital input requires an investment policy that addresses both domestic and foreign (direct) investment (FDI) and supports the acquisition by firms of both high quantity and quality equipment and machines. One common instrument for attracting FDI is the establishment of a dedicated Investment Promotion Agency (IPA), which, for example informs potential foreign investors about opportunities in the country. Other related instruments may involve various types of subsidies, tax breaks, etc. Such instruments also apply to domestic investment.

Over time, firms will have more capital per worker, and that capital will be more technologically sophisticated. Moreover, as the economy develops, increasingly sophisticated technologies become absorbable and are thus appropriate (using economic jargon). The most advanced capital currently is probably that related to Industry 4.0, e.g. an IoT platform, machines that can communicate, and 3D-printers, to name a few. While these technologies are likely to be "inappropriate" for low-income countries today, these technologies become increasingly "appropriate" as these countries develop into middle-income ones.

Therefore, policymakers need to understand the complementarities between various internal capabilities (e.g. human and physical capital), on the one hand, and between internal and external capabilities, on the other. Focusing on examples of the latter, investment in physical capital in many developing countries carries significant risks. Weak energy infrastructure, for instance, implies frequent electricity outages that disrupt production, sometimes multiple times per day. Moreover, an unstable electricity supply can damage machines and considerably reduce their lifetime. If such issues are not addressed, firms might opt for less capital-intensive production methods, resulting in a less productive manufacturing sector and slower structural change. Furthermore, more advanced developing economies that aim to adopt Industry 4.0 technologies require a suitable digital infrastructure.

Economists often emphasize the significance of technology, and we have argued that much of the observed income gaps between countries is attributable to differences in technology. In the common production framework used in this tool, technology is commonly represented by total factor productivity (TFP). Given of the importance of technology in explaining variances in labour productivity and GDP across countries, policy instruments that prioritize technological progress often take centre stage in industrial policies.

A class of growth models known as New Growth Theory[42] establishes strong and direct links between technology and policy. These models primarily emphasize the role of human capital and innovation, with R&D often representing the latter. The chain usually runs from R&D to innovation to productivity.[43] If instead we consider R&D as encompassing all innovation activities (or rather invention activities) and innovation as the expansion of the national innovation system (or any other

[42] Typical references to New Growth Theory include Romer (1986; 1990) and Lucas (1988).

[43] The famous CDM-model (Crepón, Duguet and Mairesse, 1998) is a good example of this approach.

innovation system), it immediately becomes evident that both research and innovation policy significantly contribute to development.

In fact, such policies support the domestic creation, acquisition and adoption of capital inputs, organizational and business models, ideas and know-how from abroad, and enhance firms' absorptive capacity, promote cooperation between the various actors that make up the economic system, etc. Human capital also contributes to these dimensions. Examples of concrete policy instruments include R&D subsidies, grant schemes and various tax breaks. Intellectual property rights protection and other forms of patents protection are often relatively weak in developing countries, and policymakers can use such instruments to stimulate invention and innovation. Instruments that strengthen linkages between actors within innovation systems is another example. For instance, actively increasing the information flow between the government and private sector can help connect companies to international opportunities for exporting or acquiring technology.

We have argued that the reallocation of resources and activities between sectors, preferably from low- to high-productivity sectors, is another source of aggregate labour productivity growth. Economic theory has focuses in particular on the reallocation of workers between sectors, and we use that example in **Error! Reference source not found.** above. However, shifts in the overall input composition over time, where some sectors become more intense in human and physical capital as well as technology, can also contribute to this growth. After all, this is essentially what a shift of workers implies. Obstacles to intersectoral worker mobility (or *some* pre-selected sectors that receive investment subsidies through policy or vested interests) will slow down the productivity effects of structural change if the ensuing resource allocation is targeted at sectors that contribute less to productivity than did the sectors that were previously targeted.

To facilitate structural change, government could remove or reduce mobility barriers so workers can more easily move from one activity to another. Programmes that offer reskilling or upskilling enhance workers' attractiveness among industrial sectors with relatively sophisticated production and higher wages, and as such reduces the time for structural change to be achieved. Vocational training programmes are another example bridging the demand and supply of labour.

We are not claiming that this is an exhaustive set of policy areas, policy instruments or capabilities to enhance productivity and structural change, but it shows that there are plenty of opportunities for policymakers to take action to spur economic development, even within this simple framework.

4.3 A practical application of productivity decomposition to policy

In the analytical part of this tool, we focused on how aggregate labour productivity growth can be decomposed into its different sources. We also argued that this information has practical implications for policymakers and budget allocation to policy areas.

To recap, we demonstrated that aggregate labour productivity growth can be decomposed into the contribution emanating from sectoral labour productivity growth, e.g. manufacturing labour productivity growth (so-called 'within effect') and that sourcing from shifts in activities between economic sectors (so-called 'between effect' or 'structural change effect'). If the policy goal is to increase aggregate labour productivity growth, the largest source of contribution should obtain the largest share of the budget because this is what generates the largest impact on aggregate labour productivity growth. For example, if the structural change effect dominates the within effect, policymakers could allocate more resources to policy actions that reduce barriers to workers' mobility.

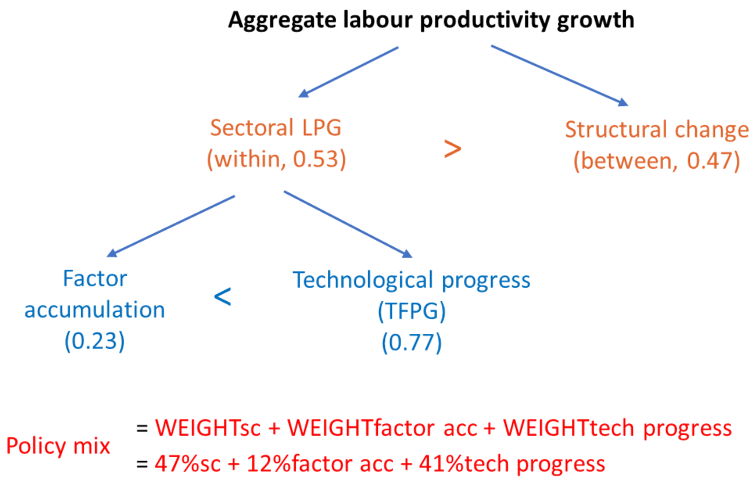
One possible policy action could be to provide more vocational training or upskilling to increase workers' attractiveness to new activities, which in turn would reduce the time to realize worker mobility.

A second useful decomposition of aggregate labour productivity growth is related to the relative contributions of adding more capital per worker (we referred to this as capital deepening), and TFP growth (technological progress). As in the case of the first decomposition, policymakers may be advised to allocate relatively more budget to the contribution that generates the most rapid aggregate labour productivity growth. For instance, if technological progress dominates capital deepening, more budget should be allocated to policy measures that generate such progress, e.g. R&D subsidies to speed up invention and strengthen linkages between actors within innovation systems.

These two decompositions are very useful in providing an initial overview of policy design and budget allocation. Can we do better? Yes, by combining them, we can delve deeper into policy detail. In a first step, we could determine whether aggregate labour productivity growth primarily stems from changes within sectors or from shifts of activities between sectors. The technical analysis suggests that the sectoral contribution tends to outweigh the effect of structural change. We can then apply the second decomposition to the result of the first decomposition. In Figure 9, we illustrate what this could look like using data from Mauritius. The first level of disaggregation is the sector level, i.e. agriculture, industry and services.

The relative contributions of sectoral labour productivity growth (LPG) and structural change in Mauritius are nearly equal: sectoral growth contributes 53 per cent to aggregate labour productivity growth and structural change 47 per cent. Capital deepening contributes 23 per cent and TFP growth (TFPG) 77 per cent. In other words, the role of technology overwhelmingly trumps that of adding more capital per worker. When these two decompositions are combined in a policy mix, we find that 47 per cent should be allocated to policies that stimulate or facilitate structural change. Out of the 53 per cent that arise from sectoral growth, 23 per cent should be allocated to policy actions that support capital deepening. This provides a total weight in the policy mix of about 12 per cent (0.53 * 0.23). The remaining share (0.53 * 0.77) is about 41 per cent, which consequently is allocated to policy actions in support of technological progress.

