



Inclusive and Sustainable Industrial Development Working Paper Series
WP 5 | 2020

CHAIN ANALYSIS TOOL (CAT)

A TOOL FOR COST STRUCTURE AND PROFIT
MARGIN ANALYSIS ALONG VALUE CHAINS

*INCLUDING AN ILLUSTRATIVE EXAMPLE OF
VENEZUELA'S RICE VALUE CHAIN*

DEPARTMENT OF POLICY, RESEARCH AND STATISTICS

WORKING PAPER 5/2020

Chain Analysis Tool (CAT)

**A tool for cost structure and profit margin analysis
along value chains**

**(including an illustrative example of Venezuela's rice
value chain)**

Frank Hartwich
UNIDO

Jose Enrique Sanchez Piñate
UNIDO Consultant

Antonio Perez Marquez
UNIDO Consultant



UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

Vienna, 2020

Acknowledgement

The authors would like to thank Anders Isaksson, Adnan Seric and Franco Javier Silva Avila for reviewing an earlier version of this paper. We would also like to thank the members of the UNIDO Venezuela Country Programme team who made essential contributions to the development of the “Chain Analysis Tool” (CAT) within the scope of the project “Fostering the integrated development of seven agricultural value chains” (ID 180021):

José Lucas Peña Suárez	Value Chain Coordinator & Value Chain Analyst – Coffee
Maria Carolina Betancourt	Value Chain Analyst – Soybean
Antonio José Pérez Márquez	Value Chain Analyst – Rice
Heberth Ivan Niño Arenas	Value Chain Analyst – Sugar Cane
Jesús Alexander Acosta Pérez	Value Chain Analyst – Maize
Mercedes Isolina Acabán Gómez	Value Chain Analyst – Cocoa
Richard Antonio Ramirez Bruno	Value Chain Analyst – Beans
Nely María Matamoros Carrasquel	Country Programme Consultant

The designations employed, descriptions and classifications of countries, and the presentation of the material in this report do not imply the expression of any opinion whatsoever on the part of the Secretariat of the United Nations Industrial Development Organization (UNIDO) concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries, or its economic system or degree of development. The views expressed in this paper do not necessarily reflect the views of the Secretariat of the UNIDO. The responsibility for opinions expressed rests solely with the authors, and publication does not constitute an endorsement by UNIDO. Although great care has been taken to maintain the accuracy of information herein, neither UNIDO nor its member States assume any responsibility for consequences which may arise from the use of the material. Terms such as “developed”, “industrialized” and “developing” are intended for statistical convenience and do not necessarily express a judgment. Any indication of, or reference to, a country, institution or other legal entity does not constitute an endorsement. Information contained herein may be freely quoted or reprinted but acknowledgement is requested. This report has been produced without formal United Nations editing.

Abstract

This paper reviews the structure and uses of a standardized chain analysis tool (CAT) for quantitative analyses of costs and profit margins. The “Chain Analysis Tool” is a computer application designed to facilitate the visualization and study of costs and profit margins along value chains. Data are entered into a preformatted Excel workbook; subsequent analyses and plotting of data on graphs are performed following unique mathematical algorithms. The data are converted into a format that presents the costs and margins based on a single product unit (e.g. kilogrammes of maize harvested or kilogrammes of rice flour processed). Data can be plotted using the CAT to illustrate the progressive aggregation of costs and profit margins up to the final value of the product; in other words, it illustrates how value is added along the chain. The CAT can display the value addition for either the entire production chain or for specific segments of the chain only (e.g. primary production, post-harvest handling, various stages of processing and commercialization). The data are presented in different formats, including box whisker charts which display the frequency distribution of data, as well as bar charts which show the average cost and profit margin contributions of a given percentile of the data set. Depending on the aim of the analysis, the input data can either be real values collected in the field or represent theoretical scenarios, future projections, best practice scenarios or a goal or target price set by a government or development programme. Analysts can also apply a range of criteria that reflect different time periods, a country or regions, type of chain actors, type of technology/technological packages applied, etc. Using the tool usually requires the collection of primary data on costs of production (from producers, processors, marketers, etc.); however, secondary data can also be entered. The more data is entered, the more meaningful the analyses will be. When new data are entered or any changes are made to the parameters, the CAT automatically updates all graphs, thus facilitating the performance of dynamic analyses. The CAT Excel sheet is available from UNIDO.

Comparisons of value addition between different cases and scenarios (according to the selected criteria) can be made using the CAT. This has multiple advantages: chain actors can compare their performance with others and identify best practices, for example. Moreover, levels of productivity can be determined and compared in each segment of the value chain. Potentials for cost reductions and increases in profit per unit can be identified as well. The distribution of profit margins across the value chain’s various segments can be distinguished and subject to policy analyses and subsequent policy interventions. Furthermore, policymakers can build scenarios to reflect policy changes and the CAT can analyse how the cost structure and profit margins (a proxy for the economic incentive to produce) would change. The CAT can also be used for comparative analyses of cost structures in different time periods, countries or regions, technologies, etc.

Finally, the CAT can be used to build a development vision among the actors within a value chain agreeing on common value chain development objectives. The tool can be applied to all phases of any project to improve chain management, diagnose current and future economic scenarios, develop action plans, evaluate impacts and monitor trends. It has been successfully used in the inclusive and sustainable development of seven agribusiness chains project within the framework of the UNIDO Venezuela Country Programme. Results were obtained in all of the above-mentioned areas. Further applications of the CAT to other value chain development contexts is beneficial for gathering further evidence of its usefulness, to learn more about the tool's most effective applications and to fine-tune its programming. The CAT has the potential to spur development in any given value chain context.

Keywords: Quantitative value chain analysis, costs and profit margins, analytical tool

Table of Contents

1	Introduction	1
2	Common practices in quantitative value chain analysis	2
3	Rationale and structure of the CAT	7
4	Using the CAT	11
4.1	Data collection	11
4.2	Data entry	12
4.3	Data processing.....	14
4.4	Programming CAT calculations	15
4.5	Creating box-whisker charts	16
4.6	Creating bar charts.....	19
4.7	Comparing cases.....	20
5	Applying the CAT: The case of the Venezuelan rice value chain.....	22
5.1	Development challenges in Venezuela’s rice value chain.....	23
5.2	Establishing costs and profits of individual production	26
5.3	Comparing costs and profits of individual production (before and after)	29
5.4	Comparing costs and profits of individual production to benchmarks and innovation..	32
5.5	Verifying existing cost structures	33
5.6	Monitor and simulate policy changes	34
5.7	Forecast of future production and profit distribution across value chain actors	35
5.8	Engaging government and stakeholders	35
6	Conclusions	36
	References.....	38

List of Figures

Figure 1: Data entry sheet for primary production (PP)	13
Figure 2: Chain table.....	15
Figure 3: Scenario selection menu	16
Figure 4: Box-whisker table.....	17
Figure 5: Box-whisker chart	18
Figure 6: Bar chart table.....	19
Figure 7: Bar graph.....	20
Figure 8: Percentages of cost elements in bar table	20
Figure 9: Comparison table.....	21
Figure 10: Comparison graph	21
Figure 11: Venezuela’s rice production and imports from 1961 to 2018	22
Figure 12: Production costs of primary rice production, 2019 in USD/kg	27
Figure 13: Production costs across the rice value chain, 2019 in USD/kg	28
Figure 14: Production costs of primary rice production, 2018 and 2019 in USD/kg	30
Figure 15: Production costs along the rice value chain, 2018 and 2019 in USD/kg	31
Figure 16: Production costs along the rice value chain, comparison with Colombia	32
Figure 17: Production costs along the rice value chain, official data versus survey data.....	34
Figure 18: Production costs along the rice value chain, before & after the introduction of policy measures (fertilizer subsidy)	35

1 Introduction

Value chain analyses are performed by many development practitioners from both the private and the public sector as well as from development agencies. The main purpose of value chain analysis is the identification of development options that go beyond the improvement of individual firms or segments of the value chain (primary production, post-harvest, handling, processing, wholesaling, retailing). Many different value chain analysis tools are available, and practitioners can choose and adopt various approaches in a flexible way, depending on the analysis' objective and country or regional context. Most tools focus on identifying constraints to and opportunities for development; the analysis is usually of a qualitative rather than of a quantitative nature. It is mostly very case-specific, with little room for comparisons and limited ability to rank or assess the impact of alternative interventions. Quantitative analysis should complement qualitative analysis to make value chain development more evidence-based and focussed on economically relevant solutions.

Most quantitative value chain tools focus on micro (firm) level strategies such as cost reduction, lead times or inventories. Approaches that explore improvements in the performance and competitiveness of segments or of a country's entire value chain usually analyse prices and costs (including the decomposition of costs) across a number of value chain actors, and often conclude with a comparison of the analysed situation with given benchmarks. Such approaches have been propagated by various institutions, including the World Bank, USAID and FAO. However, they require the analyst to manually calculate costs and profit margins; no standardized data calculation tool is currently available to perform such quantitative value chain analyses.

This paper reviews the structure and uses of a standardized chain analysis tool (CAT) for quantitative analyses of costs and profit margins. The CAT was developed within the context of a 2019 UNIDO value chain development project in Venezuela. It has been designed to be applied in any value chain context. This paper propagates the further development and use of the CAT to contribute to value chain development in any development situation. The paper's target audience are analysts working in value chain development and managers of firms. The CAT is a useful tool for both individual production and firms as well as for policy making in a broader development context.

At the *firm and producer level*, the CAT provides a) the status of costs and profits of individual operations on a per unit cost basis; b) a comparison of costs and profits in other periods; and c) a comparison with benchmarks in other regions or countries, other production schemes/technologies/packages and best practices. The sampling of data and the data set's

representativeness are not of particular relevance in this regard, because the individual firms define who they want to compare themselves to.

At the policy making level, the CAT can provide an overview of the costs and profit margins in a given value chain. It can also compare the costs and profit margins obtained from a survey with data from official cost calculations. These figures can moreover be compared across regions and countries as well as technologies and production systems to identify good practices and potentials to improve productivity and reduce costs. Policies can subsequently be defined that support the adoption of cost-reducing and productivity-increasing technologies. The CAT can further be used to monitor and simulate the effects of changes in pricing and subsidy regimes and other policy measures that influence the value chain's cost structure and profit margins. Taking the size of the profit margin as a proxy for the producer's likelihood to continue engaging in production, estimations can be made on the volume of production in the following cycle and the effects of policy measures can be monitored and simulated. In all of these cases, the data must be representative of the situation in the given value chain.

The paper is structured as follows. Section 2 summarizes common practices in quantitative value chain analysis and makes the case for a standardized tool that is of practical use for analysts in developing countries. Section 3 introduces the tool's rationale and structural design. A step by step guide on how to enter data and perform the analysis using the tool is provided in Section 4. Section 5 illustrates how the obtained results can be interpreted and used for policy making and chain development measures for Venezuela's rice value chain. The conclusions describe the tool's main uses and scenarios for additional applications as well as further development and fine-tuning of the tool.

2 Common practices in quantitative value chain analysis

Value chain analysis is a mechanism that allows producers, processors, traders/marketers and retailers (representing segments of the value chain) to gradually add value to products and services as they pass from one segment in the chain to the next until reaching the final consumer (domestic or global) (UNIDO, 2011). Firms are the main actors in value chains; while public and private services contribute to the functioning of the chain, they do not exercise product ownership.

Value chain analysis helps us understand how firms operate and coordinate their business under given framework conditions to ensure that primary materials are transformed, stored and transported to reach end consumers in a certain format and quality. Value chain analyses usually focus on existing constraints to and opportunities for value chain development, of which there are many. Such analyses also explore the various effects and impacts that operations in the chain have

on groups of people, e.g. in terms of poverty reduction, employment, income generation, firm development, economic growth or environmental sustainability (UNIDO, 2015). Value chain analyses have gained considerable attention in recent years, and a large number of approaches and tools have been developed to perform such analyses.

Most value chain analyses look at specific value chain dimensions, such as markets for end products, value chain governance, value chain finance, technologies being used or the socio-political context, among others. Others focus on specific development outcomes or certain value chain segments. A value chain analysis can be conducted to identify the potential for poverty alleviation among primary producers only, for example. The methodology used largely depends on the scope and objective of the analysis itself. Given common analytical skills as well as time and budgetary constraints, most methodologies used in practice tend to be qualitative in nature. It is also common for value chain analyses to focus on the process of value chain development (appraisal, identification of opportunities, design of interventions, implementation of value chain measures, monitoring and evaluation) as well as participation and stakeholder engagement.

