20th Meeting of the Advisory Expert Group on National Accounts,
5, 12 and 13 July 2022, Remote Meeting

Agenda item: 6

DZ.7 Improving the visibility of Artificial Intelligence in the National Accounts

Digitalization Task Team

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Improving the visibility of Artificial Intelligence in the national accounts

SECTION 1: THE ISSUE

BACKGROUND

1. Over the last twenty years, there has been marked technological progress in computer hardware and software as well as the storage and use of vast amounts of data. This has led to the development of what Alan Turing described in the 1950s as “thinking machines” which can reason as well as human beings. Years following Turing’s conceptualization, John McCarthy coined the term “artificial intelligence” which he defined as “getting a computer to do things which, when done by people, are said to involve intelligence.” The advances in hardware, software and engineering have increased the prevalence and range of applications of artificial intelligence in the economy.

2. AI has been particularly noticeable in the consumer electronics market. Voice-controlled virtual assistants, such as Amazon Alexa and Apple Siri, convert sound waves into text that are then assessed. Based on this evaluation, the technology then reviews a series of connected databases to find the most appropriate response. These databases are continually updated on the Internet rather than preloaded on the device. These applications can be used to retrieve information from the Internet, play audio or visual content, make purchases, and deliver messages to either people or other connected devices. Technology can be installed on a variety of devices, including displays, speakers, headphones, watches, or eyeglasses.

3. AI tools are also used by Internet publishers, digital content subscription services, and social media networks. AI can identify and recommend content that an individual user is most likely to be interested in. These tools gather an individual user’s viewing history, demographic profile, and geographic location along with real-time information about content that other users are viewing, then apply algorithms to predict what the user will want to view. Netflix, YouTube, and Facebook have all used these tools to generate personalized content recommendations to many millions of users.

4. Autonomous vehicles are another important application of AI. These vehicles employ a series of sensors and cameras to monitor their surroundings. This information is then integrated in real-time to software that maps a route, triggers the vehicle actions, adjusts to avoids obstacles, and follows traffic laws.

5. Businesses have used AI applications to guide decision-making in a wide array of sectors. In agriculture, AI tools absorb a wide array of data streams collected from sensors, cameras, and historical records to make recommendations on crop-planting, soil management, and pesticide use. Manufacturers use AI to improve the performance of industrial robots and to monitor and recommend improvements in production processes. Healthcare providers use AI tools to evaluate diagnostic images. In finance AI tools are used to support lending decisions and to algorithmically generate personalized investment portfolios based on user-submitted data (i.e. robo-advisors).

6. The current version of the SNA does not make any reference to Artificial Intelligence. This guidance note provides recommendations that aim to visibility of AI in the national accounts.

DEFINING ARTIFICIAL INTELLIGENCE

7. AI is currently not defined in the System of National Accounts. A first step in increasing the visibility of AI in the SNA is to define it. Defining AI poses a significant challenge given its complex

nature, its constant evolution and application of use. Moreover, AI is often not a stand-alone technology but co-exists with and is often embedded in other technologies, sometimes in a complex fashion. The definition needs to capture as clearly as possible all its dimensions to ensure that it is measured and recorded with appropriate precision. Several international and national organizations have recognized the importance of AI and have started to produce and disseminate statistics. In doing so they have had to define AI. The following table provides a summary of the current definitions that are in use.