Figure 9: From decomposition to policy action



This is admittedly a very rough guide, but serves to help the thinking process. However, there are a few obvious extensions that could generate more complicated yet also more realistic policy mixes. After determining that the sectoral effect dominates structural change, the exercise could be performed for every sector. That is, the second decomposition could be applied to agriculture, industry and services. We could consequently examine the sources of labour productivity growth in each sector, i.e. capital deepening and TFP growth in agriculture, industry and services. Needless to say, if data permit, this could be repeated at the next level of disaggregation as well (ISIC-2).

In an alternative approach, we could delve deeper into the concepts of capital deepening and TFP growth. For example, we have added the role of human capital and calculated the separate contributions of adding more physical capital per worker (machines and equipment per worker) and adding more human capital per worker (years of schooling and health per worker). In terms of technological progress, we could have asked how much of it is attributable to domestic innovation, catching up to the technology frontier and returns to scale effects?

All of this would have added another layer or two to our analysis and produced a far more complicated (and realistic) policy mix. In addition, it would have brought the policymaker closer to a selection of policy instruments by virtue of narrowing down his or her choices. Yet, the most important piece of information is that tools are available to the policymaker to understand the relative importance of different sources of aggregate labour productivity growth. These tools are particularly useful for determining the allocation of the policy budget. With tight budgets and scarce resources available to policymakers, such tools are especially beneficial.

5 Links to other EQuIP tools

The framework we consider above focuses on productivity and structural change. There are important links between that framework and several of the other EQuIP tools.

Tool 2 explores aspects of international trade, where performance is assessed based on the exports and imports. Because productivity is one of the main determinants for a firm's ability to start exporting—consider sunk costs as a major trade barrier—policies that affect firms' productivity will also have an impact on export performance and on firms' ability to exploit potential economies of scale. Similar effects can be observed in relation to import opportunities.

Turning causality around, it is equally clear that failure to import intermediate inputs or capital will render lower levels of productivity for manufacturing, and thus weaker manufacturing performance. It will also slow down the rate of structural change.

While a similar argument may apply to value chains (Tool 4), it could be argued that participation in value chains is less affected by productivity effects. This is because a part of the value chain is domestic and sunk costs are not a concern. However, it is clear that more productive firms have a greater chance of being competitive and thus of entering a value chain; as they progress within the chain, they will eventually reach the export market and be exposed to new ideas and technologies, which will enhance their productivity and contribute to structural change.

Tool 3 focuses on diversification and (technological) upgrading. The latter is closely related to the level and type of technology (TFP) used in the production process. Structural change, upgrading and diversification in some sense go hand-in-hand, since shifting from one main activity to another (structural change) often requires upgrading and implies diversification, all of which leads to an increased level of productivity and growth. Policy actions that support diversification and upgrading speak to the core elements of Tool 1.

There is also a connection with Tool 7 on the environment, and here causality is likely to be bi-directional (e.g. Brock and Taylor, 2004). Like in the case of exports, relatively productive firms have a higher probability of being able to carry the costs related to investment in, for example, abatement technologies. However, literature has emerged that accounts for undesirable outputs (e.g. pollution), which are by-products of production. Properly accounting for these will alter productivity and as such, will affect benchmarking involving several countries. Moreover, decompositions of GDP growth or productivity growth have a strong bias towards disregarding the environment (e.g. clean air and water) as a resource (e.g. Considine and Larson 2004; Brandt, Schreyer and Zipperer, 2014). Accounting for environmental costs may alter the assessment of sectoral contributions, as well as the contribution of structural change (e.g. Faere, Grosskopf, Lovell and Pasurka, 1989; Foersund, 2018, 2019).

Tool 5 deals with labour market characteristics such as employment and wages. Structural change is closely related to the labour market through several channels. For example, a direct indicator of such change is the shift in the allocation of sectoral employment. Second, a shift from a largely agro-based economy into manufacturing will have profound implications for indicators such as employment, unemployment and underemployment, as well as on their sectoral "location". Another likely dimension that will be affected is the share of workers that operate in formal or informal sectors.[44] A third example is that demand for skills changes when activities shift between sectors.

Productivity change also has an impact on labour demand and real wages. In the short term, technology-driven productivity growth can lead to (temporary) unemployment, especially if the change in the supply of labour does not keep pace with that of demand. However, this may be accompanied by increasing real wages in sectors that experience higher productivity. Alternatively, the policymaker may decide to implement a policy that changes the workforce's skill composition, which, in turn, alters the country's comparative advantage, enabling sectoral activities that were previously unfeasible. We can thus anticipate both structural change and higher productivity.

Tool 6 addresses gender, which also has several connections with this tool. There are several important links and a few are mentioned here as examples. The most obvious connection is considering the production function and labour as inputs. Recall that increasing the number of workers typically leads to increased production, especially in the short- to medium term. In societies where half of the population (i.e. women) faces challenges in terms of entering the labour market, labour supply is significantly lower compared to other types of societies. Production is thus artificially hampered due to lack of labour input.

Encouraging women to enter the labour market increases labour supply. This has at least three important impacts. First, as women who enter employment start earning income, demand for goods and services will increase, leading to an expansion of GDP in the long run. Secondly, on the assumption that women represent about half of the population and most likely also the labour force, women's increased participation therein expands the talent pool for the performance of advanced tasks. This, in turn, enhances the economy's overall productivity. Over time, more women will be encouraged to pursue higher education, creating a positive ripple effect on the supply of skilled labour. Lastly, an increase in labour supply can exert downward pressure on wages and production cost, potentially leading to enhanced competitiveness if the reduced production costs spill over to lower prices.

Finally, which of the most advanced technologies are firms more likely to invest in (Tool 8 on digitalization)? They will invest in the most profitable and productive ones. Again, causality runs in both directions because adopting and implementing Industry 4.0 technologies undoubtedly enhances firms' productivity. If we consider structural change from the perspective of the manufacturing share of employment, extrapolation of the incidence of the smart factory/workerless factory to the extreme would imply zero manufacturing employment and infinite capital intensity! This is unlikely to materialize anytime soon, however, but the tendency and risk alone are alarming enough. Incidentally, measured by employment, it would look like complete deindustrialization, while in terms of MVA/GDP, the emerging picture might very well suggest reindustrialization.

[44] Besley (2015) reports that across 110 countries, the median level of formal activity is about 67 per cent, with only around 49 per cent in the bottom quartile.

6 Possible extensions

National Statistics Offices in OECD countries and in many middle- and high-income developing countries regularly calculate several different productivity measures. In this tool, we have focused on labour productivity only, but if sectoral investment data (gross fixed capital formation or gross capital formation[45]) are collected as well, TFP (or multi-factor productivity, MFP, as used by the OECD) can also be computed. The primary reason for the income gap between countries is to the variation in TFP rather than differences in production factors. Therefore, it is reasonable to assume that TFP also plays a role in manufacturing performance and structural change (e.g. Hulten and Isaksson, 2007).

There are a number of challenges associated with calculating TFP growth. The most debated topic among economists is the interpretation of TFP, which ranges from technological progress to a measure of our ignorance (see Hulten, 2001, for an elaboration of its interpretation). Confusion arises because many approaches to its measurement rely on the residual that emerges when the growth of production factors, labour and capital have been accounted for. The OECD uses growth accounting to determine TFP, and most regression-based approaches do the same. Yet there are other methods, such as the Data Envelopment Analysis, from which a Malmquist TFP index can be derived and which in its simplest form consists of two parts: the shift of the technology frontier—technological progress—and the catching up of a country to the technology frontier—change in technical efficiency. This measure aligns more closely with a technology interpretation of the residual. Nonetheless, all approaches face the same challenge that whatever is not accounted for, ends up as TFP.[46]

Even when an interpretation such as technology is applied, there are numerous ways to specify the production function and its functional form, plenty of econometric methods and approaches to measuring, for example capital input, all of which give rise to variations in TFP. Isaksson, Shang and Sickles (2020) devised an approach to choose between different approaches and to arrive at a "consensus" or average measure of TFP.