However, value chain analyses often fall short in terms of collecting and processing quantitative data, e.g. on the number of actors, size and cost of production, and productivity among the actors in the value chain's various segments. The main approach for quantitative value chain analyses uses cost and profit margin calculations to analyse firms in the value chain's segments. This approach goes back to the theory of firm economics and microeconomic profit and gross margin calculation¹. The approach is propagated, for example, by USAID, the Donor Committee for Enterprise Development (DCEd) and the World Bank.

USAID's value chain analysis approach "Market Links", maps the distribution of value added by recording prices (i.e. gross output values) in different segments of the chain for one unit of a given good or service, beginning with raw materials used as inputs and ending with the final product sold to the consumer. It calculates input and production costs (such as bought-in materials and contracted services), which need to be subtracted from the recorded prices to determine the value added of each segment of the value chain. The results are typically presented in graphs that illustrate the accumulation of costs and value added.

¹ It can also be seen as a first step in the calculation of the internal rate of return on investment, the net present value and other financial measures.

Similarly, the “Markets for the Poor” methodology (M4P/DCED/DFID 2008) used by USAID and DCED identifies the distribution of operating (variable and fixed) and investment costs across actors along the chain as well as profit margins. It examines whether the poor can enter the chain; for example, the poor might be excluded from the chain if operating or investment costs for starting up a business are too high. For both the USAID’s and DCED’s approaches, analysts must individually develop the calculations manually as no preformatted calculation sheets or software tools to conduct such an analysis is provided.

The World Bank approach, likewise, identifies the private costs and profitability of different segments of the value chain. It makes the argument for a better understanding of cost composition by analysing the detailed cost structures of value chain actors. Conclusions on trade competitiveness can be drawn by comparing cost structures and profit margins with those of other countries. In an application of this approach, Tchale and Keyser (2010), for example, analysed the increase of agricultural input prices, accumulating transport costs, clearing fees, domestic handling, wholesale mark-ups and transport to the place of sale and place of use.

Somewhat related, in its Competitive Commercial Agriculture in Africa (CCAA) studies, the World Bank collected value chain data using a set of preformatted spreadsheets for country comparisons. The spreadsheets, organized in seven workbooks (related to 1) country data, 2) inputs, 3) farm production, 4) assembly, 5) processing, 6) logistics, and 7) policy analysis matrix) require the collection of data on indicators such as commodity prices, production costs and conversion rates. The workbooks have been designed to calculate standard indicators for accumulated production costs, private financial returns and time requirements in each segment of the value chain (Keyser, 2006). The measurement of costs, profitability and time requirements are drawn from standard per hectare or per tonne calculations (referred to as ‘budgets’) for farm production, crop assembly, industrial processing and logistics.

The CCAA methodology focusses on comparisons across countries. Moreover, Keyser (2006, p. 3) asserts that “*while the spreadsheet templates are designed to produce a standard set of indicators, any number of seemingly minor differences in how one country team values specific production factors can have an important bearing on the final results.*” He concludes that instead of insisting on high levels of detail and consistency between countries, the methodology is best used to draw a general picture of international competitiveness and relative cost levels. Keyser also highlights another limitation of the tool, namely the high level of detail required to use it. A wide array of data need to be collected, which are often not easily available or only if substantial time and resources are invested. Finally, input use, yields, production and overhead costs vary

greatly across actors, resulting in another considerable limitation of the tool, namely data accuracy, which depends on the sampling approach taken for the collection of data.

FAO developed the “FAO VCA-Tool software” (Bellù et al., 2006, Bellù and Cappi, 2010) to analyse policies and their socio-economic impacts. The tool allows for a) situational analysis of the value chain’s economic, social and environmental dimensions; b) identification of potential improvements of the value chain, which can be introduced by means of public policy measures; and c) assessments of the likely economic, social and environmental impacts of the available policy options. The tool aims to inform the stakeholders involved in policy processes and to support public policy decision. It provides answers to relevant policy concerns, such as the value created in the chain, who creates it, the relationship between value added and profit, and the distribution of value added.

Just like the USAID and DCED approaches, FAO’s tool builds on the concept of “value added”, here understood as the wealth created in an economic system by a production process, net of the resources consumed by the process itself. According to Bellù et al. (2006), there are three types of value added: 1) cumulative value added created by the overall value chain; 2) the value added and margins of each economic agent in each segment of the chain; and 3) the allocation of value added among production factors (capital labour, other assets) and the public budget, through the respective distributive variables (profits, wages, rents and taxes). A country’s gross domestic product (GDP) is an aggregate measure of the value added (gross of depreciation) produced by all economic activities in different sectors. An assessment of the value added created by the overall value chain is useful to determine the extent to which a value chain contributes to GDP. The distribution of value added among actors, on the other hand, determines the value chain’s societal significance.

The FAO tool uses value chain accounting frameworks that present the current situation (without a policy intervention) of a wide range of products (commodities) in the value chain, and builds alternative scenarios (with policy interventions), reflecting the changes policy measures could generate as well as a measurement of shifts in physical production, value added and the income accruing to the various agents involved.

The FAO tool, a unique database software package with input and output masks (currently, FAO VCA-Tool software version 3.1) allows for systematic data storage to conduct cost-benefit and value-added analyses and to calculate changes in inputs and outputs; changes in aggregated costs, benefits, net benefits and value added at the actor and aggregate level; changes of incremental costs, benefits, net benefits and value added for different policies; and a set of economic indicators

such as profitability indexes, protection and competitiveness at the international level (i.e. effective protection coefficient and domestic resource cost ratio). The tool can also be used to standardize data, compute margins and selected indicators, and to compare scenarios. FAO's tool may be the most comprehensive one for quantitative value chain analysis, at least in the field of agriculture. The tool's limitations are the requirement for exhaustive data collection and the training the analyst must undergo to learn how to correctly enter the data and compute results. The software is currently not available from FAO's website for reasons unknown to the authors.

In a different approach, Karl Rich et al. (Rich et al., 2011) applied system dynamics (SD) models to quantitatively analyse value chains using specialized SD software. SD can be used to examine the nonlinear behaviour of complex systems over time using stocks, flows, internal feedback loops, table functions and time delays. Specifically, SD constructs causal loop diagrams of systems with feedback. Rich et al. (2017), for example, constructed an SD model that captures feedback between the biological dynamics of cattle production, the economics of live animal and meat markets and trade, and the impacts that environmental effects such as rainfall and animal diseases have on the system. Various scenarios using this model were run to reflect market liberalization and animal health shocks to quantify their impacts throughout the value chain, taking into account the feedback between biology, the markets and the environment. According to the authors, the SD approach allows for a holistic evaluation of policy options for different chain actors as well as of the entire value chain's performance, providing a knowledge base for prioritizing interventions.

Taking a completely different approach, a large body of literature exists on the vertical integration of production in quantitative analyses of global value chains (GVCs), using data on the goods and services traded between countries (for a summary of the methodology used in these studies, see Foster-McGregor et al., 2015 and Wang et al., 2017). These studies use data on GVC participation from international databases that identify exports' foreign and domestic value-added content². The foreign value-added share indicates to what extent a country's exports consist of inputs produced in other countries, and thus do not add to the respective country's GDP. The studies further calculate the share of a country's value-added exports embodied in the intermediate inputs in other countries' exports. Combined, these two measures provide a comprehensive picture of GVC participation. It has recently been argued that input-output tables are not always suitable for

² The calculations require a multi-country input-output (IO) table, which builds on national IO tables by breaking down the use of products by origin. The rows in a table indicate the use of gross output from a given industry in a particular country. The columns provide information on the amount of intermediates needed for the production of gross output. The information derived from an input output table can be translated into a standard IO matrix form and computed for data analysis.

GVC analysis, and that firm-level data from surveys ought to be used instead or to complement (Antrás, 2020).

Quantitative analyses of GVCs provide useful insights to understand the participation of countries in global value chains, and to derive recommendations in which areas countries could eventually increase their participation, how policy measures could increase value chain participation and how value capture can be developed. This approach cannot, however, provide specific information on development options within a given country's value chain. It can therefore only complement information that is derived from quantitative value chain analysis tools in a national context as described above.

Finally, in the area of accounting and finance, value chain analysis is understood as a tool for cost controlling and strategic cost management. The value chain framework is used to take better account of costs that should or should not be outsourced (e.g. information and technology outsourcing, knowledge process outsourcing, business process outsourcing) (Bhargava et al., 2018). Taking such costs and how they are decomposed into account helps identify cost reduction possibilities and opportunities to increase a firm's overall competitiveness. Firms usually use accounting data from their own finance department and that of suppliers to calculate costs. The authors did not, however, find any type of software application for conducting such firm-internal value chain analysis beyond the common accounting software.

In conclusion, different approaches to quantitative value chain analysis are available, with only few, however, providing standardized tools or software. The limitation of the available tools and software (from the World Bank and FAO) is their requirement for extensive data collection, which is not always easy given limited time frames or budgets. The calculation of firms' production costs and profit margins along the value chain lies at the core of the majority of approaches, except in the case of SD models and GVC analyses.

3 Rationale and structure of the CAT

The rationale of the CAT is straightforward, following conventional microeconomic theory. Similar to USAID's and DCED's methodologies discussed in Section 2, it determines the per unit costs of production of operating firms in each segment of the value chain (primary production, post-harvest handling, two stages of industrial transformation and commercialization), as well as the price of the products the actors in the segments sell. The residue between per unit selling price and per unit cost generates the profit margin, which can also be negative in case the firm is not profitable.

The CAT plots data to display the progressive aggregation of a product's costs and profit margins up to its final value; in other words, it displays how value is added along the chain. The analyst can apply a range of criteria to reflect different time periods, a country or regions, type of chain actors, type of technology/technological packages applied, etc. The CAT displays the value addition of either the entire production chain or of specific segments of that chain (e.g. primary production, post-harvest handling, two stages of processing and commercialization). The data are plotted in the format of box-whisker charts that display the frequency distribution of data or bar charts that show the average costs and profit margin contributions of a certain percentile of the data set.

There are two versions of the tool; the first one (simple CAT) calculates the costs and profit margins of a single product (e.g. maize flour), while the second tool (multiple CAT) calculates the value of one main product including a number of its by-products (e.g. in the case of soy beans, it calculates oil, oilcake and residues). The final value added determined by the multiple CAT represents a calculated value of the intermediary product (e.g. oilseeds harvested) at the end of all value addition processes; the final value is a mix of the main product and its by-products. The multiple CAT's final value does not represent the real price of an end product, but a mix of the values of all products weighted by the share at which the intermediary product enters the end product's value addition process. It should be noted, however, that this paper only describes the use of the simple CAT.

CAT calculations represent a simplification of a comprehensive quantitative value chain analysis; the latter requires taking account of the cumulative value of the entire range of products and by-products generated by the value chain (like FAO's tool described in Section 2). Moreover, the CAT calculations only provide information on the economic value generated; other values and social benefits that the value chain generates, e.g. employment, inclusion of marginal groups, poverty alleviation, contributions to sustainable resource management, etc., are not displayed.

The CAT uses data on firms' production efficiency and profit margins, concepts that require careful interpretation. There is empirical and anecdotal evidence from many economic studies that profit can—to some extent—be used as a proxy for a firm's propensity to engage in production. If the profit margin is positive and higher than that of other businesses, an incentive for production may exist; if the profit margin is low—lower than that of alternative economic activities, or even negative—producers may disengage from production. However, many studies show that profit only provides a limited indication of the real benefits a firm generates for those engaged in it; a maximization of benefits from firms must also consider the firm's size, its risk management strategies, employment, identification with the firm, its reputation, embeddedness

in social networks, environmental service provision and many other factors. All of these factors also determine which type of production a firm engages in. This paper does not purport to discuss the limitations of the concept of profit margins; it acknowledges the limitations of the concept but also the fact that—to a certain extent—profit margins may represent an incentive for firms, thus allowing for some conclusions on the reaction of production.

The CAT only uses basic production data and lets analysts structure the costs of production, enter corresponding selling prices and allows them to visualize the costs and profit margins graphically. It is unique in the sense that it can be used across the value chain. Far more sophisticated financial and strategic analysis tools exist at the firm level. However, the difference is that the CAT combines various segments along the value chain. This allows for several conclusions on the distribution of value added across the chain as well as on competitiveness, which an analysis at the firm level cannot provide.

