Value added of Infrastructure, 1995-2016

Exploratory study

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1. Introduction

Within the Next Generation Infrastructures (NGinfra) consortium, the Executive Agency of the Dutch Ministry of Infrastructure and Water Management (Rijkswaterstaat), the Rotterdam Port Authority (Havenbedrijf Rotterdam), Alliander, Schiphol Group, ProRail and Vitens have joined forces to establish a knowledge platform in support of infrastructure operations and investment planning. The mission of NGinfra is:
"To supply the infrastructure providers with the knowledge they need to generate value for society in responding to the challenges of the future (e.g. energy transition, climate change, urbanisation), while accounting for increasing interactions and interdependencies between infrastructure systems, within and across sectors."
As part of its knowledge mission, NGinfra seeks to characterise the value that infrastructure generates for society and the economy.

The importance of infrastructure to the economy has been investigated in several international studies (for example: Baldwin and Dixon (2008), Gu and Macdonald (2009), Snieska and Simkunaite (2009), European Commission (2014), and Martin (2019)). The focus in these studies has been on aspects such as investments in infrastructure, the value of the infrastructure stock, and the relationship between infrastructure and growth. To our knowledge, however, the direct (macro)economic contribution of infrastructure-related activities to the economy in terms of value added has not been studied up to now. Looking at value added of a specific industry in relation to the entire economy provides an idea of its direct contribution to this economy. Moreover, an unambiguous definition of infrastructure used in the various studies is sometimes missing[1], and there is no internationally agreed definition of infrastructure[2].

In 2017, NGinfra commissioned a study by Statistics Netherlands on the value added of Dutch infrastructure, since prior to this, basic data on this topic were unavailable. NGinfra takes a cross-sector approach, and therefore it was important to develop a cross-sector analysis taking the interdependencies between infrastructure sectors into account. From a statistical point of view, it is also inevitable to look at various relevant industries as infrastructure is not captured in one NACE category[3]. Moreover, NGinfra requested that these estimates be placed within an existing and internationally accepted statistical framework, such as the National Accounts. Doing so would allow the estimates of value added to be placed within the context of the national economy and aid work towards an international standard for measuring value added of infrastructure building on the already standardised concepts of the System of National Accounts. In the first project, an operational definition and methodology to estimate the value added of infrastructure was developed (CBS, 2017a); as yet no internationally harmonised definition and demarcation of the value added of infrastructure exists.

However, the results of the previous study could not be interpreted within an international context. The current exploratory study is the first attempt to remedy this knowledge gap, placing the Dutch estimates of the value added by national infrastructure in an international perspective.

[1] See Chapter 2 of the paper 'Infrastructure Capital: What Is It? Where Is It? How Much of It Is There?' by Statistics Canada.
[2] Josh Martin and Rachel O'Brien describe various options for defining infrastructure in their article 'Developing new measures of infrastructure investment, 2017'.
[3] Activity classification of the European Union (Nomenclature statistique des activités économiques dans la Communauté Européenne, NACE).

Comparing the resulting estimates of the value added of national infrastructure for different countries may yield a better understanding of, or meaningful hypotheses on the importance of certain factors influencing the value added of national infrastructure.

The current study uses the same definitions and methods as developed during the previous study. In addition, the following three economic activities, which are included within the definition of national infrastructure but for which data were previously unavailable, are included in the current study:

- Retail and wholesale of fuels;
- Data processing, hosting and related activities;
- Employee compensations for government infrastructure related activities.

The operational definition and method as developed for the Dutch estimates in the initial study, including the additions mentioned above, were also used to obtain an estimate of the value added of infrastructure for several member states of the Organisation for Economic Co-operation and Development (OECD)[4]. In general, data available from international databases were less detailed than the data used for the Dutch analyses. Consequently, the international estimates are less robust than the Dutch estimates. Even though it is important to interpret these results with caution, they do provide some interesting insights into the value added generated by infrastructure in an international perspective. At the same time, it shows how well the Dutch approach can be employed to compile international estimates when reliant on internationally available databases.