If policymakers decide to incorporate TFP into their training, there is one important aspect that to consider for sectoral measurement: the value-added production function is no longer suitable and should be replaced by the gross output version, where the former is a subset of the latter. On the output side, value added is replaced by gross output, while intermediate inputs must be added on the input side. A standard version would include materials (M), energy (E) and services (S), in addition to capital (K) and labour (L)— the so-called KLEMS production function. The main impact on training is the need to obtain data on EMS.

There are additional ways to address structural change, especially in terms of "where to go next". A recent approach makes use of detailed product-level export data to determine the economic complexity of countries and of individual products (see Hidalgo and Hausmann, 2009[47]). Structural change and upgrading can then be considered a process of shifting a country's specialization pattern towards one that entails the production and export of more complex products. The identification of products and sectors to target as areas to develop specialization will depend on existing specialization patterns. Countries may find it easier to move into products and sectors that require similar

[45] The difference is that the former includes changes in inventories.

[46] Such factors, for example may include capital and capacity utilization, quality improvement of both capital and labour and mismeasurement.

[47] Hidalgo and Hausmann (2009).

capabilities to those required for the production of goods currently being produced by the country of interest.

So far, we have treated labour and capital inputs as aggregates. However, it is possible to break down labour by dimensions such as gender, age, skill level, etc., all of which have policy implications. Similarly, capital input can be broken down into different types of capital such as ICT and machines, each with its own depreciation rates, prices and asset lives. They also have policy implications. This approach requires a significant amount of data.

An important category of capital recently introduced by economists is intangible capital.[48] This category includes items such as R&D, software, mineral exploration, brand names, design and other "difficult-to-measure" items. We mention this because hitherto, it was not included in the production framework, and its inclusion has resulted in a reduction in the size of TFP, or technology. These items largely belong to manufacturing, just like technology (TFP), so it is not clear how this redistribution within the production framework affects the contribution of manufacturing or structural change.

[48] Corrado, Hulten and Sichel (2009).

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Annex

This Annex contains technical information on how to calculate structural change and productivity and its components, when necessary. Ideally, this should help policy analysts perform their own calculations. Subsections A1-A3 are based on Oulton (2020).

A1 Sectoral sources of GDP growth (Laspeyres chain index)

GDP growth must be the weighted sum of the growth of individual industries. This can be formulated as:

$$\frac{Y_t}{Y_{t-1}} = \sum_{i=1}^{N} \gamma_{i,t-1} \left(\frac{Y_{it}}{Y_{i,t-1}} \right), \qquad \text{(A1)}$$

where Y_t is real GDP in time t, $Y_{i,t}$ is real value added of industry i in time t, and $\gamma_{i,t}$ is the share of the i-th industry's nominal value added in aggregate nominal value added in the previous year t-1 (that is, the output share in current prices):

$$\gamma_{i,t-1} \equiv \frac{P^Y_{i,t-1} Y_{i,t-1}}{Y_{t-1}}, \qquad i = 1, \dots, N$$

with P representing the price level for industry i (skipping super- and subscripts).

A2 Sectoral sources of labour productivity (Laspeyres chain index)

The growth of aggregate labour productivity can be attributed to growth within individual industries and reallocation effects (structural change). The second source of aggregate growth of labour productivity consists of two parts. First, labour can shift from relatively low productivity sectors to those that initially have a higher-than-average level of productivity. This would represent a positive shift; however, an opposite, unfavourable shift is possible as well. Secondly, labour can also shift to industries with a higher-than-average growth rate of productivity, which would raise the growth rate of aggregate labour productivity. Again, the opposite may also occur.

By defining the general case (A2) and comparing two special cases (A3a and A3b), we can assess the impact of these two reallocation effects. The formula for the growth of aggregate labour productivity LP is:

$$\frac{LP_t}{LP_{t-1}} = \sum_{i=1}^{N} \left(\frac{\gamma_{it-1}}{\mu_{it-1}} \right) \mu_{i,t-1} \left(\frac{LP_{it}}{LP_{i,t-1}} \right), \qquad \text{(A2)}$$

where LP is real labour productivity and μ is the labour share weight (skipping super- and subscripts). The first special case assumes that there is no change in labour shares over time (A3a; $\mu_{it} = \mu_{it-1}$ for all t), while the second special case assumes equal initial productivity levels (A3b; $\gamma_{i,t-1} = \mu_{it-1}$ for all t). This can be presented as follows:

$$\frac{LP_t}{LP_{t-1}} = \sum_{i=1}^{N} \gamma_{i,t-1} \left(\frac{LP_{it}}{LP_{i,t-1}} \right), \qquad \text{(A3a)}$$

and

$$\frac{LP_t}{LP_{t-1}} = \sum_{i=1}^{N} \mu_{i,t-1} \left(\frac{LP_{it}}{LP_{i,t-1}} \right) \qquad \text{(A3b)}$$

A3 Decomposition of aggregate labour productivity growth using the Törnqvist index

The Törnqvist index is a convenient formula to decompose aggregate labour productivity growth into its within- and between (reallocation) effects. This is a discrete approximation of the continuous case. It replaces continuous time growth with log differences, and the point-in-time output and labour shares are replaced with the average shares between *t* and *t–1*. This is probably simpler and is formulated as:

$$\Delta logLP_t = \sum_{i=1}^{N} \overline{\gamma_{it}}\, \Delta logLP_{it} + \sum_{i=1}^{N} (\overline{\gamma_{it}} - \overline{\mu_{it}})\, (\Delta logL_{it} - \Delta logL_t), \qquad (A4)$$

weights:

$$\overline{\gamma_{i,t-1}} \equiv \frac{\gamma_{i,t-1}\gamma_{i,t-1}}{2},$$

$$\overline{\mu_{i,t-1}} \equiv \frac{\mu_{i,t-1}\mu_{i,t-1}}{2},$$

where *Δ* is the difference operator and *L* is a measure of labour input, e.g. hours worked or employment.

A4 A simple calculation of capital stock

There are several different ways of calculating capital input. The OECD has developed a manual on this topic (OECD, 2009). Here we demonstrate the method applied by the majority of empirical economists.

National Statistics Offices (NSOs) around the world collect data on gross capital formation and gross fixed capital formation[49] (gross investment) in current prices, and in the best case by asset type, with appropriate deflators and by sectors. While NSOs in industrialized countries are able to provide detailed capital input data, this is not always the case in most developing countries.[50]

When detailed data are lacking, the analyst will have to resort to assumptions and approximations. For example, the only available deflator is very often that for MVA, which is then used to transform the investment series into one that is based on constant prices. Another example is that often only an aggregate measure of investment that lumps together different types of assets and sectors. In that case, it is very difficult to compute sectoral capital stocks without bold assumptions about, for example, sectoral MVA shares and their relationship with sectoral investment.

[49] The difference between the two is that the former accounts for changes in inventory.

[50] UNIDO provides technical assistance to NSOs in developing countries to help them build their capacity to collect detailed data.

Nonetheless, with an investment series in constant prices and a depreciation rate δ (rate of decay or rate of deterioration[51]), there is sufficient information to calculate what is referred to as the productive stock of capital. Why productive? Because over time, machines deliver less services due to decay and a given stock becomes less productive. **Table 13** lists the indicator and its components.