The CAT is available in form of a preformatted Excel workbook that analysts can use to enter data and criteria to analyse costs and profit margins along value chains. Based on the data inserted in the CAT entry sheets, it generates tailored analyses and plots data on graphs following specific algorithms. Before the CAT workbook can be used, some explanations (provided in this paper) or a demonstration is necessary. However, no further knowledge of mathematical formulas or Excel programming is required; data simply needs to be entered in the correct fields and the resulting outputs need to be accurately interpreted. With a bit of practice, any analyst is able to conduct a value chain analysis using the CAT.

The CAT uses a simple database (Excel workbook) with five types of sheets:

1. *Data entry sheets*: Data from interviews with producers and other sources can be entered into preformatted data entry sheets for the value chain's various segments, including primary production (PP), post-harvest handling (PH), processing stage 1 (1AT), processing stage 2 (2AT) and commercialization (COM). Up to 12 different cost categories can be defined in every entry sheet. Furthermore, the analyst can enter general information and categories that can later be used to filter data. Each column in the data entry sheet holds information for one observation, i.e. the data from an interview with a producer or from some other source.

2. *Menu sheet:* This is an initial menu that allows the analyst to define which categories of data shall be selected for the analysis. The analyst can furthermore choose a “chain point criterion”, which establishes the method of calculation for the accumulated cost of each element and chain segment. Either the minimum, percentile 25, percentile 50, percentile 75, maximum or the average of the selected observations can be selected.
3. *Hidden calculations sheets:* A “Chain Table” is used for the main calculations on the data selected. “Statistics Analysis” is used for basic statistical calculations for all box-whisker charts, and “Statistical Summary” for basic math calculations for all bar charts. The calculation of the chain points is also performed in this last sheet.
4. *Data table sheets:* The CAT comes with three preformatted sheets for data tables to develop box-whisker charts and additional three sheets for data tables to develop bar charts. There is also one data table sheet to compare two data sets. Each of the data table sheets is located just before its corresponding graph. In these data tables, the analyst selects which cost elements and chain segments he or she wishes to display in the graphs.
5. *Output sheets (graphs):* The CAT comes with three pre-formatted box-whisker charts and three pre-formatted bar graphs that draw from the above-mentioned data table sheets. Finally, it also includes a preformatted comparison bar chart that is based on the comparison table sheet. The data in the data table sheets can also be copied into other tables or be exported for statistical analysis in other programmes.

Analyst usually use various versions of the workbook to analyse different scenarios. Several versions of the CAT can be saved under different file names. Sheet criteria can be adapted in the menu to reflect different scenarios. New data must be included in the data input sheets (PP, PHH, 1AT, 2AT and COM).

4 Using the CAT

The CAT is primarily used to enter data on costs and prices and to generate a graphical visualization of the data. The data on costs must be converted into a format that is based on a single product unit (e.g. kilogrammes of maize harvested or kilogrammes of rice flour processed). Depending on the type of analysis, the input data can be real values collected in the field, outputs from producers (primary producers, processors, marketers, etc.) or theoretical scenarios, future projections, best practice cases or target costs or product prices set by a government or development programme³.

4.1 Data collection

Data to be entered into the CAT is usually collected from producers across the value chain. Data can be collected through structured interviews on firm-specific cost elements in the various segments of the value chain. This implies that the analyst is familiar with standard production procedures in the value chain and is able to understand the main costs that arise in firms along the value chain. Data can be directly entered into the spreadsheet during the interview. However, interviewees might not have the per-unit costs of their operations readily available, in which case it is best to enter the data after the interview, allowing for proper calculations and the application of corresponding conversion rates.

The analyst can apply any sampling technique to identify the actors in the value chain segments to be interviewed. He or she should preferably apply a sampling technique that will provide a sufficient level of representativeness. The sample size, i.e. the number of interviews to be conducted, depends on the population and on the specific categories (e.g. technology applied, region, etc.) that make up the population. The crucial questions the analyst must address are: which part of the value chain am I collecting representative data for? Am I collecting data for a certain region; certain types of actors, e.g. smallholders or SMEs; users of a certain type of technology, e.g. eco-certified production or adopters of cleaner production technologies; or for a country's entire value chain? The analyst should consult the literature to identify the appropriate sampling methods and define the degree of sophistication of the sampling method. To paint a picture of a country's entire value chain, a representative sample across regions, types of actors and commonly applied production models should be selected and weighted by the share of these categories in overall production.

³ The CAT Excel® workbook (currently version 1.0) is available from UNIDO (please contact f.hartwich@unido.org or j.sanchez@unido.org).

Proper sampling is key if the analyst aims to obtain results on policies and chain-wide dynamics. However, the CAT is also a valuable tool for individual firms and producers without the need for advanced sampling, because it can be used to establish firms' individual costs and profit margins and compare these to any benchmarks (neighbours, best practices, other regions, other technologies).

In many situations, the collection of data along the value chain is often challenging, time-intensive and costly. It is particularly difficult to collect data from a representative sample if there are many firms of different sizes and types dispersed across regions. The case may be that only few processors and marketers exist, who are not willing to share their data, which makes it even more difficult to cover this particular segment of the value chain.

If insufficient resources are available to carry out a scientifically recommended sampling exercise, a practical approach to data collection is obtaining a sample from each producer category (small/medium/large, region, type of technology, and segment of the value chain). The sample can then be extended by asking the producers in the sample for the contact details of similar producers (snowballing) and interviewing those producers until the resources have been exhausted or the time is up. The search for additional samples can end once additional interviews within the given producer category only produce data inside the already observed range. When an observation falls out of the range of the given category, it may be evidence for the existence of a new category for which sufficient additional data then need to be collected.

4.2 Data entry

The data collected from the producers interviewed are entered into the CAT's preformatted Excel workbook (currently version 1.0). The subsequent sheets (tabs on the bottom of the Excel window) are used for data entry; the codes (preformatted PP, PH, 1AT, 2AT and COM) can be modified. In the preformatted version, the PP sheet refers to primary production, the PH sheet to post-harvest handling, the 1AT sheet to 1st industrial transformation, 2AT for 2nd industrial transformation and the COM sheet to commercialization to end users. The columns in these sheets represent an observation point, which is a single producer along the value chain for which data is entered into the CAT. Figure 1 presents the PP entry sheet.

Figure 1: Data entry sheet for primary production (PP)

A	B	C	D	E	F	G	H	I	J
1			CONTROL =>	1	0	2	3	0	0
2		PP	Product group	Example					
3		Code	Sample code	ExamplePP1	ExamplePP2	ExamplePP3	ExamplePP4	ExamplePP5	ExamplePP6
4	General info	Text	General info 1						
5		Text	General info 2						
6		Text	General info 3						
7	Filter criteria	Text	Criterion 1	A	B	A	A	B	
8		Text	Size of firm	small	large	medium	large	small	
9		Text	Region	Lara	Portuguesa	Lara	Sucre	Portuguesa	
10		Text	Criterion 4						
11		Text	Criterion 5						
12	Cost information	\$/Kg	PP	0.010000	0.020000	0.025000	0.025000	0.030000	
13		\$/Kg	Workforce	0.010000	0.011000	0.012000	0.012000	0.011000	
14		\$/Kg	Harvest	0.030000	0.025000	0.025000	0.020000	0.010000	
15		\$/Kg	Admin	0.010000	0.011000	0.012000	0.012000	0.011000	
16		\$/Kg	Margin	0.010000	0.020000	0.025000	0.025000	0.030000	
17		\$/Kg	Cost element 6						
18		\$/Kg	Cost element 7						
19		\$/Kg	Cost element 8						
20		\$/Kg	Cost element 9						
21		\$/Kg	Cost element 10						
22		\$/Kg	Cost element 11						
23		\$/Kg	Cost element 12						

The cells highlighted in yellow allow the user to define the name of the primary product and the measuring units for the costs that will be used throughout the entire CAT. These can only be defined in the first data entry sheet (in this case, the PP).

General information (e.g. name of or code for the production unit, location, person interviewed, telephone number, etc.) is entered in the fields of rows 4 to 6, starting from column E. In column D, the different types of general information are labelled. To protect the identity of the sources of information (e.g. in case the workbook data is to be shared with other actors or with the government), it is recommended to enter codes instead of names and other information that would allow identification of the individual producers. In rows 7 to 11, criteria to filter the data is entered (e.g. size, type of production unit, country, region, time period, etc.). Criteria can be entered as different letters (e.g. A, B and C) or the criteria can be spelled out (e.g. small/medium/large or region1/region2). In row D, the criteria is labelled.

Information on costs is entered in rows 12 to 23; data for 12 different cost elements can be entered here. All cost elements can be freely defined by the analyst. The sheet suggests USD per kg of output as the standard monetary unit, but USD can be replaced by any other monetary unit. As regards cost elements, it is useful to work with cost elements that are commonly used among producers in the value chain, e.g. in their accounting. The data entered for each cost element must be converted into monetary units per kg of output. The output can either be an intermediary one, such as paddy, or a final product, such as processed and packaged rice ready for end consumption.

Data must be carefully calculated for each cost element taking into account the volume of production, the depreciation of fixed assets and equipment, seasonal and fixed labour, opportunity costs of family labour, the share of the product in overall production or overall management and administrative costs, just to mention a few. The margin is entered in the last row. This is usually calculated using a formula defined by the difference between the price at which the interviewed producer claims to have sold the product and the accumulated costs. This calculation can also be copied from or linked to an existing formula on the same page or in a separate file. In fact, all calculations for the conversions could be performed on the same sheet from row 24 and below. The only rule is that no columns should be inserted. It is recommended to place the names of the variables in column “D”, and the source data corresponding to each producer should be placed under its corresponding column. In the input cells for the cost elements located in rows 12 to 23, a formula could be placed that points to the cells of the calculations for the conversion located in rows 24 and below.

Row 1 automatically identifies the interviews that meet the case or scenario criteria. The numbers in the cells in this row are assigned in ascending order. The columns with a zero (0) identify the non-selected interviews and are not included in the calculations. In row 3, a formula automatically assigns a code to the production unit. Blanks do not distort calculations but will simply be omitted during data processing.

The data in the PP, PH, 1AT, 2AT and COM data entry sheets can be extracted for any other type of analysis and the generation of tables and graphs. They represent a database from which data can be extracted and further analysed. The CAT does not provide further support for such analyses, but a large number of readily available data analysis programmes exist to conduct an analysis across sections and time.

4.3 Data processing

The CAT calculates costs in a cumulative manner; for example, the cumulative cost of a producer up to cost element 3 is the sum of the first three cost elements, and the costs accrued up to element 12 are the total cost of each producer in the first chain segment. These calculations are developed in a sheet called “Chain Table” (Figure 2); it is hidden in the original Excel workbook structure of the CAT.

The connection between chain segments is made by establishing a “Chain Point”, which can be the average, the minimum, a percentile or the maximum value of the chain. In the next segment, costs continue to accumulate from that established value.

Data on the cost elements and segments obtained in the “Chain Table” sheet are used to calculate their minimum, P25, P50, P75, maximum and average values. This is done in the hidden “Statistics Analysis” and in the “Statistical Summary” sheets, which contain the data for all table and chart analytical manipulations to follow.

A row is reserved at the end of the “Chain Table” for the subtotal for each segment; the CAT can use this to “pack” all of the costs and margins to generate summary graphs, showing the total costs of the segment only, hiding the detailed cost elements.