It is important to keep in mind that within this exploratory study, only the direct economic and monetary value added of infrastructure is estimated. This means that other economic, social or environmental effects infrastructure might have on society are not taken into account.

Since the previous study was written in Dutch, the next two chapters will shed light on the definition, operational approach, data sources and methodology as developed in the initial study. Chapter 4 presents the results from both the Dutch and international estimations. Chapter 5 highlights the differences between the Dutch and international data sources, based on the value added of infrastructure estimates for the Netherlands. Concluding remarks are provided in Chapter 6, focusing on reflections, limitations and recommendations for further research.

The results presented in this exploratory study provide preliminary insights into the differences of the structure of VA of infrastructure between countries. Feedback or suggestions are very much welcome.

Acknowledgement
We would like to thank *Next Generation Infrastructures* and the *members of the advisory council*[5] for their comments and suggestions during the course of the study.

[4] Sixteen countries were selected based on the availability of data from within the Organisation for Economic Co-operation and Development (OECD) database.
[5] Prof. Arnoud Boot (University of Amsterdam), Prof. Luc Soete, emeritus (University of Maastricht), Dr Peter van de Ven (Head of Dept. of National Accounts OECD), Prof. Roger Vickerman (University of Kent), Josh Martin (UK Office for National Statistics)

2. Definition and operational approach

2.1 Scope: infrastructure

The System of National Accounts (SNA) 2008 describes transactions by industry and sector on the basis of international guidelines. Industries are classified according to the NACE Rev2 classification (SBI 2008[6]). Companies are classified into industries according to their main economic activity. For example, producers whose main activity is transportation are classified as part of the 'transportation, storage and communication' industry. This provides a clear overview of the total production value of producers in a certain industry, one that is consistent with the industries in which the producers operate. However, this approach means that production in any secondary activities is also included in the production value of the relevant industries. For example, this can be the case for a textile factory which also sells products directly to consumers (retail trade).

There is no separate industry for 'infrastructure' within the NACE classification. Statistics Netherlands therefore attempted to construct value added (VA) of infrastructure from relevant and already existing NACE classes. In order to do so, it is important to use an unambiguous definition of what infrastructure is. NGinfra and the advisory group from the first study, proposed a definition that expresses the *functionality* of capital-intensive immovable assets. A railway contributes little to society itself, unless there are also trains that can move people and goods according to a timetable and with traffic control. In the same way, a drinking water supply network is useless if it is not used to supply clean drinking water to consumers and other users. As such, infrastructure as defined by Statistics Netherlands in consultation with NGinfra and the advisory group constitutes *the total of immovable and movable assets and activities that are necessary to ensure the provision of the primary services upon which society and the economy rely*:

- Flood safety and water level management
- Energy supply: electricity, gas, fuels (for transportation and space heating) and heat
- Information and telecommunications (both analogue and digital, both using fixed lines and wireless transmission)
- Transportation of passengers and goods by road, water, rail and air
- Drinking water supply
- Waste (and wastewater) removal and processing

The delineation of infrastructure in this manner is in line with definitions applied elsewhere. For example, in the UK National Infrastructure Delivery Plan 2016-2021[7], a distinction is made between economic infrastructure and social infrastructure. The key economic infrastructure sectors that have been identified are: transportation; energy; communications; flood defences; and water & waste. Social infrastructure on the other hand concerns schools, hospitals and prisons. The definition of economic infrastructure as used by the UK government seems to be

[6] The Dutch standard industrial classification (SBI 2008) is based on the activity classification of the European Union (Nomenclature statistique des activités économiques dans la Communauté Européenne, NACE) and on the classification of the United Nations (International Standard Industrial Classification of All Economic Activities, ISIC). The first four digits of the SBI are the same as the four digits of NACE and the first two digits of the SBI and NACE are the same as the first two digits of ISIC.