Table 13: Capital stock

Indicator	Variable	Source
Capital stock*	Gross (fixed) capital formation	NSO, UNIDO, UN Statistics or WDI
	Depreciation rate	NSO or by assumption

NSO = National Statistics Office; WDI = World Development Indicators (World Bank)

Using the Perpetual Inventory Method, we can formulate the productive capital stock as:

$$K_t = I_{t-1} + (1-\delta)I_{t-2} + (1-\delta)^2 I_{t-3} \ldots = \sum_{\gamma=0}^{\infty}(1-\delta)^{\gamma} I_{t-\gamma-1},$$

which is equal to the total volume of services obtained from this asset. If we further assume that δ is constant for each period, that geometric depreciation occurs and that assets will last forever but their services will approach zero without ever truly reaching zero, we arrive at the simple standard formula commonly used (A5):

$$K_t = I_{t-1} + (1-\delta)K_{t-1}. \qquad \text{(A5)}$$

The "only" thing left to do now is to determine or estimate δ and the starting stock of capital K_0. The depreciation rate δ is often *assumed* to be around 6 per cent, and variation around this figure does not have any major impact. The initial capital stock K_0 is sometimes assumed to be the accumulation of ten years of investment (data which are lost, rendering the time series shortened by ten years). To avoid loss of data, economists make assumptions about the first year of data, e.g. steady-state assumptions, which becomes K_0. The advantage is that it saves on data, while the major disadvantage is that it is difficult to know for sure whether that particular year is well represented by a steady-state assumption. OECD (2009) discusses different ways of computing δ and K_0.

Before closing this section, it is important to understand an implicit assumption here, namely that the volume of services can be proxied by, or is proportional to, the stock of capital. This is far from obvious, but the "cost" in terms of data requirements, assumptions and effort required to calculate the necessary *user cost of capital* could be too high in most developing countries.

A5 Calculation of total factor productivity (TFP)

As mentioned in the main text, there are several methods for calculating total factor productivity (TFP). Here, we will present one of the most commonly used approaches to measuring TFP and discuss its underlying assumptions.

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[51] This is not to be confused with the accounting view of depreciation.

The measurement of the level of TFP typically begins with an assumption about the relationship between output (*Y*) and the production factors capital (*K*) and labour (*L*). In the main text, we used a general form Y = TFP*F(K, L) to illustrate this relationship. In reality, what connects *Y*, *K* and *L* is a functional form (mathematical form), which needs to either be estimated or assumed, where the latter is a common approach. In the general form, it was not necessary to explicitly mention all the components of the functional form, particularly the two parameters representing labour and capital shares. We encountered these parameters when decomposing the growth of aggregate labour productivity into capital deepening and technological progress, and sought to measure the relative contributions of these two. Labour and capital shares can be estimated statistically, but it is more common is to make assumptions them or to obtain them from the national accounts. The latter approach is the easiest and can be achieved with a few assumptions; in practical terms, it boils down to using income shares.

With this in mind, the following common production function (A6), where technology (TFP) is assumed to affect the relationship proportionally (so-called Hick-neutrality), is formulated as follows[52]:

$$lnY_t = lnA_t + \alpha * lnK_t + \beta * lnL_t, \qquad (A6)$$

where *Y* is output, *K* and *L* are capital and labour, respectively, *A* is a measure of the level of technology, i.e. TFP, and the subscript indicates the year for which the calculation takes place.[53] Parameters α and β are capital and labour shares in output, which, when perfect competition in factor markets prevails, equal the respective marginal products. As is standard at the aggregate level, constant returns to scale (that is, $\alpha+\beta=1$) are assumed.[54] **Table 14** summarizes the indicators and variables involved in the calculation.

Table 14: Total factor productivity (TFP)

Indicator	Variable	Source
Total factor productivity (TFP)*	Labour productivity (Y/L)	NSO, UNIDO, UN or WDI
	Capital intensity (K/L)	NSO, UNIDO, UN or WDI
TFP growth*	Change in labour productivity (Y/L)	NSO, UNIDO, UN or WDI
	Change in capital intensity (K/L)	NSO, UNIDO, UN or WDI
α, β*	Income shares	NSO or UN

The level of TFP with subscripts suppressed is, then, measured as (A7):

$$lnA_t = lnY_t - \alpha * lnK_t - \beta * lnL_t. \qquad (A7)$$

52 Solow (1956; 1957). As is customary, we express the production function in natural logarithms, since it simplifies both calculations and interpretation.

53 It is common to include some form of human capital, either as an individual factor or by adjusting labour input for the level of human capital, just as in the benchmark case above. Moreover, if sectors are analysed, intermediate inputs will also need to be accounted for and output measured as gross output rather than as value added.

54 If this does not hold, the divergence will end up in TFP. However, at the macro level, this divergence is likely to be very small, but as more disaggregated data are analysed, the greater the impact tends to be.

That is, TFP is "backed out" as a residual when all production factors have been accounted for. The intriguing part of this exercise is that technology is not directly observable, but the production factors are. Since output is produced using observable production factors and technology, accounting for the observables gives us a measure of the unobservable input, technology.

The growth version of (A6) in discrete growth form is simply (A8):

$$\Delta lnA_t = \Delta lnY_t - \alpha * \Delta lnK_t - \beta * \Delta lnL_t, \qquad (A8)$$

where Δ is the symbol for the change between two years.[55] Using (A8) we can, for example explore how much of GDP growth is sourced from capital, labour and TFP growth each. The contribution of factor accumulation, for example of capital growth, to GDP growth is calculated as (A9):

$$\alpha * \frac{\Delta K_t}{\Delta Y_t}, \qquad (A9)$$

where the contribution of capital growth is weighted by its income share α. The same calculation is performed for the contribution of an increase in labour, this time adjusted for labour share (β), the same way capital growth is adjusted for capital share (α) in (A9). Finally, the contribution of technological progress is backed out as a residual since the contributions must sum up to 100 per cent. Hence, whatever output growth is not accounted for by capital and labour growth, must be due to technological progress.

A6 Calculation of the relative contributions of capital intensity and TFP

For policymakers, it is useful to understand the individual contributions of differences in capital intensity and TFP to variations in labour productivity. For this, we need to revisit the case of comparing productivity levels between two countries at any point in time. In this case, and for variation, consider (A10) in per worker form (still in logs and *t* suppressed to keep focus on two countries, *i* and *j*):

$$\left((lnY_i - lnL_i) - (lnY_j - lnL_j)\right) = \left(lnA_i - lnA_j\right) + \alpha * \left((lnK_i - lnL_i) - (lnK_j - lnL_j)\right), \qquad (A10)$$

where *i* and *j* are two countries. The difference in output per worker between countries *i* and *j* sources from differences in the two countries' level of technology and capital per worker, respectively. If we are interested in understanding the difference in technology between two countries, we only need to reformulate (A10) in the form of (A11):

$$\left(lnA_i - lnA_j\right) = \left((lnY_i - lnL_i) - (lnY_j - lnL_j)\right) - \alpha * \left((lnK_i - lnL_i) - (lnK_j - lnL_j)\right). \qquad (A11)$$

The contribution of country differences in capital per worker to country differences in output (A12) is calculated the same way as for the case of growth (see equation A9 above) and again the contribution of country differences in TFP is the remainder of 100 per cent that has not been accounted for by country differences in capital per worker:

$$\alpha * \frac{\left((lnK_i - lnL_i) - (lnK_j - lnL_j)\right)}{\left((lnY_i - lnL_i) - (lnY_j - lnL_j)\right)}. \qquad (A12)$$

[55] Clearly, one may simply calculate the change in (A7) to obtain (A8).

A7 Manufacturing subsectors

The following two tables list the 2-digit manufacturing subsectors according to ISIC revision 3.1 as well as revision 4. They include a classification of their technological intensity according to UNIDO (2010).