Figure 2: Chain table

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1																		
2			ACCURED COSTS				Chain Table											
3																		
4			Spl 1	Spl 2	Spl 3	Spl 4	Spl 5	Spl 6	Spl 7	Spl 8	Spl 9	Spl 10	Spl 11	Spl 12	Spl 13	Spl 14	Spl 15	Spl 16
5	PP	PP	Supplies	0.0100	0.0200	0.0250	0.0250	0.0300	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
6	PP		Workforce	0.0200	0.0310	0.0370	0.0370	0.0410	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
7	PP		Harvest	0.0500	0.0560	0.0620	0.0570	0.0510	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8	PP		Admin	0.0600	0.0670	0.0740	0.0690	0.0620	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
9	PP		Margin	0.0700	0.0870	0.0990	0.0940	0.0920	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10	PP		Cost element 5	0.0700	0.0870	0.0990	0.0940	0.0920	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
11	PP		Cost element 7	0.0700	0.0870	0.0990	0.0940	0.0920	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12	PP		Cost element 8	0.0700	0.0870	0.0990	0.0940	0.0920	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
13	PP		Cost element 9	0.0700	0.0870	0.0990	0.0940	0.0920	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
14	PP		Cost element 10	0.0700	0.0870	0.0990	0.0940	0.0920	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
15	PP		Cost element 11	0.0700	0.0870	0.0990	0.0940	0.0920	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
16	PP		Cost element 12	0.0700	0.0870	0.0990	0.0940	0.0920	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
17	PP		PP	0.0700	0.0870	0.0990	0.0940	0.0920	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
18	PHH	PHH	Operational	0.1184	0.1134	0.1134	0.1084	0.0984	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
19	PHH		Margin	0.1484	0.1384	0.1384	0.1284	0.1084	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
20	PHH		Cost element 3	0.1484	0.1384	0.1384	0.1284	0.1084	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
21	PHH		Cost element 4	0.1484	0.1384	0.1384	0.1284	0.1084	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
22	PHH		Cost element 5	0.1484	0.1384	0.1384	0.1284	0.1084	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
23	PHH		Cost element 6	0.1484	0.1384	0.1384	0.1284	0.1084	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
24	PHH		Cost element 7	0.1484	0.1384	0.1384	0.1284	0.1084	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
25	PHH		Cost element 8	0.1484	0.1384	0.1384	0.1284	0.1084	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
26	PHH		Cost element 9	0.1484	0.1384	0.1384	0.1284	0.1084	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
27	PHH		Cost element 10	0.1484	0.1384	0.1384	0.1284	0.1084	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
28	PHH		Cost element 11	0.1484	0.1384	0.1384	0.1284	0.1084	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
29	PHH		Cost element 12	0.1484	0.1384	0.1384	0.1284	0.1084	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
30	PHH		PHH	0.1484	0.1384	0.1384	0.1284	0.1084	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
31	IAT	IAT	Operational	0.1424	0.1524	0.1574	0.1574	0.1624	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
32	IAT		Margin	0.1524	0.1724	0.1824	0.1824	0.1924	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
33	IAT		Cost element 3	0.1524	0.1724	0.1824	0.1824	0.1924	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
34	IAT		Cost element 4	0.1524	0.1724	0.1824	0.1824	0.1924	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
35	IAT		Cost element 5	0.1524	0.1724	0.1824	0.1824	0.1924	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
36	IAT		Cost element 6	0.1524	0.1724	0.1824	0.1824	0.1924	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
37	IAT		Cost element 7	0.1524	0.1724	0.1824	0.1824	0.1924	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
38	IAT		Cost element 8	0.1524	0.1724	0.1824	0.1824	0.1924	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
39	IAT		Cost element 9	0.1524	0.1724	0.1824	0.1824	0.1924	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
40	IAT		Cost element 10	0.1524	0.1724	0.1824	0.1824	0.1924	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

4.4 Programming CAT calculations

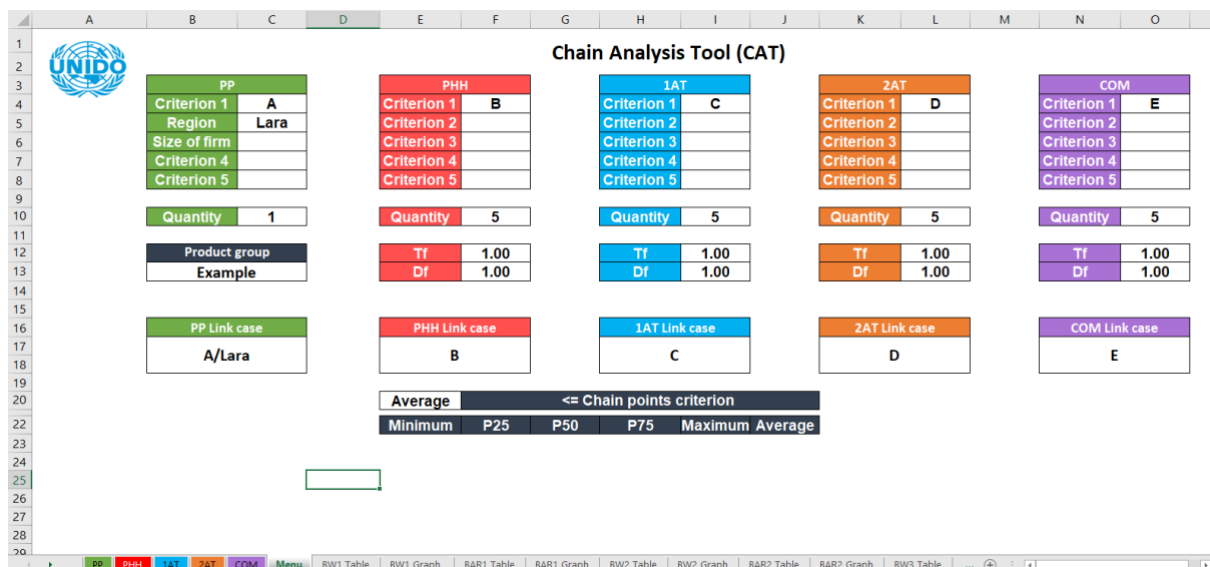
Figure 3 depicts the “Menu” sheet (tab) in which the analyst chooses criteria that define the subsequent calculations and graphical representations. For the first segment (PP), for example, the criteria are entered in the “C4 to C8” range. In Figure 2, the codes for Criterion 1 and Criterion 2 at the PP level are A and B. The number of interviews that were selected based on those criteria are automatically shown in cell “C10”. Each segment has a different column: “C”, “F”, “I”, “L” and “O”. The boxes on lines 17 and 18 indicate which criteria have been chosen; these are A/B for the case of PP in Figure 2, for example.

The spaces adjacent to the cells labelled “Tf” and “Df” in lines 12 and 13 of the menu are intended to introduce correction factors for the degree of “transformation” and of “diversification” identified in industrial processes. These are necessary when product volumes are subject to natural

waste during industrial processing or to reductions caused by diversification into different by-products. For example, the drying of rice (part of processing) can result in a 5 per cent loss in weight (the Tf factor would in that case be 0.95). The diversification factor Df is used when total industrial costs must be distributed among different final products. For example, the value of husks from the dehusking of rice in our example would be 10 per cent (the Df factor would be 0.90). Both Tf and Df factors have a default value of “1.00”, which means no correction was made.

In cell E20, the analyst can choose the “Chain Point Criterion”, which establishes the method used to calculate the accumulated costs of each element and chain segment, either the minimum, percentile 25, percentile 50, average, percentile 75, maximum or average of the selected observations.

Figure 3: Scenario selection menu



4.5 Creating box-whisker charts

Box-whisker plots illustrate the distribution of cumulative values (in this case, costs and margins) across the set of observations selected in the menu sheet (in this case, producers interviewed along the value chain). For this purpose, the CAT calculates the main parameters characterizing the frequency distribution of observations (minimum, percentile 25, percentile 50, percentile 75 and maximum) as well as the position of the boxes and whiskers. The “BW1 Table” sheet (tab) in Figure 4 presents those calculations in rows 7 to 17.

Figure 4: Box-whisker table

	A	B	I	J	K	L	M	N	O	AB	AO	BB	BO
1													
2		GRAPHS DATA											
3		Box-Whisker											
4													
5			PP	PP	PP	PP	PP	PP	PP	PHH	1AT	2AT	COM
6		Box Whisker graph	Cost element 7	Cost element 8	Cost element 9	Cost element 10	Cost element 11	Cost element 12	PP	PHH	1AT	2AT	COM
7		Minimum	0.0700	0.0700	0.0700	0.0700	0.0700	0.0700	0.0700	0.1084	0.1524	0.1964	0.2304
8		25th percentile	0.0785	0.0785	0.0785	0.0785	0.0785	0.0785	0.0785	0.1184	0.1624	0.2064	0.2354
9		50th percentile	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	0.0920	0.1384	0.1824	0.2264	0.2454
10		75th percentile	0.0965	0.0965	0.0965	0.0965	0.0965	0.0965	0.0965	0.1434	0.1874	0.2314	0.2479
11		Maximum	0.0990	0.0990	0.0990	0.0990	0.0990	0.0990	0.0990	0.1484	0.1924	0.2364	0.2504
12		Box1	0.0785	0.0785	0.0785	0.0785	0.0785	0.0785	0.0785	0.1184	0.1624	0.2064	0.2354
13		Box2	0.0135	0.0135	0.0135	0.0135	0.0135	0.0135	0.0135	0.0200	0.0200	0.0200	0.0100
14		Box3	0.0045	0.0045	0.0045	0.0045	0.0045	0.0045	0.0045	0.0050	0.0050	0.0050	0.0025
15		Upper whisker	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0050	0.0050	0.0050	0.0025
16		Bottom whisker	0.0085	0.0085	0.0085	0.0085	0.0085	0.0085	0.0085	0.0100	0.0100	0.0100	0.0050
17		Average	0.0884	0.0884	0.0884	0.0884	0.0884	0.0884	0.0884	0.1324	0.1764	0.2204	0.2424
18													
19													
20		COLOR PALETTE											
21		Series 2											
22		Series 3											
23		Plot area											
24		Axis											
25		Grid lines											
26													
27													
28													
29													
30													

In the “BW1 Table”, the cost elements (in-fact costs, cost aggregates and profit margins) are arranged in columns. The table allows the analyst to choose the cost elements to be included in the box-whisker charts. This is done by hiding and un-hiding the columns; one box-whisker chart is created for each unhidden column. The reason for restricting cost elements (costs and margins) to be included in the box-whisker chart is due to the limited space available for proper visualization. In fact, the analyst must try to identify the most adequate way to plot the data for proper visualization and interpretation. For example, in the data entry sheet it is useful to combine cost elements that are marginal or that do not contribute much information to the overall interpretation of the situation.

Adjustments to the scale of the graphs’ horizontal axis must be made to achieve a good visualization of bars and labels. This is done by right-clicking the graph and choosing the “format plot area” link from the task menu.

Figure 5 presents a BW1 Graph that was generated by hiding all detailed cost elements and only keeping the cumulative costs and profit margins per segment (PP, PHH, 1AT, 2AT and COM) of the value chain. In Figure 5, the whiskers to the left indicate the minimum, the purple box depicts the segment of the 25th to the 50th percentile, the green the segment between the 50th to the 75th percentile, and the right whisker presents the maximum. The values correspond to the costs accumulated for the sample of observations selected for every segment.

Figure 5: Box-whisker chart



The CAT comes with two more predefined box-whisker tables (BW2 Table, BW3 Table) and box-whisker charts (BW2 Graph and BW3 Graph), which the analyst can use to visualize certain combinations of cost elements, cumulative costs and profit margins. The analyst shall define each chart visualization according to his or her needs. The CAT automatically updates all graphs when new data is uploaded or if the parameters are modified.

Box-whisker charts are created even if the sample consists of only one single interview, in which case only one data point is plotted. If the sample consists of only two interviews, two whiskers linked by a segment are plotted, corresponding to the two different accumulated cost values. The idea, however, is to use box-whisker charts when we want to ascertain variance in the data. Bar charts are more appropriate for a graphical presentation of single values,.

The box-whisker charts provide information on the distribution of the observed data. For example, the analyst can check whether the data is too dispersed and marked by outliers that ought to better be eliminated. If the data is biased towards the 75th percentile, for example (as is the case in Figure 5), it is recommended to actually use the 75th percentile as the “Chain Point Criterion”.

4.6 Creating bar charts

Bar charts can illustrate the scope of the costs and profit margins; the length of the bar represents the costs. The analyst can thereby visualize how the various costs sum up to the total value added in the value chain. To create bar charts, the CAT user needs to define the cost elements (i.e. costs, cost aggregates and profit margins) to be included in the bar chart. This is done in a BAR Table (see “BAR1 Table” tab in Figure 5). This table, contrary to the box-whisker chart table (Figure 4), is arranged in rows. By hiding and un-hiding the rows, the analyst can choose the bars to be displayed in the BAR table (Figure 6): a bar is created for each unhidden row.