Organization	**Definition**
OECD	"An AI system is a machine-based system that can, for a given set of human-defined objectives, make predictions, recommendations, or decisions influencing real or virtual environments. It does so by using machine and/or human-based inputs to: i) perceive real and/or virtual environments; ii) abstract such perceptions into models through analysis in an automated manner (e.g. with machine learning, or manually); and iii) use model inference to formulate options for information or action. AI systems are designed to operate with varying levels of autonomy." (OECD, 2019a)
Eurostat	Artificial intelligence refers to systems that use technologies such as: text mining, computer vision, speech recognition, natural language generation, machine learning, deep learning to gather and/or use data to predict, recommend or decide, with varying levels of autonomy, the best action to achieve specific goals. Artificial intelligence systems can be purely software based, e.g.: chatbots and business virtual assistants based on natural language processing; face recognition systems based on computer vision or speech recognition systems; machine translation software; data analysis based on machine learning, etc.; or embedded in devices, e.g.: autonomous robots for warehouse automation or production assembly works; autonomous drones for production surveillance or parcel handling, etc. 2
Canada (Statistics Canada, 2019)	Artificial Intelligence (AI) refers to systems that display intelligent behavior by analyzing their environment and taking actions – with some degree autonomy – to achieve specific goals. AI-based systems can be purely software-based or embedded in a device.
France (INSEE, 2019)	Artificial intelligence includes all the technologies aiming at computerization of cognitive tasks traditionally performed by humans: voice recognition, biometrics, image recognition, decision support, etc.
Japan (Communication Usage Trend Survey 2017, Ministry of Internal	AI (Artificial Intelligence) can be defined as something that can perform, learn, infer, recognize, judge, etc. through data analysis.

Affairs and Communications)	
Korea (2018 yearbook of Information Society Statistics, Ministry of Science and ICT and The National Information Society Agency)	Artificial intelligence technologies and services are machine-generated intelligence (artificial intelligence) ….Refers to a technology that embodies abilities, reasoning skills, perception skills, and natural language comprehension skills……Example) AI assistant service that provides necessary information while talking by voice (S Voice and Bixby of Samsung, Q-Voice of LG, Apple's Siri, Google's Now, Microsoft's Cortana, Amazon's Alexa and Echo, SK Telecom's AI Speaker)
U.S. National Institute of Standards and Technology	Technologies and systems comprised of software and/or hardware that can learn to solve complex problems, make predictions, or undertake tasks that require human-like sensing (such as vision, speech, and touch), perception, cognition, planning, learning, communication, or physical action.

8. While each of the above definitions are different and emphasize various aspects of Artificial Intelligence, they have several similarities. First, they refer to a "system" or "technology / technologies." They note that AI can either be a stand-alone application or embedded in a device. AI also must function with some degree of autonomy in executing cognitive tasks, solving problems, or making predictions. Finally, AI can take in and process information faster and with accuracy comparable to or better than a human. AI also frequently adapts and refines its methods based on new data and an evaluation of its own previous performance. Given these characteristics AI seems best placed within the SNA intellectual property products class.

9. The SNA defines intellectual property products as "the result of research, development, investigation or innovation leading to knowledge that the developers can market or use to their own benefit in production because use of the knowledge is restricted by means of legal or other protection (2008 SNA 10.98)." This concept captures some of the characteristics of AI but is not fully sufficient. The first part of the concept seems to apply to AI in that AI "is a result of research, development, investigation or innovation." AI is produced and is the result of development, involving human ingenuity. The second part of the IPP definition seems limiting when applied to AI. Does AI lead only to knowledge that the developers can market or use for their benefit? AI is more than a set of blueprints, designs, software, or formula. AI seems to go beyond the embodiment of knowledge towards the performance of tasks that ordinarily require human intelligence.

10. There are five classes of intellectual property products in the SNA (1) Research and Development, (2) Computer Software and Databases, (3) Mineral Exploration and Evaluation, (4) Entertainment, Literary or Artistic Originals and (5) Other Intellectual Property Products. The definition of each is provided in table 2.

Table 2 – Selected Intellectual Property Products (Definitions)

Research and Development	Research and [experimental] development consist of the value of expenditures on creative work undertaken on a systematic basis to increase the stock of knowledge, including knowledge of man, culture and

	society, and use of this stock of knowledge to devise new applications. This does not extend to including human capital as assets within the SNA.
Mineral Exploration and Evaluation	Mineral exploration and evaluation consist of the value of expenditures on exploration for petroleum and natural gas and for non-petroleum deposits and subsequent evaluation of the discoveries made.
Computer software and databases (with separate classes for computer software and databases)	Computer software consists of computer programs, program descriptions and supporting materials for both systems and applications software. Databases consist of files of data organized in such a way as to permit resource-effective access and use of the data.
Entertainment, literary and artistic originals	Entertainment, literary and artistic originals consist of the original films, sound recordings, manuscripts, tapes, models, etc., on which drama performances, radio and television programming, musical performances, sporting events, literary and artistic output, etc., are recorded or embodied.
Other intellectual property products	Other intellectual property products include any such products that constitute fixed assets but are not captured in one of the specific items above.