[7] https://www.gov.uk/government/publications/national-infrastructure-delivery-plan-2016-to-2021

similar to the one applied in this study. With the exception of financial services, the set of primary services contained in our definition of infrastructure largely coincides with the essential services to which every European citizen is entitled according to Article 20 of the European Pillar of Social Rights[8]. The comprehensive definition of infrastructure used in this study is very different from the narrow definition used in the paper 'Infrastructure in the EU: development and impact on growth' published by the European Commission (2014), in which only the physical infrastructure involved with inland transportation and energy networks is considered.

In substantiating the comprehensive definition of infrastructure used in this study, a pragmatic approach was adopted: for the NACE industries that are part of the production and supply chains of the aforementioned primary services, the VA was included. In doing so, the entire system is taken into account from production up to and including delivery of primary infrastructural services. A given NACE industry may also contain secondary activities, which should not be allocated to infrastructure. Where possible, a correction was made to exclude that part. Hence, value added of infrastructure is constructed from the value added of the following industries:

- *Mining and quarrying*
  This industry includes the extraction of minerals occurring naturally as solids (sand, gravel, coal and ores), liquids (petroleum) or gases (natural gas), as well as exploration activities. Hence, it is part of the whole production and supply chain of the primary services of energy supply and the construction of, for example, roads and dykes.

- *Manufacture of coke and refined petroleum products (fuels only)*
  This industry includes the transformation of crude petroleum and coal into usable products. This study only takes into account the conversion into fuels (for transportation), as the transportation industry cannot function without fuel supply.

- *Energy supply*
  This industry includes the provision of electric power, natural gas, steam, hot water and the like through a permanent infrastructure (network) of cables, lines, mains and pipes. Also included are the distribution of electricity, gas, steam, hot water and the like in industrial parks or residential buildings. It therefore includes the operation of electric and gas utilities, which generate, control and distribute electric power and gas.

- *Retail and wholesale of fuels*[9]
  Since the whole energy supply chain is included, from production to the actual distribution and delivery, the sale of fuels should be included as well. The 'land, water and air transport' industry cannot provide any services without fuel supply. The sale of other energy carriers is already included via 'energy supply'.

[8] Everyone has the right to access essential services of good quality, including water, sanitation, energy, transport, financial services and digital communications. Support for access to such services shall be available for those in need. See https://ec.europa.eu/commission/priorities/deeper-and-fairer-economic-and-monetary-union/european-pillar-social-rights/european-pillar-social-rights-20-principles_en

[9] New activity included in this *follow-up* study.

- *Water collection, treatment and supply*
  The collection, purification and distribution of water is another as a primary service to the economy and society. Returns on investments in production and transportation facilities are obtained through exploitation activities carried out by water companies.

- *Sewerage and waste treatment*
  This industry provides primary services such as the prevention, reduction, processing and disposal of hazardous substances into and from the environment.

- *Land, water and air transport*
  These industries provide the transportation services needed to move people and goods.

- *Warehousing and support activities for transportation*
  This industry includes (among other things) the basic services of airports (transfer of goods and passengers) and ports (trans-shipment of goods), including warehousing activities.

- *Telecommunications*
  This activity includes the activities of providing telecommunications and related service activities, i.e. transmitting voice, data, text, sound and video. The transmission facilities that carry out these activities may be based on a single technology or a combination of technologies: wireless (e.g. satellite) or fixed (e.g. cable, fibre optic) networks. These constitute the basis of telecommunications.

- *Data processing, hosting and related activities*[10]
  This activity includes the provision of infrastructure for hosting, data processing services and related activities, as well as the provision of search facilities and other portals for the internet.

- *Public administration and government services*[11]
  In the Netherlands, the government manages and invests in public infrastructure such as roads, dykes and other water infrastructure. The services produced (flood risk management, road access etc.) are consumed collectively. These services are included in NACE industry 'Public Administration'.

2.2 Indicator: value added

The key indicator in this study is value added of infrastructure in basic prices (for the period 1995-2016), see box A for more information.

Box A. What is value added?

Value added (basic prices) is the value of all goods and services produced (output at basic prices), minus the goods used up in production (intermediate consumption at purchasers'

[10] New activity included in this *follow-up* study

[11] The estimation of this activity has been fine-tuned. In the first study, only VA generated by the use of public infrastructure was taken into account. Now the VA generated by the compensation of employees for public infrastructure related activities is included also.

prices).