ISIC 2-digit, revision 3.1

ISIC	Industry/subsector/activity description	Technology intensity
15	Manufacture of food products and beverages	Low tech
16	Manufacture of tobacco products	Low tech
17	Manufacture of textiles	Low tech
18	Manufacture of wearing apparel; dressing and dyeing of fur	Low tech
19	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear	Low tech
20	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	Low tech
21	Manufacture of paper and paper products	Low tech
22	Publishing, printing and reproduction of recorded media	Low tech
23	Manufacture of coke, refined petroleum products and nuclear fuel	Medium tech
24	Manufacture of chemicals and chemical products	Medium-high and high tech
25	Manufacture of rubber and plastics products	Medium tech
26	Manufacture of other non-metallic mineral products	Medium tech
27	Manufacture of basic metals	Medium tech
28	Manufacture of fabricated metal products, except machinery and equipment	Medium tech
29	Manufacture of machinery and equipment n.e.c.	Medium-high and high tech
30	Manufacture of office, accounting and computing machinery	Medium-high and high tech
31	Manufacture of electrical machinery and apparatus n.e.c.	Medium-high and high tech
32	Manufacture of radio, television and communication equipment and apparatus	Medium-high and high tech
33	Manufacture of medical, precision and optical instruments, watches and clocks	Medium-high and high tech
34	Manufacture of motor vehicles, trailers and semi-trailers	Medium-high and high tech
35	Manufacture of other transport equipment	Medium-high and high tech
36	Manufacture of furniture; manufacturing n.e.c.	Medium-high and high tech

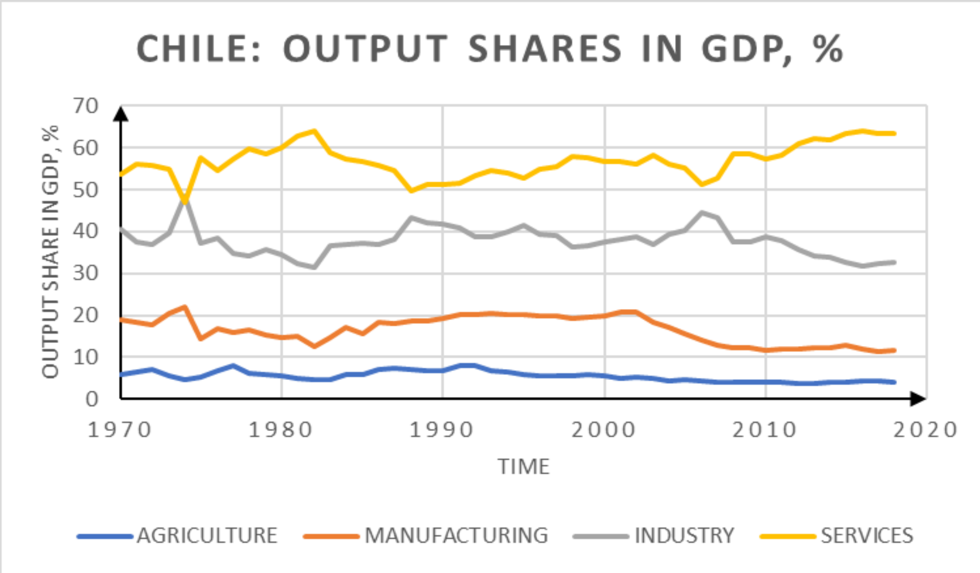
ISIC 2-digit, revision 4

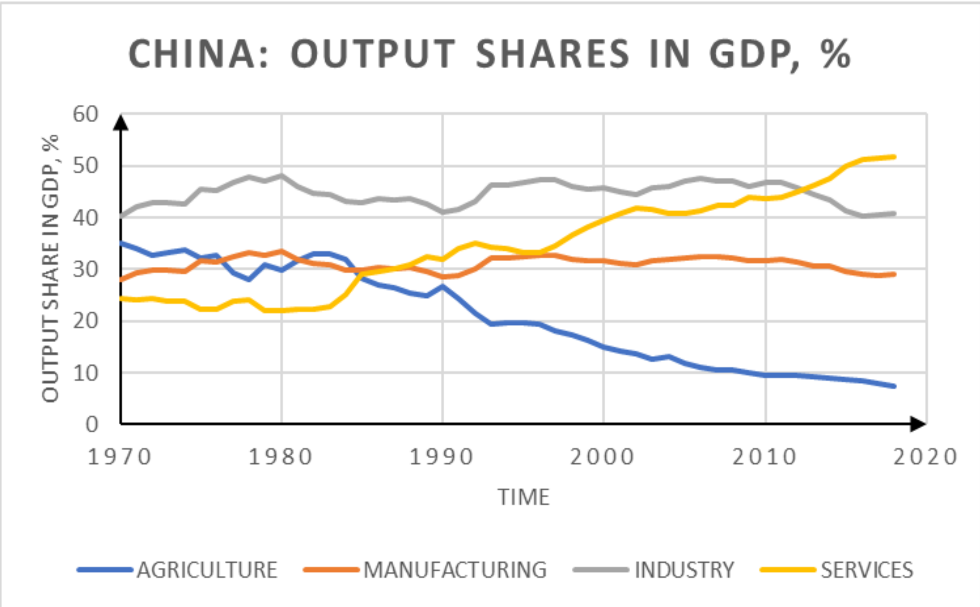
ISIC	Industry/subsector/activity description (short)	Technology intensity
10	Food products	Low tech
11	Beverages	Low tech
12	Tobacco	Low tech
13	Textiles	Low tech
14	Wearing apparel	Low tech
15	Leather	Low tech
16	Wood and wood products	Low tech
17	Paper	Low tech
18	Printing	Low tech
19	Coke and refined petrol	Low tech
20	Chemicals	Medium-high and high tech
21	Pharmaceuticals	Medium-high and high tech
22	Rubber and plastics	Medium tech
23	Non-metallic minerals	Medium tech
24	Basic metals	Medium tech
25	Fabricated metals	Medium-high and high tech
26	Computer, electronics, optical	Medium-high and high tech
27	Electrical equipment	Medium-high and high tech
28	Other machinery and equipment	Medium-high and high tech
29	Motor vehicles	Medium-high and high tech
30	Other transport equipment	Medium-high and high tech
31	Furniture	Low tech
32	Other manufacturing	Medium tech
33	Repair and install. of machinery and equipment	Medium tech

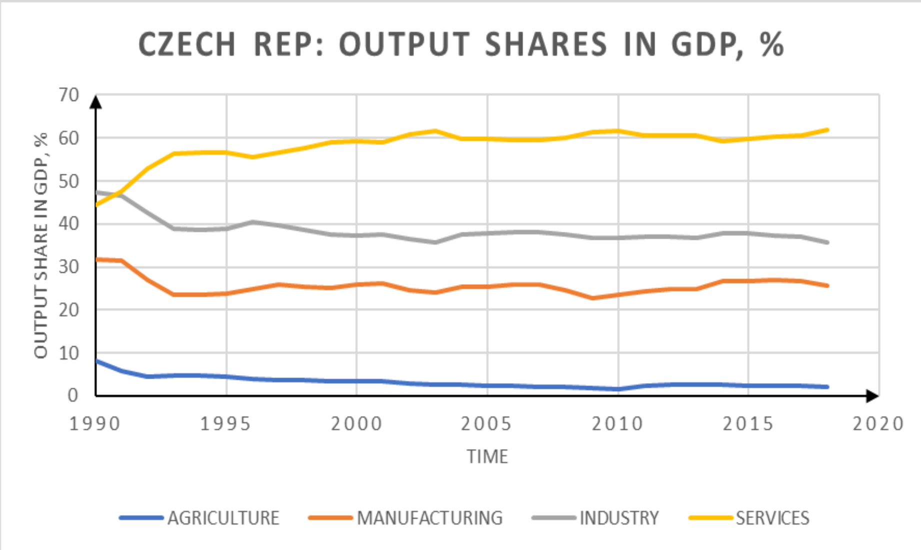
A8 Additional analysis

The following graphs were not included in the main text for brevity.