11. While AI is similar to computer software in that at its most basic level it consists of a set of programs or code, it is a specialized type of computer program designed to be self-operating free from human intervention or intended to replace human intervention. As with software, AI tools can either be sold on their own, or installed into hardware prior to sale as a bundled product. This latter option is known as sales to the original equipment manufacturer or OEM market. The bundled product sold by the manufacturer is then classified based on its primary use, with the software-enabled features considered quality characteristics. As with software, inputs to AI technologies frequently include open-source repositories of text and images, open-source development tools, and shared programming code. While an argument can be made that the definition of AI should include both the “software” and “hardware”, for pragmatic and analytical reasons it may be best to restrict the definition to the software nature and indicate that this software can be integrated on various platforms (from a desktop speaker to a car).

12. While AI fits broadly within the SNA concept of intellectual property products a refinement of the concept is proposed. The broad definition of IPP does not captures the idea of an AI system, its autonomous nature and the cognitive / decision making ability. The current definition is more geared towards something that is the result of intellect (and may embody that intellect), rather than something that is intellectual. Refining the concept to include the idea that IPPs are not just the creation and embodiment of knowledge but also systems capable of applying knowledge to perform tasks in an autonomous manner that the developers can market, and use seems appropriate. Expanding the concept of IPP to the “*result of research, development, investigation or innovation leading to knowledge or* ***the creation of intelligent systems*** *that the developers can market or use to their own benefit in production because use of the knowledge or system is restricted by means of legal or other protection*” seems to better encompass the notion of AI.

13. Although not explicitly mentioned in the asset classification, Artificial Intelligence is already covered under the existing asset class ***Computer Software and Databases***. However, it is recommended to give Artificial Intelligence explicit visibility within the asset classification. Building on GN DZ.6 “Recording of Data in the national accounts”, which recommends creating two separate classes for ***Computer Software and Data and Databases, Artificial Intelligence*** should be associated to the former, ideally with an “of which” category. This would permit countries to distinguish between AI and non-AI computer programs when analytically useful to do so. Within this “Computer software and Artificial Intelligence” asset class, it is proposed to define Artificial

Intelligence as "*computer programs operating a system capable of recognition and reasoning consistent with human recognition and reasoning*."

14. AI can be developed and adopted in various forms. AI systems may be developed fully in-house by a firm's own employees as an own account system. AI can also be developed by third-party providers, either those that specialize in developing AI or those that also provide other computer programming, systems design, and related services. AI can be developed under a hybrid approach with vendor-provided solutions customized either by internal staff or by external professional service firms. Finally, AI can be adopted indirectly, i.e. by acquiring devices or systems that embed AI. Given these features, the recording of AI in the national accounts can (and currently does) inherit the recommendations associated with software. While the valuation and recording of AI in the SNA can broadly follow that of software there are a few nuanced recommendations that should accompany its recording.

15. The first nuance relates to the valuation of own-account AI. The SNA recommends that "software developed in-house is valued at its estimated basic price, or at its costs of production if it is not possible to estimate the basic price." (SNA 10.111). The nuance with AI relates to the components of the cost of production. Many applications of AI require either a "training data set" or continuous access to a large database that the AI uses to "interpret" and "reason." Training datasets are data that are used to teach an AI to make accurate decisions. For example, an AI used in a self-driving car will need to first be trained to tell the difference between a car, street sign or person. The cost of developing training datasets is not negligible and therefore its "production" should be captured and recorded in the national accounts. The question is whether the cost of developing the training dataset should be considered part of the value of the AI or if it should be included in a separate asset class related to databases and data. Since the training dataset is developed specifically for the AI, and if the AI is sold on the market the producer would set a price that recovers the cost of developing the training dataset, it would be logical to include the cost of training datasets in the value of own-account AI. However, this approach entails a high risk of double counting if the development of such datasets is also capitalized as data assets. To address this issue, it is therefore recommended that the cost of developing training datasets should be excluded from the value of own-account AI. This could lead to discrepancies between the recorded values of marketed AI and own-account AI as the costs of developing training datasets may be included in the basic prices of marketed AI products.