Output (basic prices) is the total of goods and services created during the reporting period, also called production. Three types of output are distinguished:

- market output: goods and services disposed of on the market or intended for disposal on the market;
- the own-account production of all goods that are retained by their producers for their own final consumption or own gross fixed capital formation;
- non-market output: goods and services delivered for free or at economically non-significant prices to other units.

Output is valued at basic prices. These are the prices encountered by the producers: taxes on products are subtracted from the original prices, and product-related subsidies are added to them. Costs of transportation, when charged separately by the producer, are not included. Changes in the values of financial and non-financial assets during the reference period are not included either. The output by all kind-of-activity units (KAU) residing in the Netherlands, also those that are held by foreign owners, is included in total output. The kind-of-activity units include general government units and other non-commercial units.

Intermediate consumption (purchasers' prices) is the sum of goods and services used as input in a production process, with the exception of capital goods. Intermediate consumption consists of goods transformed into other goods or used up entirely in the course of the production process (by definition, this holds for all hired services). According to international standards an acquired good or hired service is classified as a fixed asset rather than intermediate consumption when it lasts longer than one year in a production process. Goods and services that are part of intermediate consumption are valued at market prices at the time of consumption.

Gross domestic product (GDP) is a quantity that expresses the size of an economy. The volume change of GDP during a reference period expresses the growth or decline of the economy. Gross domestic product at market prices is the final result of the production activity of resident units. It can be defined in three ways:

- production approach: GDP is the sum of gross value added of the various institutional sectors or the various industries plus taxes and minus subsidies on products (which are not allocated to sectors and industries). It is also the balancing item in the total economy production account.
- expenditure approach: GDP is the sum of final uses of goods and services by resident institutional units (final consumption and gross capital formation), plus exports and minus imports of goods and services.
- income approach: GDP is the sum of uses in the total economy generation of income account (compensation of employees, taxes on production and imports minus subsidies, gross operating surplus and mixed income of the total economy).

According to the income formation method, value added is the sum of employee compensation, gross operating surplus and the balance of non-product related taxes and subsidies.

Compensation of employees is the total remuneration, in cash or in kind, paid by employers to their employees in return for work done during the reporting period. Compensation of employees consists of wages and salaries and employers' social contributions.

The *balance of non-product related taxes and subsidies* consists of taxes and subsidies that are not directly related to the value or quantity of produced and sold products. Examples of non-product related taxes are property tax, cleaning rights and sewerage fees paid by producers and consumers. An example of a non-product related subsidy is wage subsidies.

The balance remaining after the value added at basic prices has been reduced by the remuneration of employees and the balance of taxes and subsidies on production and imports is the *gross operating surplus*. For self-employed persons (who form part of the household sector) this balance is called mixed income because it consists of a reward for their entrepreneurship and compensation for their labor.

Relationship Gross Domestic Product (GDP) and value added
GDP is the sum of the gross value added of all institutional sectors or industries and the balance of product related taxes and subsidies (which are not allocated to sectors and industries). Hence, the difference between the sum of value added of all sectors/industries and GDP is the balance of product related taxes and subsidies.

A breakdown of value added into compensation of employees, gross operating surplus and the balance of non-product related taxes and subsidies is provided in this report. This facilitates a useful interpretation of the results, as it describes the capital-intensity of an activity.

Value added is also broken down into exploitation activities and investment activities. Exploitation activities involve direct use of existing infrastructure assets by the operators. Consider the value added generated by an energy company from transporting energy over an already existing energy network. Investment activities concerns value added linked to investments in new infrastructure (the construction of the assets themselves). An example is the value added that occurs during the construction of power lines. This only concerns the value added that is generated by the producer of the investment, namely the construction industry.