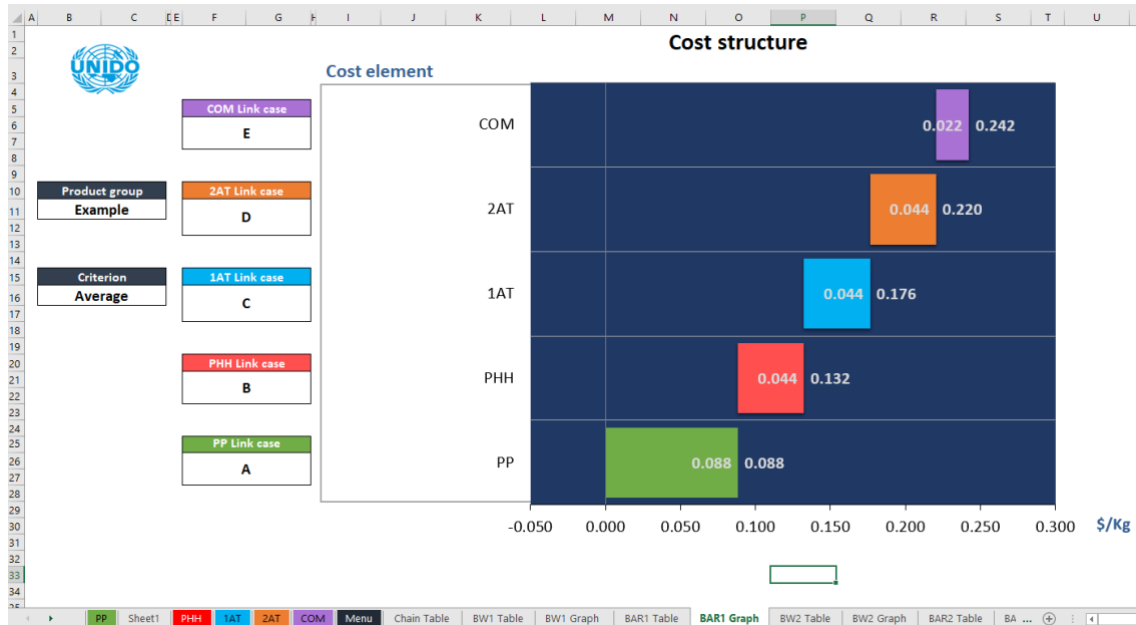
Figure 6: Bar chart table

Box-Whisker Graph Table								BW1 Graph Data Table								BAR1 Table			
																Bar graph table / Percentages			Critical
Element	Minimum	P25	P50	P75	Maximum	Average		Element	Item cost	Accrued cost	% of Overall Cost								
PP	0.0700	0.0785	0.0920	0.0965	0.0990	0.0884		PP	0.0884	0.0884	36%								
PHH	0.1084	0.1184	0.1384	0.1434	0.1484	0.1324		PHH	0.0440	0.1324	18%								
1AT	0.1524	0.1624	0.1824	0.1874	0.1924	0.1764		1AT	0.0440	0.1764	18%								
2AT	0.1964	0.2064	0.2264	0.2314	0.2364	0.2204		2AT	0.0440	0.2204	18%								
COM	0.2304	0.2354	0.2454	0.2479	0.2504	0.2424		COM	0.0220	0.2424	9%								
									0.2424		100%								
Pack =>		PP	PHH	1AT	2AT	COM													
		Yes	Yes	Yes	Yes	Yes													

Figure 7 presents the bar graph resulting from the “BAR1 Table”. Only the cumulative values added by each segment of the value chain have been defined in this case (the pack modus has been activated in line 73 of the bar chart table – Figure 6). The labels shown inside the bars correspond to the individual values of the cost components, while the external labels, located at the right side of the bar, correspond to accumulated costs.

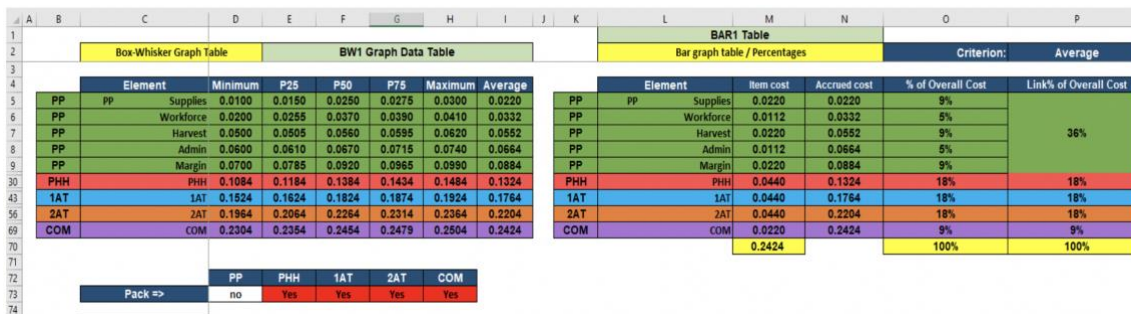
Many other graphs can be created by entering different criteria (in the menu tab) and different details on cost elements (in the bar table). The CAT provides two additional predefined BAR tables (BAR2 Table, BAR3 Table) and BAR graphs (BAR2 Graph and BAR3 Graph) allowing the analyst to visualize certain combinations of cost elements, cumulative costs and profit margins. Again, the analyst shall define each chart visualization according to his or her needs.

Figure 7: Bar graph



One advantage of the bar graph table is that it displays the shares (in percentage) of each cost element in the value chain (see columns “O”, “P” and “Q” in Figure 8). In Figure 8, some segments are packed, giving attention primarily to detailed costs in the primary production (PP) segment.

Figure 8: Percentages of cost elements in bar table



4.7 Comparing cases

The CAT’s comparison analysis is a powerful tool for comparing the cost structure and profit margins of different cases or scenarios. It uses bar charts. Two cost structures can be compared, with a maximum of 12 cost elements. Data is entered in the “Comparison Table” sheet (Figure 9), and the resulting bar graph is shown in the “Comparison Graph” tab (Figure 10).

Figure 9: Comparison table

General Info	Code	Sample code	Example	CASE 1	CASE 2
Text	PP	Product group	Example		
Text	Text	General info 1			
Text	Text	General info 2			
Text	Text	General info 3			
Filter criteria	Text	Criterion 1			
Text	Text	Criterion 2			
Text	Text	Criterion 3			
Text	Text	Criterion 4			
Text	Text	Criterion 5			
Cost Information	\$/Kg	PP	0.015000	0.029000	
\$/Kg	Workforce	0.015000	0.012250		
\$/Kg	Harvest	0.024250	0.048500		
\$/Kg	Admin	0.025000	0.050000		
\$/Kg	Margin	0.027500	0.055000		

Titles	Bottom1	CASE 1	Label1	Bottom2	CASE 2	Label2
PP	Supplies	0.000	0.015	0.015	0.000	0.029
	Workforce	0.015	0.015	0.030	0.029	0.041
	Harvest	0.030	0.024	0.054	0.041	0.049
	Admin	0.054	0.025	0.079	0.090	0.140
	Margin	0.079	0.028	0.107	0.140	0.195

Figure 10: Comparison graph

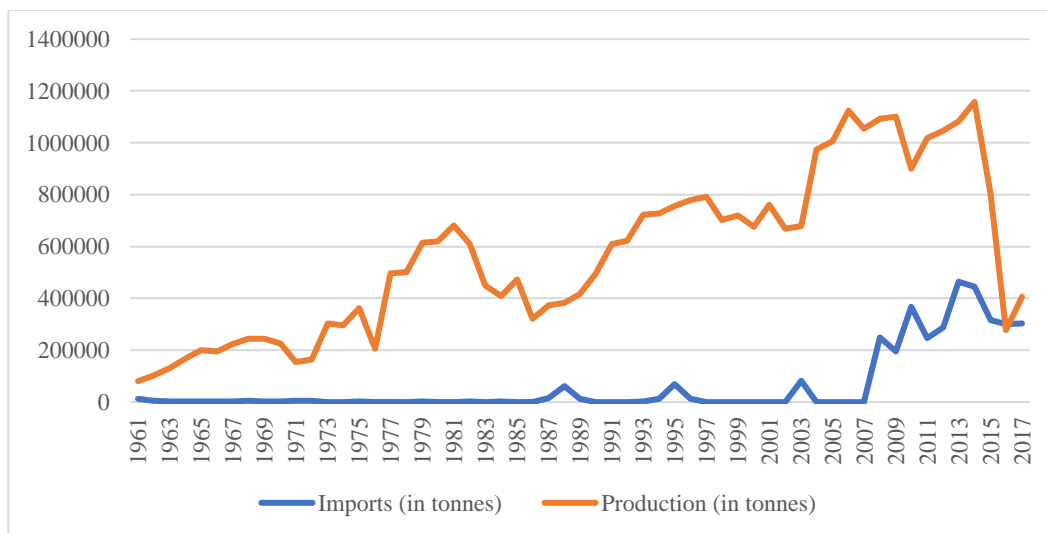


For further comparative studies, using the Microsoft PowerPoint® application is recommended. The study's selected charts can be copied and pasted onto adjacent sheets, taking care to locate each one in the precisely same coordinates. The graphs to be compared must have exactly the same scales on the horizontal axis, and the same cost elements on the vertical axis. When presenting the successive sheets in PowerPoint, the differences in costs between the two cases becomes evident immediately.

5 Applying the CAT: The case of the Venezuelan rice value chain

Rice, together with maize and beans, is a main staple crop, significantly contributing to food security among Venezuelans. The country has near ideal agro-ecological conditions for the cultivation of rice and a substantial processing industry. In the last decade, however, the country imported rice in an amount of up to 30 per cent of domestic demand. The country's large oil revenues allowed for the import of agricultural commodities, such as rice, and contributed to a shift of economic activities away from agriculture. In recent years, in parallel to the country's political and economic crisis and the international embargo, both rice imports and production have plunged drastically (see Figure 11). The latest figures from 2018 and 2019 on rice production and imports suggest that the country's rice supplies are facing severe deficiency, with few alternatives to meet the demand of poorer households in particular.

Figure 11: Venezuela's rice production and imports from 1961 to 2018



Source: FAOStat

*2016-18 figures may understate overall production, given a certain amount sold on parallel markets.

5.1 Development challenges in Venezuela's rice value chain

Given Venezuela's land endowment, the potential to expand its rice cultivation is substantial. UNIDO studies (UNIDO, 2019a and UNIDO, 2019b), however, suggest that there are a number of systemic factors that disincentivize national rice production. Rice has been produced under a pricing regime since 2003 that sets farm-gate and consumer prices; both have been adjusted over time to reflect changes in production costs and other conditions. Primary producers were provided with access to seeds and inputs at subsidized prices (sometimes free of charge) as well as credits (to pay labour and invest in equipment). Under these conditions, rice production remained at a level of around 1 million tonnes for several years.

When domestic production no longer met demand, the government began importing rice and selling it at a lower than world market price (the reference rate was the regulated farm gate price) to processors (i.e. rice mills). Processed rice was also imported and sold to packagers and distributors at below world market prices, ensuring a similar profit margin as for locally processed rice. Over time, this system became increasingly costly to the government for three reasons: first, the quantity of imported rice increased as local production decreased; secondly, with the national currency's increasing devaluation, the difference between the local farm gate price and the world market price increased; and thirdly, due to the currency's devaluation, the price of the seeds and fertilizers supplied by the government to primary producers increased.

The regulation of the value chain not only became quite costly to the government, but also resulted in disincentivizing production. Under the pricing regime, the profit margins of primary production and processing provided sufficient incentives to produce rice (i.e. production and processing were profitable). Since 2015, the government⁴ has introduced a 30 per cent ceiling for profit margins in both production and processing, and price fixation tried to take that particular scale of profit margin into account. Producers (private, community-based and state companies) began applying cost structure and profit margin calculations based on official average cost scenarios that did not always match the real cost and profit scenarios producers encountered. While real profits may have been higher than the reported ones, producers became less aware of their levels of productivity and the real costs of production and, hence, may have lost competitiveness.

In 2019, the government began deregulating many food prices while state agencies, given the decreasing access to inputs, profits and funding, were forced to reduce the delivery of subsidized inputs. This caused drastic changes in production costs and sale prices of agricultural products. Producers found it difficult to monitor these changes and include them in their profit calculations

⁴ Ley orgánica de precios justos, artículo 31, Gaceta N° 40.787, from 12/11/2015.

and many may have focussed on managing risks by producing less or by producing other products. The difficulty in estimating the profitability of production was in particular associated with the mix of prices producers had to pay to purchase inputs; these were in part subsidized by the government and purchased in the parallel market at much higher prices. Likewise, part of their harvest was sold at government prices—to ensure continued delivery of subsidized inputs for the next production cycle—and part of it was sold on the parallel market. The government records may have therefore understated the overall level of production because a lower rate was officially being declared. The hyperinflation and the existence of an official rate as well as of a parallel (black market) rate further complicated estimations on whether production was profitable or not.