16. In addition to the need of training datasets, AI tools also often require ongoing access to large datasets to "operate" the devices they reside on. For example, an autonomous tractor requires a continuous feed of weather, geo-positioning data and data obtained from sensors to operate. The question from a national accounting perspective is whether the value of these databases or data collecting devices should be included in the value of the AI. Given that in most cases these data collecting devices (e.g. satellites) or databases are not exclusive to the AI it would not be appropriate to include the value of these products in the cost of production of an AI. In most cases the costs of the data services required to operate an AI would be included as an intermediate input borne by the users of the AI. It is recommended that the costs of the "data service / subscription" not be included in the value of the AI but rather recorded as intermediate consumption.

17. In many cases AI is embedded on a device / machine. Examples include AI that are embedded on autonomous vehicles, robots, and household devices. As noted earlier it is not possible or practical to separate the AI from the machine in these cases such that the purchaser is purchasing both the AI (software) and the machine / device that it operates. When a farmer purchases an autonomous tractor, they are not purchasing an AI and a tractor, they are purchasing a tractor with an AI system embedded in the tractor. The AI asset resides with the firm that produced

/ owns the AI and embeds it on the device / machine. This treatment is identical to the way embedded software is treated in the SNA.

18. While the SNA already includes a well-established treatment for embedded software, care should be taken into monitoring the way AI is embedded. In some cases, it may be embedded as a subscription in which the purchaser needs to pay a regular fee for the use of the AI including potential data services needed for the AI to function. In these cases, national accounts should adopt the convention used for software more broadly. AI made available under a licence can be treated as a fixed asset if "*it is expected to be used in production for more than one year and the licensee assumes all the risks and rewards of ownership. A good, but not necessary, indication is if the licence to use is purchased with a single payment for use over a multiyear period. If the acquisition of a copy with a licence to use is purchased with regular payments over a multiyear contract and the licensee is judged to have acquired economic ownership of the copy, then it should be regarded as the acquisition of an asset. If regular payments are made for a licence to use without a long-term contract, then the payments are treated as payments for a service. If there is a large initial payment followed by a series of smaller payments in succeeding years, the initial payment is recorded as gross fixed capital formation and the succeeding payments are treated as payments for a service. If the licence allows the licensee to reproduce the original and subsequently assume responsibility for the distribution, support, and maintenance of these copies, then this is described as a licence to reproduce and should be regarded as the sale of part or whole of the original to the unit holding the licence to reproduce."* (2008 SNA 10.100)

19. It will also be important to consider quality improvements associated with AI. A key quality of AI is the ability to learn – to improve with time and experience. Consider the case of the personal styling service firm "Stitch Fix[1]." This company employs stylists who recommend clothing for fashion conscious men and women. Each month they ship a box of clothing to their customers who keep the items they like and return the items they do not like. This company uses AI to assist the stylist with selecting those cloths the customer is most likely to keep. As the AI gains experience with the customers' preferences by monitoring the cloths kept and returned it becomes increasingly accurate in selecting those styles the customer ends up keeping. The improved predictive ability of the AI is an important productivity improvement and should be reflected in the volume measures. If the AI is a purchased expense it should be reflected as a price decline in the subscription cost of the AI. If the AI is owned by the firm outright it will be reflected in the increased capital service flow of the AI. Given AI's can become more productive over time, they will most likely have a different consumption of fixed capital profile than software.