Output shares in GDP (Indicator 2)






CZECH REP: OUTPUT SHARES IN GDP, %
OUTPUT SHARE IN GDP, %
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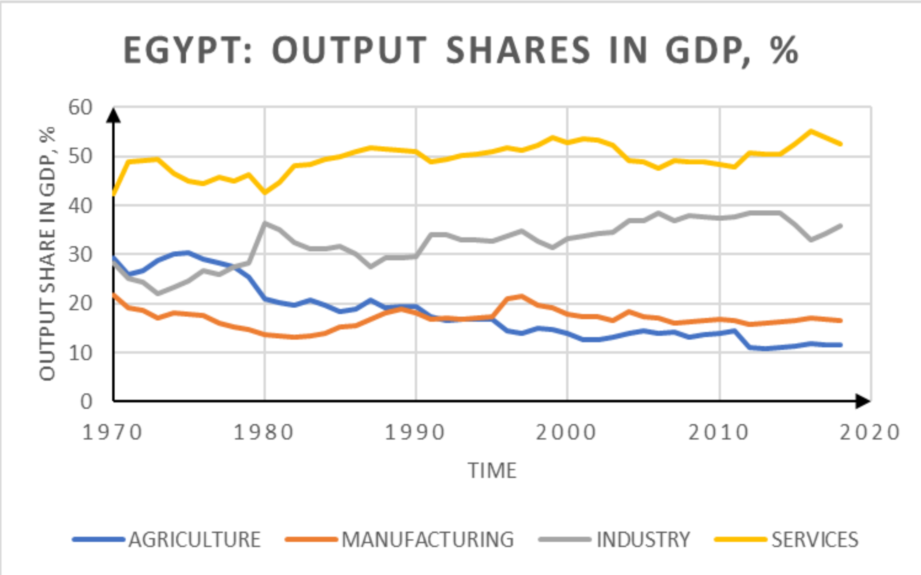
EGYPT: OUTPUT SHARES IN GDP, %
OUTPUT SHARE IN GDP, %
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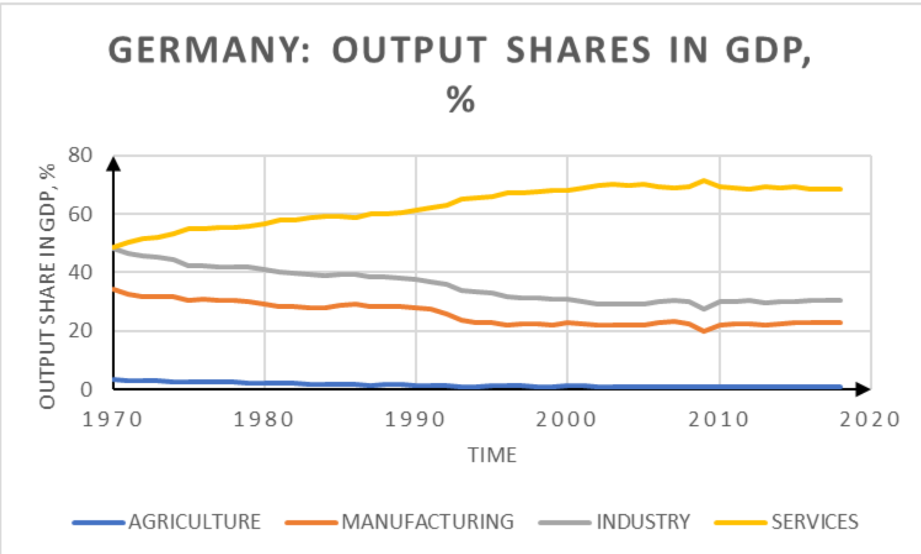
GERMANY: OUTPUT SHARES IN GDP, %
OUTPUT SHARE IN GDP, %
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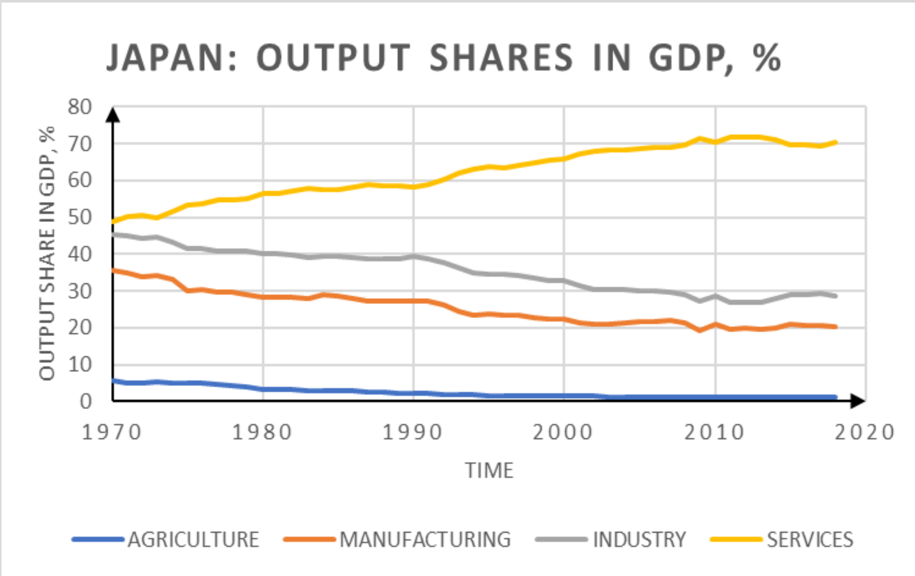

JAPAN: OUTPUT SHARES IN GDP, %
OUTPUT SHARE IN GDP, %
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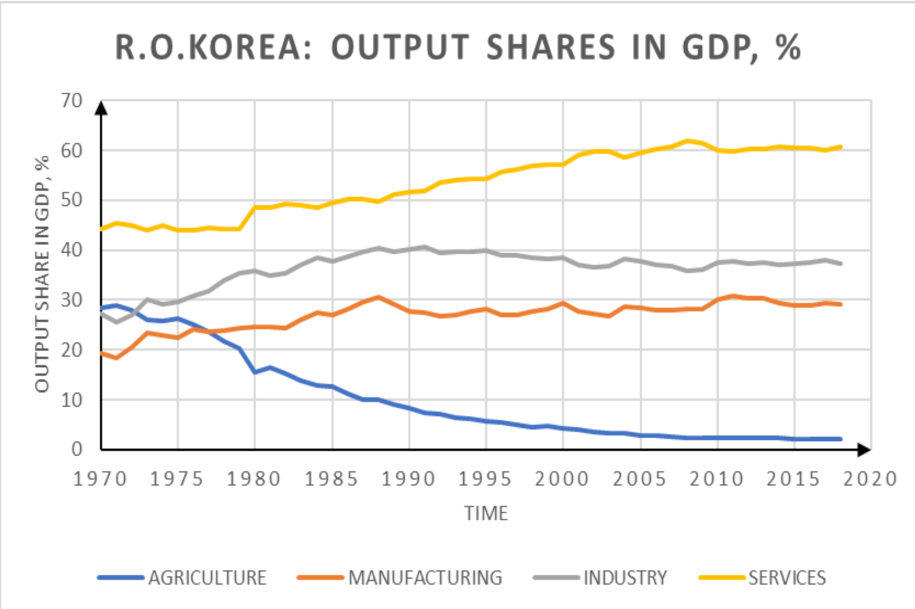