3. Sources and Methodology

The methodology described in this chapter is similar to the methodology developed in the previous study. As the method is largely based on data sources that are produced by most developed countries and transmitted to international organisations, the method could in theory be applied in other countries as well. However, in compiling international estimates we only have access to international databases (for example from the OECD and Eurostat). These data are often available at a higher aggregated level only. Therefore, this chapter will pay extra attention to the points where the international data availability differs from the more detailed data available for the Netherlands, necessitating adjustments in the VA estimation method previously established, hereafter referred to as 'the Dutch approach'.

3.1 Sources

The following main sources were used to estimate the VA of infrastructure:

National accounts (NA)
National accounts form the official statistics that provide an overview of an economy. The transactions by industry are systematically described in supply and use tables (SUT). Supply and use tables are used to determine the VA of exploitation activities. Additionally, NA contain data on investments and depreciation of capital. Depreciation of investments in civil engineering by the public sector is used as a component of VA of exploitation by the public sector.

For investment activities, value added is based on investments in civil engineering works[12] by the relevant infrastructure industries (as described in Section 2). Information from SUT is used in order to convert the value of these investments from purchasers' prices to basic prices and to transform it into VA and its components.

NA are revised periodically. During a revision new sources, methods and concepts are implemented in the NA. This results in an updated picture of the Dutch economy that optimally matches all underlying statistics, sources and international guidelines for compiling the NA. Such a revision occurred shortly after the first study was completed. Therefore, the current results differ from the previous study for all years, even though the methods have remained the same.

Structural Business Statistics (SBS)
Structural Business Statistics provide an image of the employment and financial developments within an industry. Information from SBS is used for certain economic activities to determine the share that should be allocated to infrastructure, as SBS data is often more detailed than the published NA-data.

Polis (Dutch register of wages)[13]
The Polis contains information on jobs and income of employees of Dutch firms. Since Polis data are more detailed than the published NA data, the number of employees according to the Polis

[12] In compiling the international estimates the data on investments in civil engineer works also includes 'other buildings and structures'. No further details are available here. Hence, there is an overestimation.
[13] Only used for the Dutch estimation regarding the share of Data processing, hosting and related activities (NACE 6311) in Information service activities (NACE 63), as the quality of SBS-data was not sufficient.

was used to determine the share of the economic activities that should only partly be allocated to infrastructure and for which the quality of SBS data is insufficient.

Classification of the Functions of Government (COFOG)
The Classification of the Functions of Government is an internationally used classification standard for a structure of state expenditures (state budgets) with regard to their purpose (function). The expenditure categories of COFOG are aligned with NA-definitions.

Information on the compensation of employees for infrastructure related COFOG-functions are used to determine the VA generated by the government services related to infrastructure such as waste management, road maintenance and water management.

International Energy Agency (IEA) [14]
The database from IEA consists of data on the supply and consumption of energy per product category, which is used for the international estimation to determine the share of fuels in total production by the manufacturing of coke and petroleum industry.

3.2 Methodology: exploitation activities

For most industries VA is readily available from the NA and no additional transformations are necessary. Hence, we take the VA of the whole corresponding NACE category, see table 3.1. This applies to both the Dutch and international estimates.

There are however a few industries which do require additional calculations. These specific calculations are described below. For each of these items an additional explanation is given on whether, and how, the international methodology differs.

Table 3.1 Economic activities included in this study

Economic activities	NACE	Further processing needed?
Mining and quarrying (extraction of crude petroleum and gas + exploration)	B (05 - 09)	Yes
Manufacture of coke and petroleum (fuels only)	C (19)	Yes
Energy supply (Production, transmission, distribution and trade of electricity)	D (35)	No
Retail and wholesale of fuels	G (46.71, 47.3)	Yes
Water collection and distribution	E (36)	No
Sewerage and waste treatment	E (37 – 39)	No
Land, water and air transport (people and goods, incl. warehousing and services for transport)	H (49 – 52)[1]	No
Telecommunications	J (61)	No
Information service activities (data processing, hosting and related activities)	J (63.11)	Yes
Public administration and government services	O (84)	Yes

[1] The international estimates also include Postal and courier activities (NACE H.53), as this data was more complete for both exploitation and investment activities at a higher aggregated level.