RECOMMENDATIONS FOR ISIC AND CPC

20. Adopting a recommendation to include AI as a separate asset class within the SNA framework implies a need to update the need to update the product and industry (activity) classifications used by the SNA so that AI can be property reflected in the full set of national accounts and tables such as supply and use tables. Recording AI as a separate asset class within the SNA requires an update to the Central Product Classification (or country variants). CPC 2.1 does not refer to Artificial Intelligence, nor does it refer to the words "autonomous" or "intelligence."

[1] https://sloanreview.mit.edu/article/using-analytics-and-ai-subscription-e-commerce-has-personalized-marketing-all-boxed-up/

Extensive reference is made to package software, licensing fees for software and IT consultancy. Given much of the source data required by the national accounts will be derived from business statistics programs - updating the CPC to include AI is required. The updates to CPC should be consistent with those proposed by the SNA.

21. This implies that business surveys will need to add detailed questions about the use of key AI-technologies, such as applications that employ natural language processing, machine learning, or machine vision. Businesses often provide expenditure information based on accounting classifications; therefore, if a definition for AI is based on specific characteristics that the program is capable of recognition, uses machine learning and deep learning algorithms, does not require human input and is capable of reasoning businesses should be able to delineate expenditure in their accounts based on such specific characteristics.

22. A second possibility for delineation could be the expected lifespan of the asset, as firms often delineate assets (and the expenditure on them) based on this characteristic. Due to AI's learned skills, these tools may become more valuable over time, as more data is provided for learning, thereby extending its useful life. While this will not always be the case, as some specific tasks that are learnt may simply become obsolete, the potential for AI to exhibit a useful life much longer than standard assets, provides a reason for it to be separately accounted for both in business and macro-economic accounts.

23. The need to update ISIC Rev 4 to delineate an AI industry is less clear (and urgent). Currently much AI development is in-house or being undertaken by existing software development and IT consulting firms. In some respects, AI is a new product line rather than a new line of businesses. ISIC Rev 4 does not refer to AI as an activity. ISIC Rev 4 makes extensive reference to software publishing and computer programming, consultancy and related activities which would encompass AI activities.

24. Automation (e.g. robotics) over the last half century has displaced a significant amount of labor pushing more jobs into the service sector. Such possibilities may still be some time off, but it is important to continue to review such possibilities so that statistical standards evolve and appropriately reflect the technology it is tasked with measuring. In many respects AI has the potential to automate many of the jobs in the service sector. Customer service centers, consultancy services, transportation services may all see an increase in the use of AI and decrease in the need for labor. Given the potential transformative nature of AI it is important that the SNA provides the granularity users will need to analysis, understand, and develop effective policy to address a potential increased prevalence of AI in the economy. Such a commitment is the national accountants' best chance to continue to provide data and information that is accurate and meet user's demands.

4. RECOMMENDATION

25. To summarize this guidance note proposes the following updates to the 2008 SNA.

- First that the definition of Intellectual Property Products be updated to the *result of research, development, investigation, or innovation leading to knowledge or the creation of intelligent systems that the developers can market or use to their own benefit in production because use of the knowledge or system is restricted by means of legal or other protection.*

- Second, the updated SNA includes the following definition of AI. AI is a "*computer program operating a system capable of recognition and reasoning consistent with human recognition and reasoning*."

- Third that Artificial Intelligence is explicitly mentioned in the asset classification in a new class called "Computer Software and Artificial Intelligence", derived from the current "Computer Software and Databases" class by separating Databases (which will be merged with Data in a separate class). In this new class, Artificial Intelligence would appear with an "of which" category.

- Fourth that the value of the cost of producing training datasets be excluded from the value of own-account AI and included instead in the value of Data assets.

- Fifth, that the value of the cost of data services required by an AI are excluded from the value of AI and recorded as intermediate consumption.

- Sixth, that the next CPC update includes specific classes for AI and that this guidance note serves as the SNA drafting recommendations.

- Seventh, that the ISIC update considers the need to establish separate ISIC classes for AI and that this guidance note serves as the SNA drafting recommendations.

Questions for the AEG:

1) *Do you agree with the seven recommendations regarding the recording of Artificial Intelligence in the SNA?*

2) Do you agree that this guidance note is ready for global consultation.

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