The increasing scarcity of inputs and credits further aggravated the situation. Seeds, fertilizer and pesticides, even gasoline, became very rare in some parts of the market, and this was paired with a decrease in credits by finance institutions. Producers simply no longer had the means to produce. In addition, spare parts and supplies for maintenance became more expensive and even inaccessible in some parts of the country, while equipment further deteriorated and new capital investments did occur given limited availability and high prices. The rising insecurity led to rampant theft and other crimes; the poor road conditions and transport logistics further complicated the situation.

By the end of 2019, the situation stabilized, with prices for commodities and processed products as well as for inputs having—for the most part—been adjusted to those in neighbouring countries. Moreover, the official exchange rate of the bolivar was aligned to the exchange rate on the parallel market. Access to supplies, equipment, spare parts, etc., as well as credit—today production has become much more expensive—remains problematic and is severely affecting production.

The government aims to substantially expand rice production again, but no easy solutions seem to be at hand. According to UNIDO (2019a), the key challenges in developing Venezuela's primary rice production lie in improving agronomic practices and promoting technology transfer, expanding the use of certified seeds, applying crop rotation and eventually achieving zero tillage, recovering deteriorated irrigation systems, providing (private) technical assistance and advisory services, improving the post-harvest and farm management and promoting the development of financial solutions. The challenges for processing lie in modernizing the available machinery and equipment, improving factory management in small and medium firms, and diversifying final products to increase competitiveness and gain access to new and better markets. The value chain would also benefit from the introduction of training programmes, technical support and technology transfer to producers and technicians, the mobilization of financial resources for research and innovation and updating specific technical norms. Based on its diagnostics and in

response to those challenges, UNIDO, collaborating with value chain actors, developed an action plan to develop the value chain (UNIDO, 2019a). A value chain committee has been set up by stakeholders to ensure the exchange of information and the rolling out of the action plan with the aim of improving the situation of all value chain actors.

The CAT was applied in this situation of rapidly changing production conditions in the Venezuelan rice value chain illustrated above where it was able to reveal the following results:

For individual producers (primary producers, processors and marketers):

1. The status of the costs and profits of their individual production in the second half of 2019.
2. A comparison of costs and profits of individual production in 2018 and 2019.

For individual producers, development planners and decision makers in the government:

3. A comparison using benchmarks (best practices, users of other schemes and technologies, other regions, other countries) and identification of improvement opportunities (cost reduction, productivity increase).

For decision makers in the government:

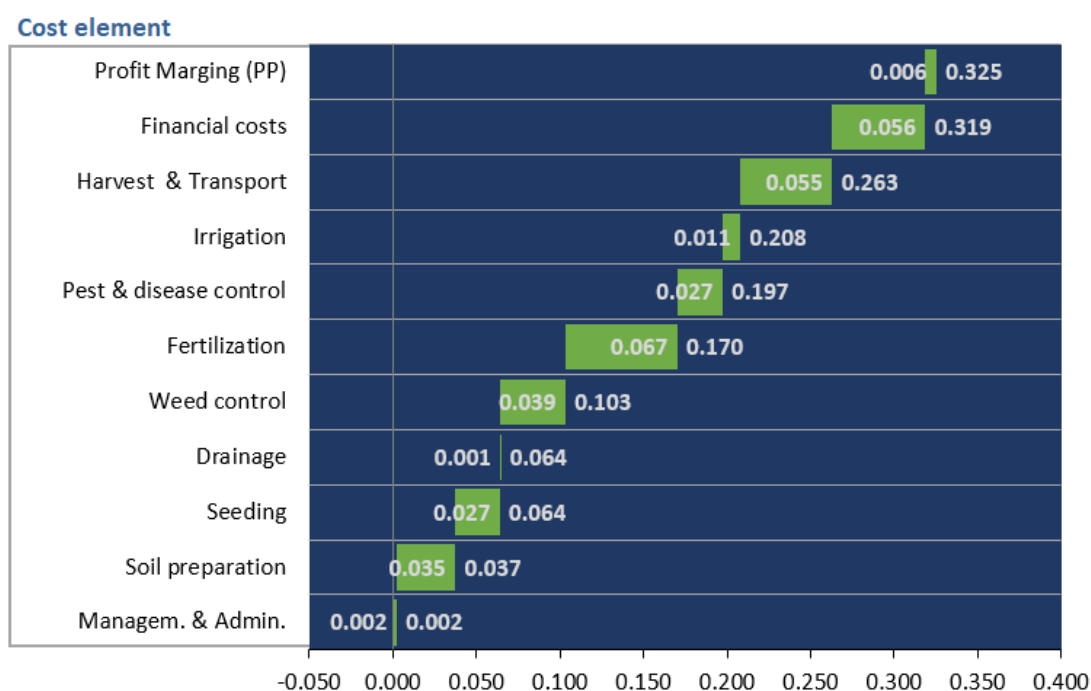
4. Providing information from the field to inform official cost calculations used for policy and decision making (e.g. price fixation).
5. Monitoring and simulation of the effects of policy changes on cost structures and profit margins.
6. A few conclusions on future production.

5.2 Establishing costs and profits of individual production

Starting in July 2019, data on costs of production and selling prices were collected from 109 primary producers. The costs were converted into USD to reflect correction for inflation. One difficulty was translating the costs into USD on the actual date of purchase of inputs or services. The interviewees had to remember the purchase price, which then had to be linked to the exchange rate on that day. The majority of producers had to buy part of their agricultural inputs from the informal market at higher prices due to an insufficient supply on the formal (subsidized) market. The cost parameters included both variable and fixed costs. For the calculation of fixed costs, the cost of equipment and installations were used and divided through the number of years of use and the share of rice production/processing in total production/processing.

Figure 12 presents the costs of production and selling prices in 2019. The various cost components are added subsequently. The costs of administration are USD 0.002 when the costs of land preparation (USD 0.035) are added, they amount to USD 0.037 per kg of rice. The selling price of 1 kg of rice at the farm gate price is USD 0.325 whereby the profit margin per kg—calculated as the difference between the selling price and the accumulated costs—is 0.006 cents. For a farm with a size of 35 ha that produces an average of 3.500 kg/ha, the profit is USD 735. The cost of production is nearly 98 per cent of the value of production (the profit margins on investments in farming are only 2 per cent), and thus production cannot be considered particularly profitable. Nevertheless, the profit margin of rice production needs to also be compared to that of other cultivations and other economic activities in rice producing regions. If rice still provides higher profit margins than other activities, the level of production can remain the same or increase. When this is not the case, producers will most likely switch to other economic activities. In fact, the project's results reveal that current profit margins in soy production are USD 0.093 per kg and even USD 0.27 in bean production, suggesting that primary producers would rather engage in those more profitable crops if agro-ecological conditions and equipment allow.

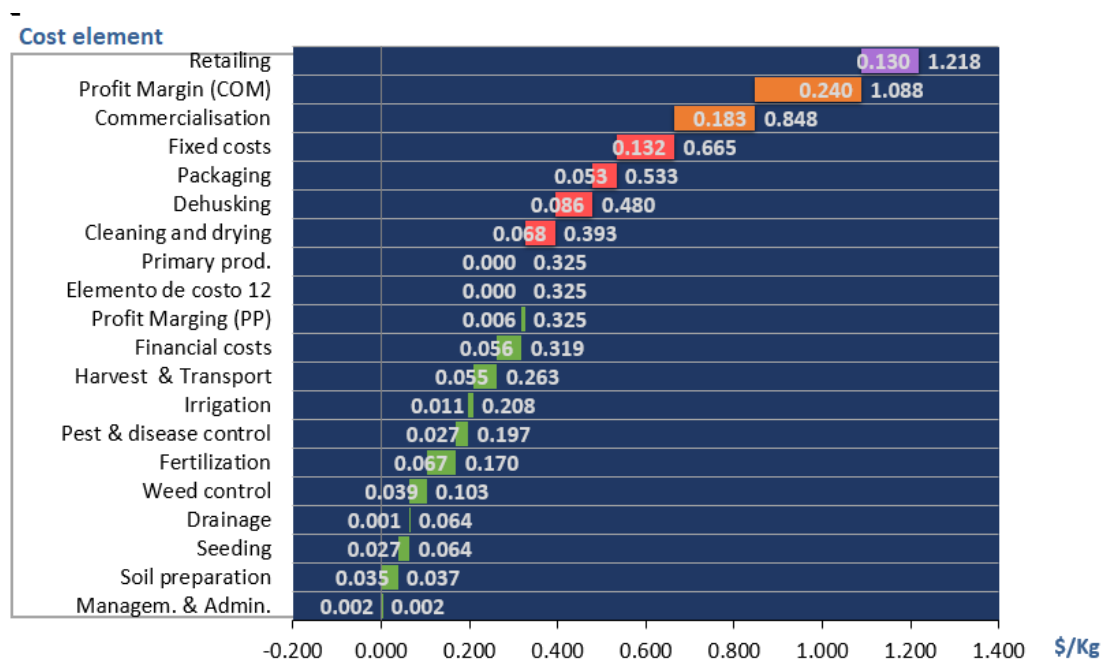
Figure 12: Production costs of primary rice production, 2019 in USD/kg



Source: Project data

Data was also collected from 15 processing firms and 16 firms that package and market rice products. Figure 13 shows a bar chart of the entire rice chain's cost structure in 2019. Cost elements of primary production and its margins are marked in green. Processing (rice milling) is marked in red and distribution is marked in orange. Retailing, for which no cost data was collected, is marked in violet and denotes the difference of wholesale to retail (=consumer) price only.

Figure 13: Production costs across the rice value chain, 2019 in USD/kg



Source: Project data

While the profit margin for primary production is limited, it is substantial in processing and commercialization. Additionally, processing firms' and marketers' scope of operations must be considered, as they deal with far more tonnes of rice than primary producers. For example, a rice mill that processes 19,800 tonnes per month accrues an annual profit of around USD 4.8 million.

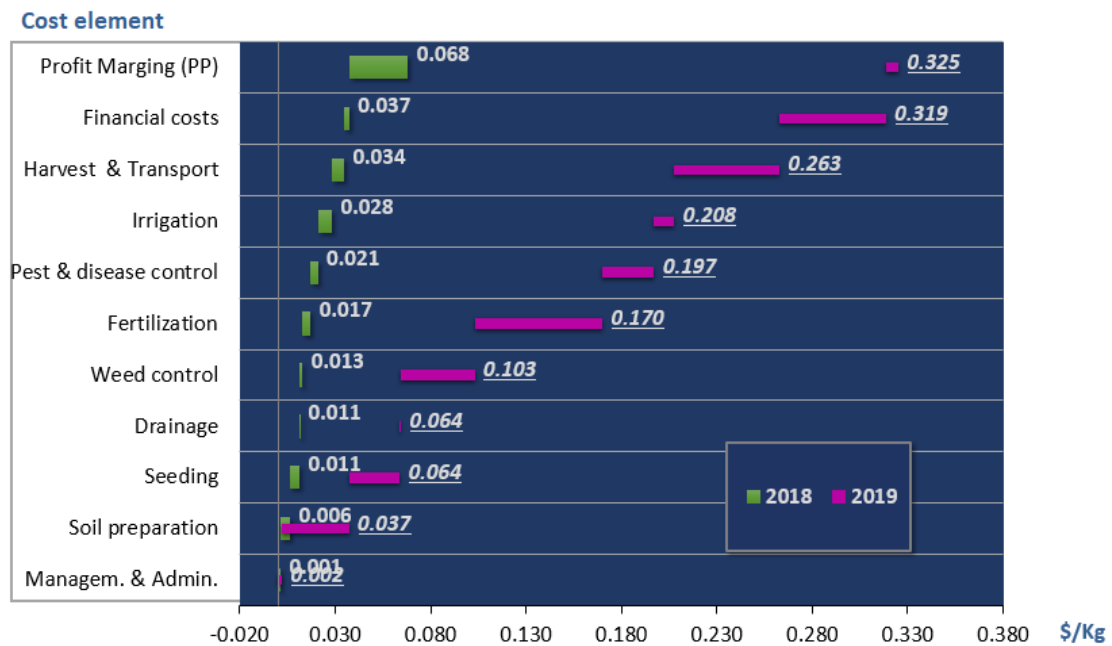
A comparison of profit margins along the value chain can also be used to build win-win scenarios in which some actors in the value chain (in this particular case, processing firms and marketers) redistribute a share of their profit per kg to others. This stimulates production (in this case, among farmers) and the resulting increase in production enhances processing firms' overall (per volume) profit. The share of profits to be redistributed to achieve maximum benefits for all chain actors depends on various factors, including production economics, economies of scale and entrepreneurial behaviour; it can be established through economic modelling (not part of the CAT).