R.O.KOREA: OUTPUT SHARES IN GDP, %
OUTPUT SHARE IN GDP, %
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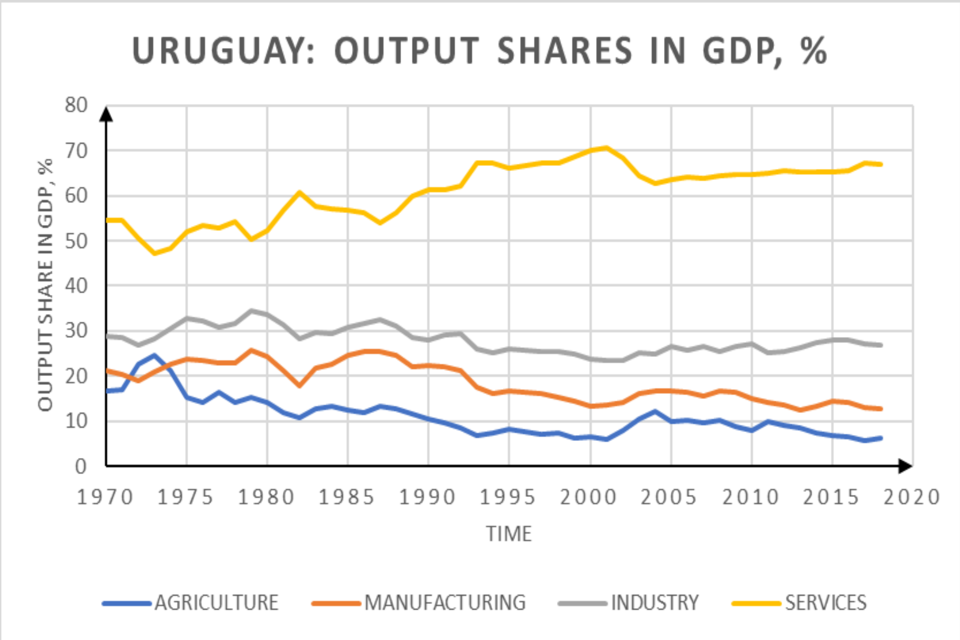
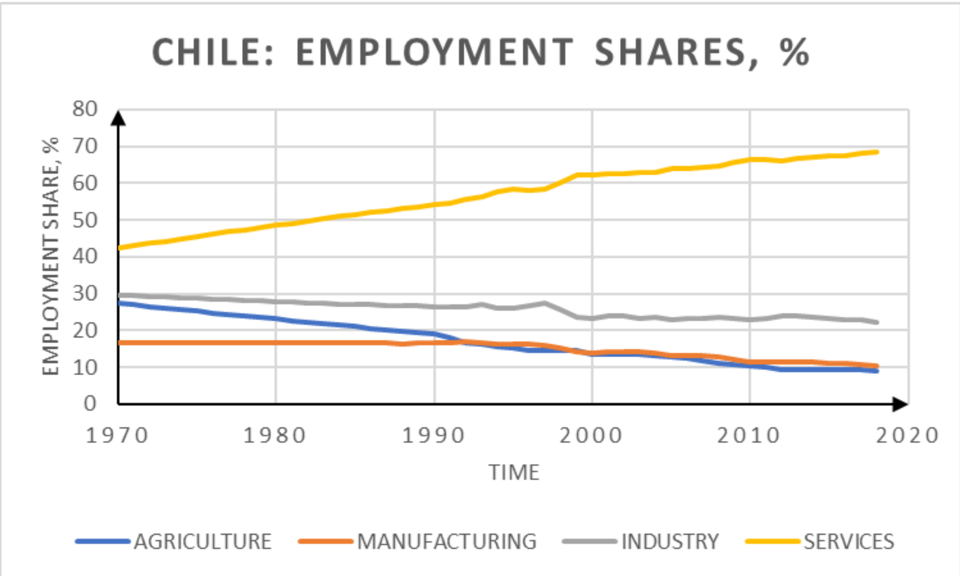
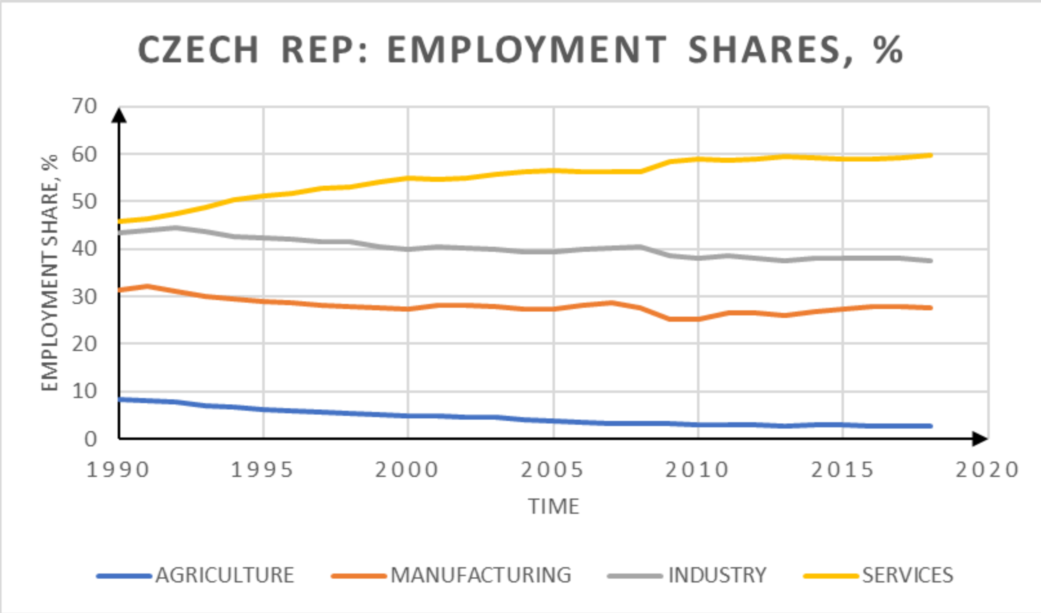


Employment shares (Indicator 3)