5.3 Comparing costs and profits of individual production (before and after)

The CAT can also be used to compare costs and profit margins across time and segments. Drastic changes in production conditions occurred due to the liberalization of the official pricing regime. To compare the situations in 2018 (without flexibilization) and in 2019 (with flexibilization), the 2019 data was compared with that collected in 2018 (data collected from interviews with 45 producers, 6 processors and 8 marketers).

The changes in the primary production costs of rice are presented in Figure 14. The cumulative costs in 2018 were less significant than in 2019, and the profit margin was much higher. By contrast, the costs in 2019 expanded drastically while the profit margin decreased in absolute and relative terms. The reason is that while some inputs maintained a high subsidy component in 2018, the prices of these inputs converged to correspond to international values in 2019. Consequently, for a farm with a size of 35 ha that produces an average of 3,500 kg/ha, profit dropped from USD 3,798 in 2018 to USD 858 in 2019; rice farming profits plunged to a marginal rate. The costs of primary production in 2018 made up slightly over 50 per cent of the primary product's value, whereas this figure was 2 per cent in 2019. The same conclusion as in Section 5.2 applies here, namely that production is currently not profitable, but now this finding also relates to the drastic drop in profits: if there are alternative economic activities that rice producers can engage in, they are likely to reduce their involvement in rice production (or abandon it entirely). In any case, with prices close to international values, producers' efforts should be directed towards measures that help to further optimize costs, increase productivity and quality and to produce higher volumes.

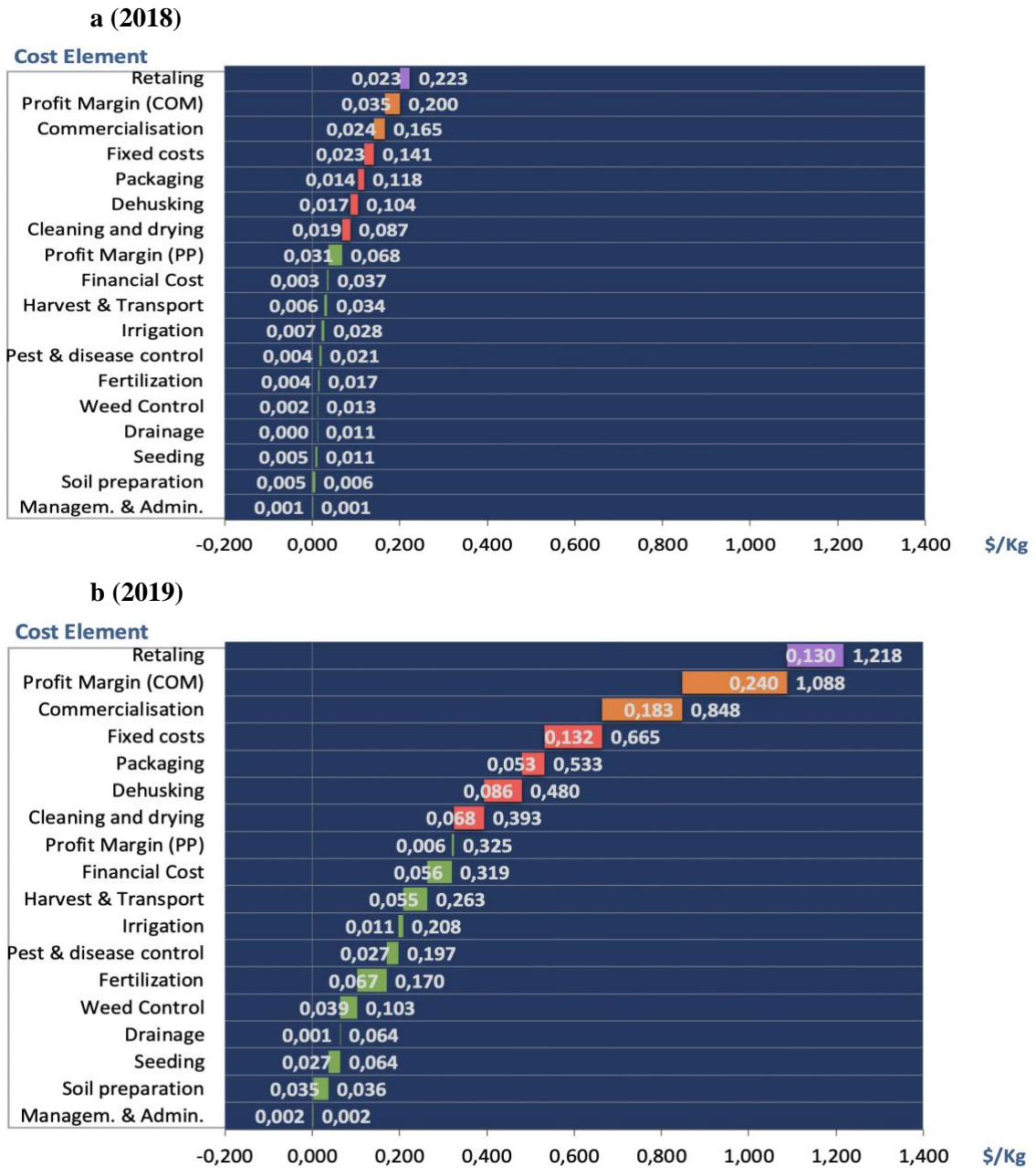
Figure 14: Production costs of primary rice production, 2018 and 2019 in USD/kg



Source: Project data

Figures 15a and b compare costs along the entire value chain in 2018 and 2019. The comparison reveals that processing firms and marketers, in particular, were able to capture the increased value added that rice gained in 2019; while their costs rose disproportionately lower, their profit margins increased disproportionately higher. Hence, the winners of the price adjustment (on the basis of 1 kg of processed rice) were the processors and marketers while the primary producers lost and might consider reducing their involvement in rice production in the future. One policy implication could be the introduction of measures to increase the profits of primary producers, even if this implies some partial redistribution of profits per kg for actors downstream in the value chain.

Figure 15: Production costs along the rice value chain, 2018 and 2019 in USD/kg



Source: Project data

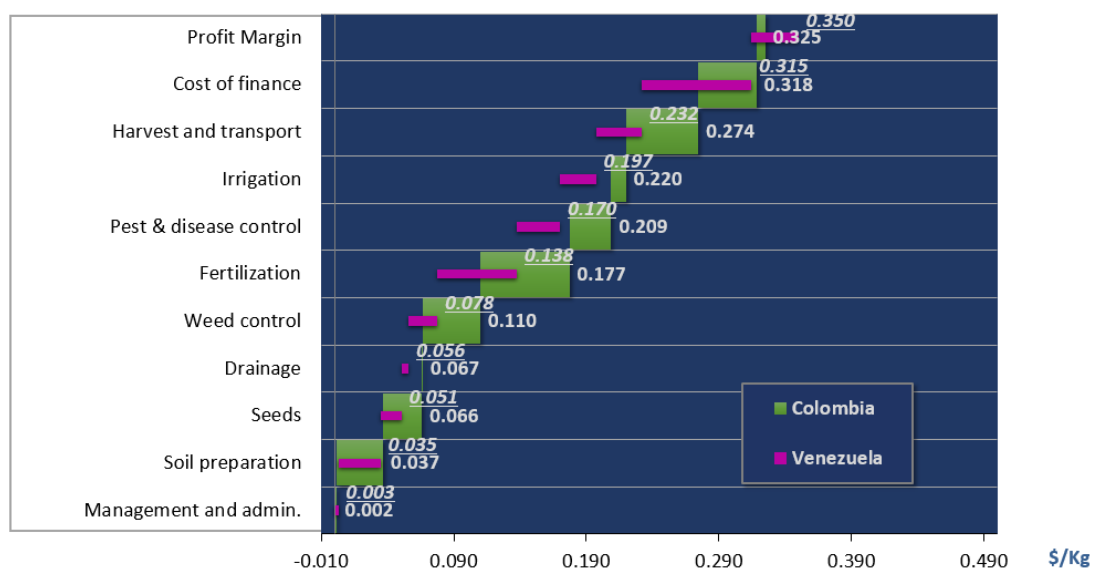
5.4 Comparing costs and profits of individual production to benchmarks and innovation

The CAT also allows for a comparison of production costs with those in other countries. Figure 16 illustrates the overall average cost structure of primary production in Venezuela compared with Colombia's. The data from Colombia were drawn from the website of the national rice producer federation in Colombia (<http://www.fedearroz.com.co/new/costos.php>). Per hectare costs were converted into per kg costs, taking average yields/hectare from Colombia into account.

Figure 16 shows that the price for a paddy in Venezuela has aligned with world market prices. However, Colombia has a higher profitability because its per/kg costs are generally lower. This is certainly attributable to the greater productivity with which rice is produced in Colombia. While the average yield in Venezuela ranges between 3.5 tonnes/ha and 3.8 tonnes/ha, Colombia's average is 4.8 tonnes/ha. Capital costs in Colombia also seem to be higher: this may indicate that more capital is being used to finance the purchase of inputs and that more productive technology and production procedures are used.

The per kg figures generated by the CAT should be interpreted with caution as they represent averages that take yields and productivity into account. For example, high costs associated with the use of fertilizers does not imply that (too) many fertilizers are being used. The per unit costs of fertilizer might even decrease if more fertilizers are used and the output of additional fertilizer use is higher than its costs (depending on the slope of the production function of fertilizer use).

Figure 16: Production costs along the rice value chain, comparison with Colombia



Source: Project data and FEDEARROZ

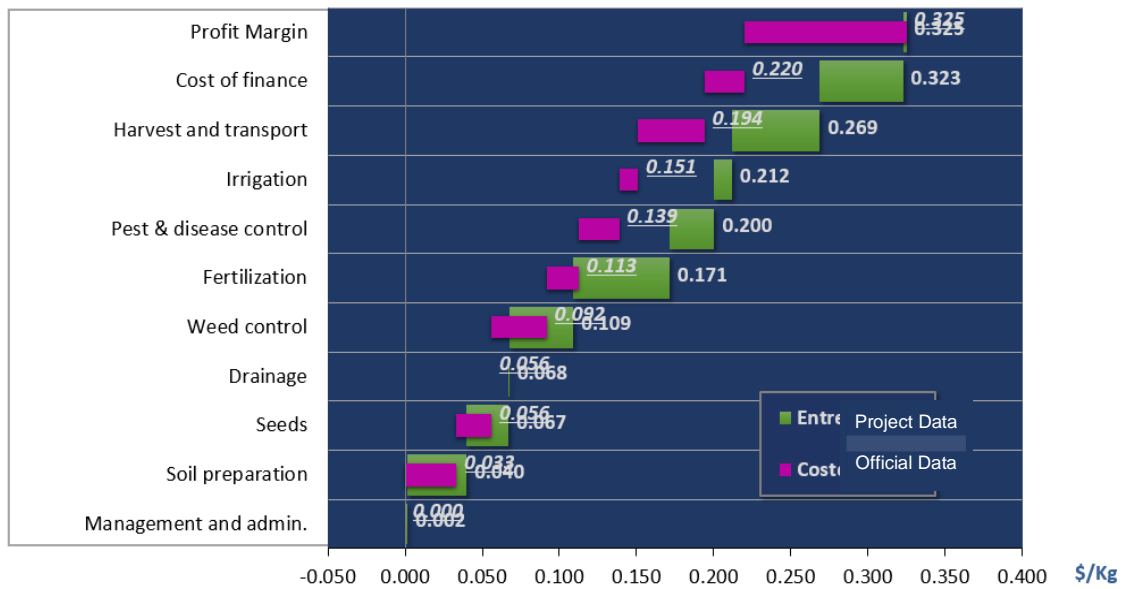
The CAT can also compare the current production model in a given context with best practices in the value chain. If the difference in profit margin is significant, producers may want to learn how they can improve production (e.g. via demonstrations, trainings and field days).