CZECH REP: EMPLOYMENT SHARES, %
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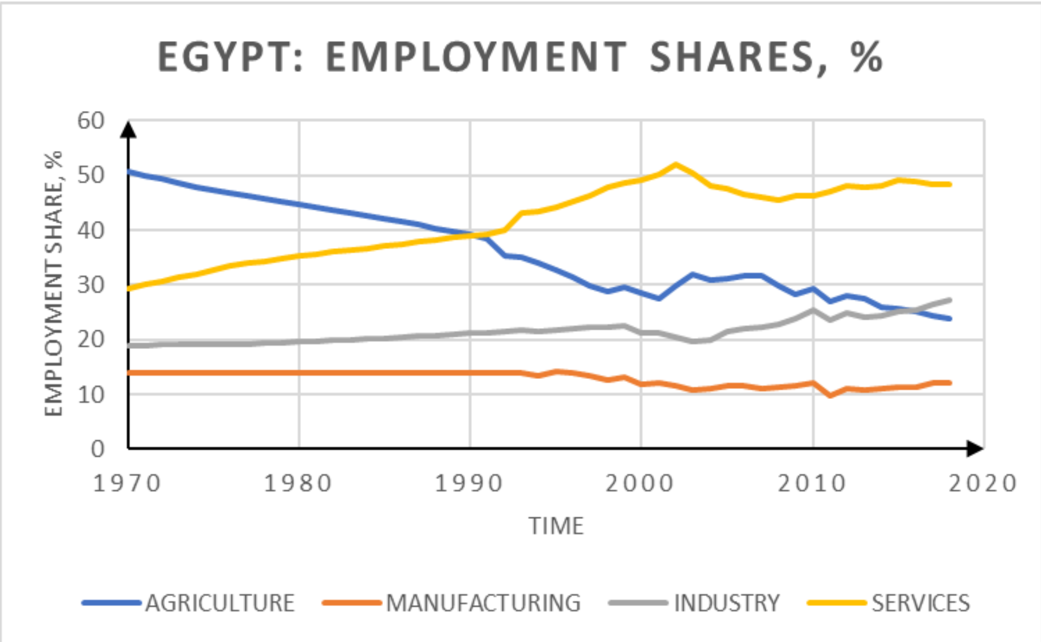
EGYPT: EMPLOYMENT SHARES, %
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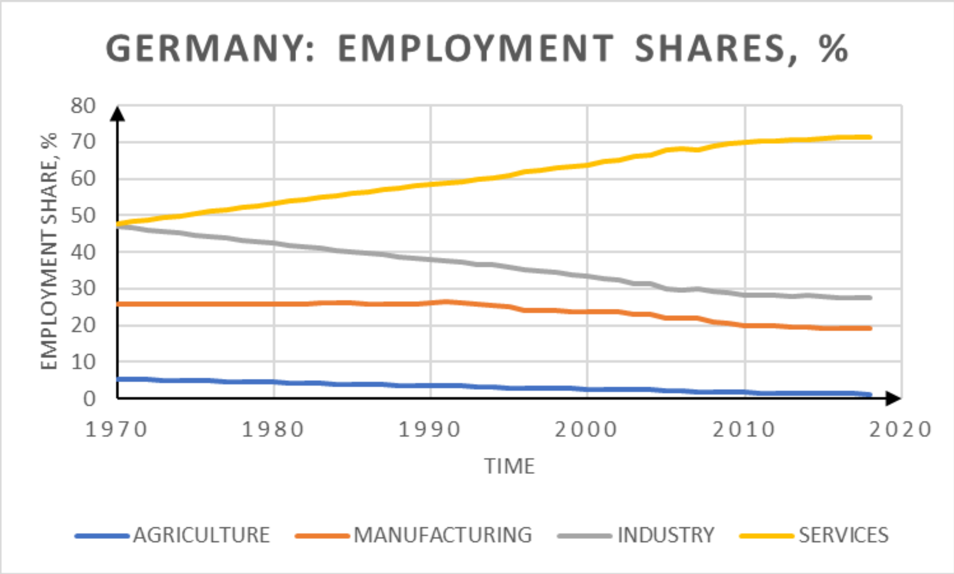
GERMANY: EMPLOYMENT SHARES, %
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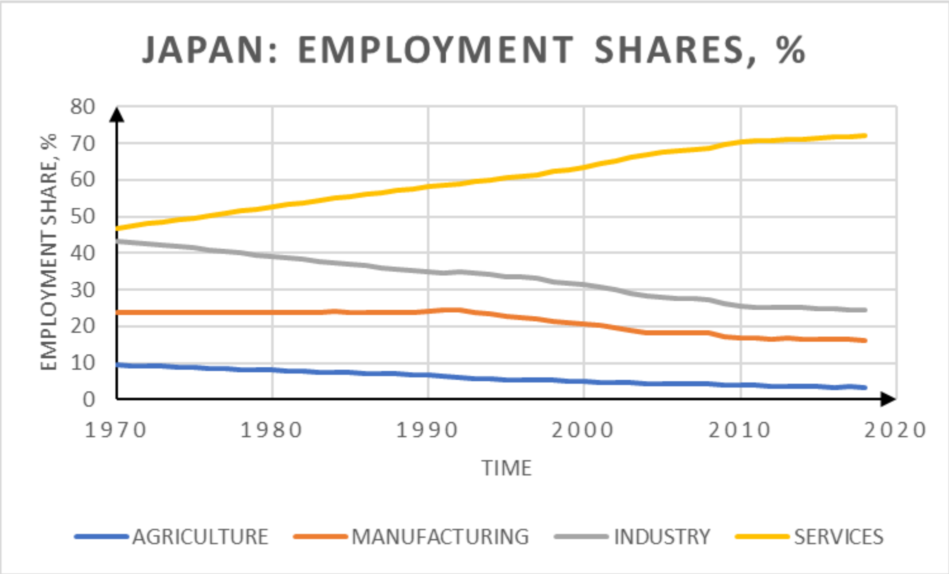
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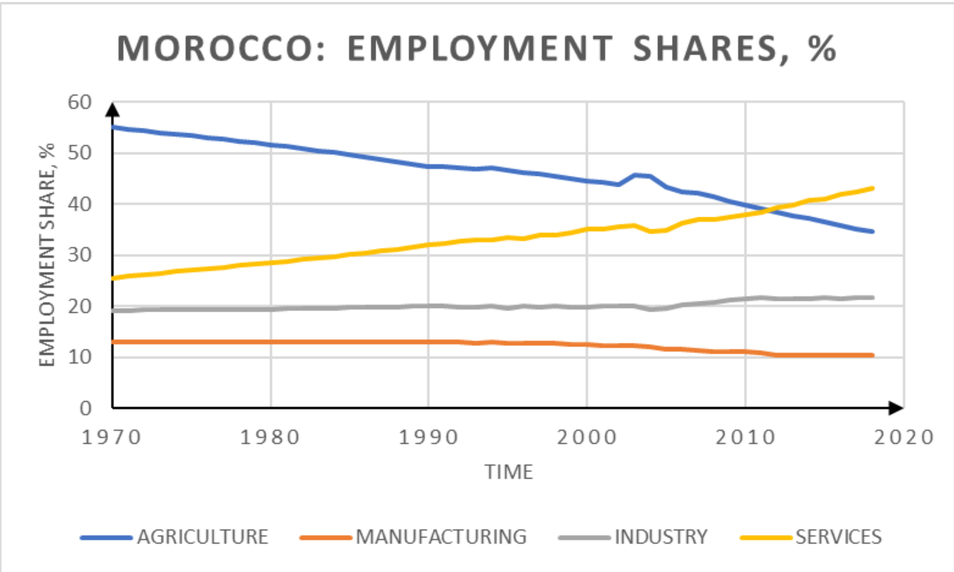
MOROCCO: EMPLOYMENT SHARES, %
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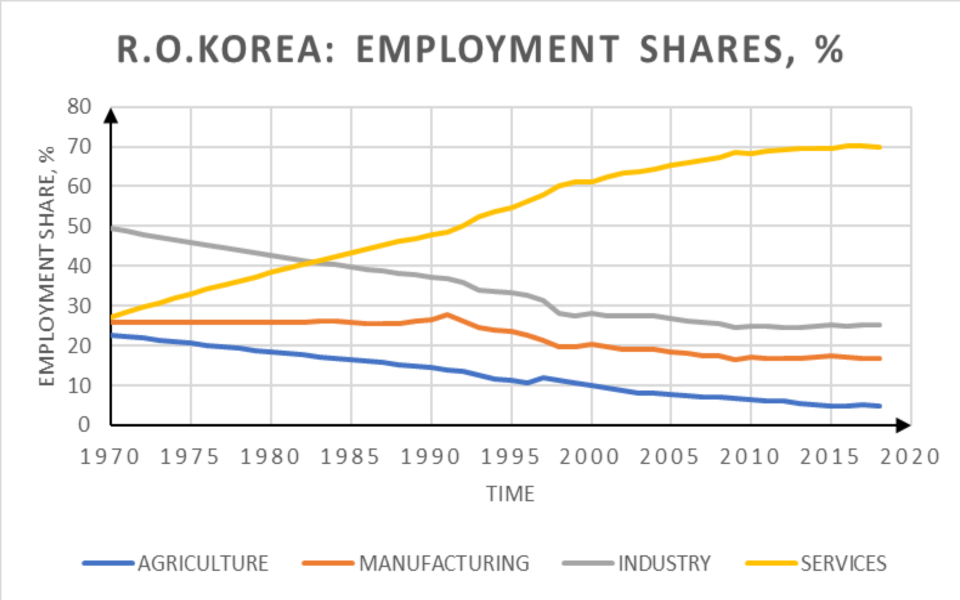
R.O.KOREA: EMPLOYMENT SHARES, %
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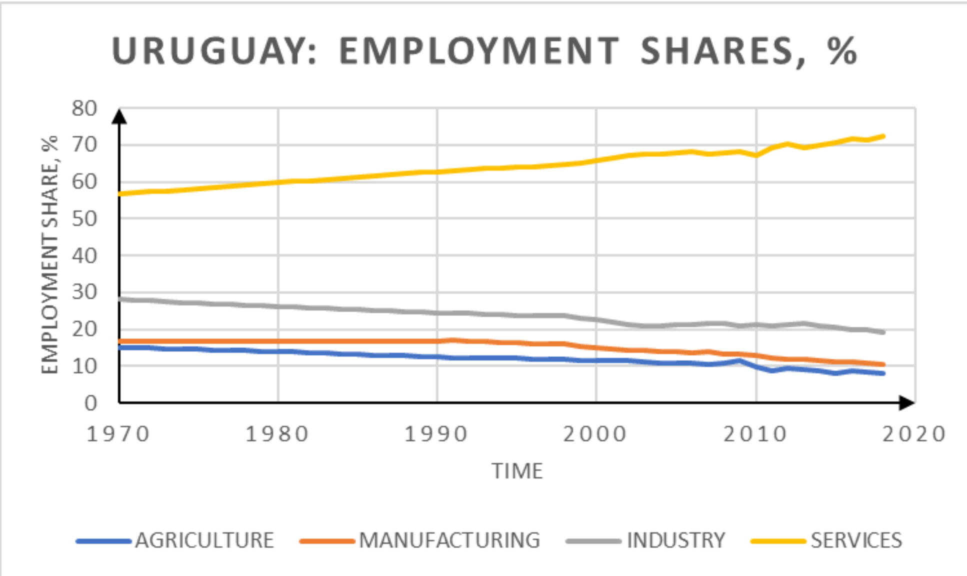
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AGRICULTURE
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