A comparison of current practices with innovative ones is also particularly interesting. For example, current practices by rice processing firms can be compared with those that use more efficient state-of-the-art technology and produce higher quality rice. The increase in profit can then be related to investment costs for new machinery to determine whether the investment (with or without subsidies) is justified.

5.5 Verifying existing cost structures

A comparison of the existing cost structures the government (Ministry of Agriculture, but also the Ministry of Nutrition) uses for its planning can also be made. Figure 17 shows the “official” scenario based on non-published data from the Ministry of Peoples Power for Agriculture and Land. The figure reveals that the government’s cost structure reflects much higher profit margins and underestimates the real costs of inputs. Apparently, primary producers pay higher prices for at least part of their inputs than the prices calculated by the government. The government seems to assume that primary producers purchase inputs at cheaper (i.e. government controlled) prices from public agencies engaged in the production and distribution of farm inputs. In fact, however, they purchase some of their inputs from more expensive parallel markets. The government’s cost structure might also be based on an estimation of higher yields and productivity compared to the actual figures reported by producers interviewed for the UNIDO project. According to the government’s estimations, the margin is large enough for producers to engage in rice production, while the data collected by UNIDO implies otherwise. In any case, the data used by the government (including on yield and productivity) would need to be analysed in depth to understand the basis of calculation and eventually come to a conclusion on which data needs to be adapted and adjusted (either UNIDO, the government or both).

Figure 17: Production costs along the rice value chain, official data versus survey data

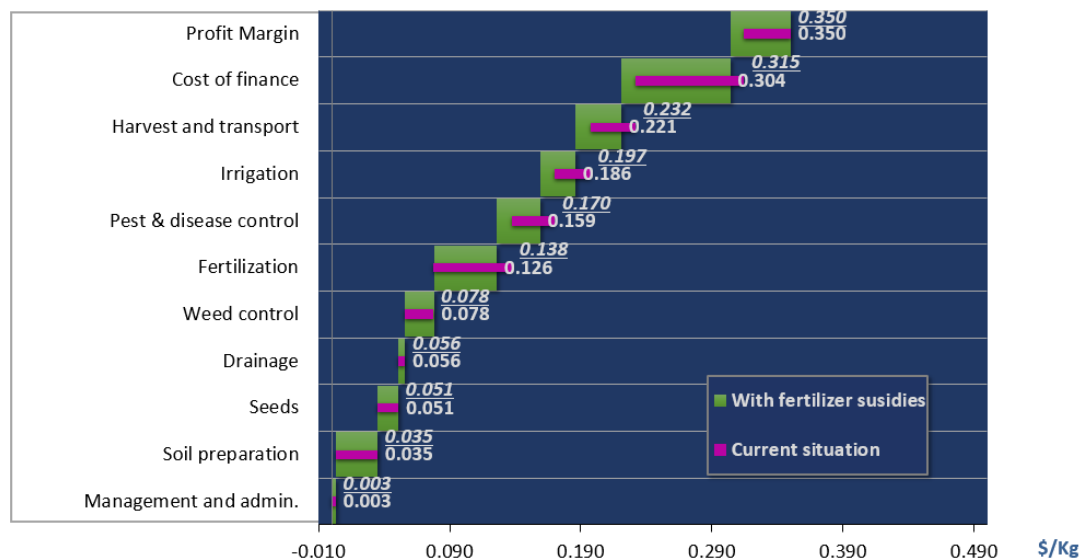


Source: Project data and “Ministerio de Poder Popular para la Agricultura y Tierras”

5.6 Monitor and simulate policy changes

The CAT can also be used to simulate the effects of policy measures to determine how cost structures and profit margins would react to such changes. For example, the government could introduce a 20 per cent subsidy on the fertilizer purchases of primary producers. The resulting cost structure is illustrated in Figure 18. It shows that *with* subsidies, the profit margin for primary rice production is USD 0.046 cents compared to USD 0.035 *without* subsidies. Additional studies are necessary to better understand whether this incentive would result in producers expanding their rice production. The procedures of how fertilizer subsidies would be effectively operationalized (many fertilizer subsidy schemes have proven inefficient) and who would receive subsidies need to be analysed as well. The CAT calculations only provide initial indications on how the profit margins might change.

Figure 18: Production costs along the rice value chain, before & after the introduction of policy measures (fertilizer subsidy)



Source: Project data

5.7 Forecast of future production and profit distribution across value chain actors

Additional data and methods are required to investigate whether production would likely expand or decline. Production data (in hectares or value of product) are required for this purpose as well as information on profit margins and the production of alternative crops and return on investment of other economic activities. However, the profit margins for rice production that the CAT can generate for future scenarios are an important indication of the future profitability of rice cultivation. The analyst needs to further understand (eventually by conducting surveys) how producers would react to the new profit margins; would they continue engaging in rice production because of habit or risk aversion? Would they have the capacity (and necessary land) to expand production? Would they have access to the necessary credit and equipment? All of these factors need to be further explored to reach a conclusion on the level of production in a future scenario.

5.8 Engaging government and stakeholders

If the CAT is to provide relevant information, interviews need to be conducted to collect data; the more data is entered, the more meaningful the CAT’s calculations become. This requires close collaboration with the producer community along the value chain. It is important to note that the process of data collection cannot only be a one-way street from farmer to analyst, it has to be a two-way process, i.e. the information the CAT generates should preferably be conveyed back to the producers in the value chain. The project in Venezuela has already initiated reciprocity via the creation of a value chain committee, which includes representatives of producers, associations and industrialists. Some producers were only willing to provide data on their cost structures when

they saw data from the CAT. Some of the current committee members became interested in joining the committee when they saw that relevant information was being made available by the CAT.

Interviewees became particularly interested in participating when the project analyst responsible for the rice value chain demonstrated how their cost structure compares to the average and best practices and some started using this information to develop strategies to optimize their cost structures. Analysts can furthermore use the CAT to help producers along the chain determine the efficiency of their production. Thereby, the CAT can function as a support tool for practical advisory services.

CAT data was also shared with the government so it could compare CAT data with its own data, and use it for further analysis. Additionally, the project informed a high-level policy dialogue organized by the Vice-Presidency of the Economy among various ministries (the Ministry of Agriculture, of Nutrition, of Economy, of Transport, of Industry and of Trade) as well as specialized government agencies. CAT data and simulations were presented at a number of meetings with high-level policymakers, informing on recent trends in value chains. The presentations led to discussions on the effectiveness of current policy measures, estimations on production volumes in the future and the effects of higher prices on consumers as well as additional policy actions required (e.g. provision of additional credit and agricultural inputs through government agencies). The government was offered use of the CAT to simulate the effects of future policy measures the government aims to introduce.

To conclude, the CAT's real value does not only lie in the analysis of data per se, but in its role to develop reference data that allows stakeholders to enter evidence-based discussions and the planning of joint actions. Due to its straightforward application (easy to use for all Excel literates) and its easy-to-grasp visualization function, the CAT represents a powerful decision support tool.

6 Conclusions

The CAT is a useful tool for the study of value chains. It provides an overview on costs and profit margins for segments of the value chain, calculating them based on per-unit cost data and prices that need to be entered in the tool, drawing from data derived from interviews or secondary sources. The data must be entered as per unit costs and prices in categories relevant to production as defined by the analyst. The CAT provides useful visualizations of the distribution of data with graphs, also allowing for comparisons of different scenarios. While the data on costs and profit margins can be analysed in detail, the graphs usually illustrate summaries of different aspects. The box-whisker charts allow verification of distribution levels in the selected samples.

The data and graphs generated by the CAT can be used to interpret a number of aspects of value chain development, including identification of best practices, cost reduction potential and productivity increase strategies, as well as policies to improve production across the chain. The CAT analysis could also lead to case studies to determine the root causes of problems and lack of competitiveness.

The CAT is a useful contribution to the existing landscape of quantitative value chain analysis tools. Few other costs and profit margin analysis tools seem to exist that are preformatted and are easy to use. The CAT standardizes and structures the analysis of costs and profit margins, also allowing for comparisons across countries, regions and technologies. Using standard Excel tables, it is easy to understand and analysts can apply the tool to cost items and categories of firms to be analysed.

The visualization of per-unit costs and profit margin calculations is easy to understand, which distinguishes the CAT from more comprehensive “national accounting” approaches propagated, for example, by the World Bank and FAO, which often require extensive data collection and analytical capacity.

The quality of CAT’s results depends on the data collected and entered into it. It is recommended for analysts to strengthen their capacities in per unit cost calculation using the data made available by producers. Capacity strengthening programmes should be provided for users of the CAT if they do not have the necessary skills to conduct surveys and perform cost calculations.

The application of the CAT in the Venezuela’s challenging business environment has shown that it is easy to use and intuitive enough for value chain actors to quickly buy into. In fact, sharing information on costs and profit margins in a standardized way throughout the chain has motivated value chain actors—from both the public and the private sector—to provide data and participate in value chain coordination meetings and engage in subsequent joint actions.

Efforts should be undertaken to analyse more value chains using the CAT in different contexts to gradually improve its user-friendliness and analytical capacities. Another step that should be taken in the future is the application of CAT’s algorithms and formulas to different types of database management software and the possible development of a smartphone application that helps users enter data directly and generate analyses in a more sophisticated way, combining it with “big data” from other sources.

References

- Antrás, P. (2020). Conceptual Aspects of Global Value Chains. Policy Research Working Paper 9114. The World Bank, Washington D.C., USA.
- Bhargava, A., A. Bafna and N. Shabarisha (2018). A Review of Value Chain Analysis as a Strategic Cost Management Tool. Account and Financial Management Journal, 3(3).
- Bellu, L.G. (2012). FAO VCA-Tool: A Software for Value Chain Analysis. FAO, Agricultural Development Economics Division. Rome, Italy.
- Bellu, L.G. (2013). Value Chain Analysis for Policy Making: Methodological guidelines and country cases for a quantitative approach. FAO, Agricultural Development Economics Division. Rome, Italy.
- Diyee, K., D. Baker and K. Rich (2017). A quantitative value chain analysis of policy option for the beef sector in Botswana. Agricultural Systems, Vol 156.
- Foster-McGregor, N., F. Kaulich, and R. Stehrer. F. and UNIDO (2015). Global value chains in Africa. Research, Statistics and Industrial Policy Branch Working Paper 4/2015. UNIDO, Vienna.
- Keyser, J.C. (2006). Description of Methodology and Presentation of Templates for Value Chain Analysis: Background paper for the Competitive Agriculture in Sub-Saharan Africa (CCAA) Study. The World Bank, Washington D.C. Available at <http://siteresources.worldbank.org>.
- Making Markets Work Better for the Poor (M4P) Project - Donor Committee for Enterprise Development (DCED), UK Department for International Development (DFID) (2008). Value Chain Analysis Tools – Quantitative Tools. In: Making Value Chains Work Better for the Poor: A Toolbook for Practitioners of Value Chain Analysis. Agricultural Development International (Cambodia Representative Office). Available at <http://valuechains4poor.pbworks.com>.
- Rich, K.M., R.B. Ross, A.D. Baker, and A. Negassa (2011). Quantifying value chain analysis in the context of livestock systems in developing countries. Food Policy 36(2).
- Tchale, H and J. Keyser (2010). Quantitative Value Chain Analysis: An application to Malawi. Policy Research Working Paper 5242. The World Bank, Africa Region, Agricultural and Rural Unit.
- UNIDO (United Nations Industrial Development Organization) (2011). Industrial Value Chain Diagnostics: An Integrated Tool. UNIDO. Vienna, Austria. Available at www.unido.org/publications.
- UNIDO (2015). Global Value Chains and Development: UNIDO's support towards inclusive and sustainable industrial development. Vienna. Available at www.unido.org/publications.
- UNIDO (2019a). Diagnóstico y Plan de Acción del Arroz. Project Report. UNIDO. Vienna, Austria.
- UNIDO (2019b). Desarrollo en la Cadena de Arroz: Informe de Progreso. Project Report. UNIDO. Vienna, Austria.

USAID - Market Links (no date). 5.3.2. Quantitative Analysis. Available at www.marketlinks.org.

Wang Z., Wei, S. J., Yu, X. and Zhu, K. (2017). Measures of Participation in Global Value Chains and Global Business Cycles. NBER Working Paper, No. 23222. Cambridge MA: National Bureau of Economic Research.



UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Vienna International Centre · P.O. Box 300 9 · 1400 Vienna · Austria
Tel.: (+43-1) 26026-0 · E-mail: info@unido.org
www.unido.org