[14] For the Dutch estimation, the detailed SUT could be used for determining this share.

3.2.1 Mining and quarrying

In the published NA data, the intangible asset 'mineral exploration and evaluation' is included in NACE B - Mining and quarrying. However, since exploration is related to investments, they have to be allocated to investment activities for the purpose of this study.

In the initial study, the share of exploration activities in the VA of the mining and quarrying industry had to be estimated using the share of production. In the current study, new and revised NA data provide separate estimates on exploration activities for the years 2015 and 2016. Hence, VA of exploration activities are already known for those recent years and no extra calculations are required. As a result, the year-to-year changes in VA of the exploration activity from the initial study have been applied to the new 2015 level to get new estimates for the earlier years (1995 – 2014). Box B provides a step-by-step description of this method.

International approach
NA data is published at the aggregated level (NACE B – Mining and quarrying) only. Therefore, the share of exploration is determined using SBS data, which provides a breakdown into product groups per industry for production. Hence, VA of product group i in industry j in year t, ($\mathrm{VA}_{\mathrm{t}}^{\mathrm{ij}}$), is calculated using the following formula (1):

$$VA_t^{ij} = \frac{P_t^{ij}}{P_t^j} VA_t^j, t \in \{1995, \dots, 2016\}$$

where $\mathrm{VA}_{\mathrm{t}}^{\mathrm{j}}$ is the VA of the whole industry j, P_t^{ij} the production value of product group i in industry j and $\mathrm{P}_{\mathrm{t}}^{\mathrm{j}}$ the production value of the entire industry j in year t. The three VA components for each product group are calculated in the same way as the total VA ($\mathrm{VA}_{\mathrm{t}}^{\mathrm{ij}}$).

The assumption underlying this method is that the ratio between production and VA is the same for all product groups within an industry. It is also assumed that the distribution of the VA to compensation of employees, gross operating surplus and the balance of non-product related taxes and subsidies within an industry are the same for all underlying product groups. These two assumptions may be less likely to hold for industries with a wide variety of product groups.

3.2.2 Manufacture of coke and petroleum

In this study, only the activities related to fuels are relevant. The VA generated by all other product groups has to be excluded. First, the fuel-related product groups are determined among the large[15] product groups within this industry. The ratio between the fuel and non-fuel product groups is used to determine the relevant share of VA generated by this industry, similar to formula (1).

Following the NA revision, detailed information on the different product groups is available for the years 2015 and 2016 only. Prior to the revision this information was available for all years. Therefore, data before the revision was used as a secondary source to determine the levels for the 1995-2014 time series (see box B).

[15] All product groups with a share of more than 5 percent of the total industry production in any year are considered large.

International approach

The same method was applied, although the share of VA was determined using information obtained from the International Energy Agency (IEA) on the production volume of fuels, since NA data is not published at this level internationally.

Box B. Detailed time series using *splicing*

The national accounts are intended to provide an accurate and up-to-date picture of the development of the economy. This requires the data to be comparable in time (i.e. over the course of the reporting period). The national accounts have been revised and the new data have been published in 2018 (benchmark year 2015). Comparability in time of the national accounts has been restored by adapting the time series from 1995 onwards to the new level estimates of the benchmark year 2015. This is however only done at a higher aggregated level.

For the purpose of this study, more detailed data for the entire period are preferable. Often there are secondary sources available which can serve as a proxy for the new, detailed data. However, this secondary source often differs (slightly) from the original source and cannot be used directly, and would otherwise render the data inconsistent over time.

A method often applied in these cases is *splicing*: setting the new *level* of the series using the most recent detailed data, and determining the time series using the *year-to-year changes* from a secondary source.

3.2.3 Public administration and government services

VA of infrastructure related activities by public administration is calculated differently from other industries. It consists of VA generated by the use of public infrastructure and VA generated by the compensation of employees for public infrastructure related activities. The second item is new compared to the first study.

VA generated by the use of public infrastructure is approximated by the depreciation on the capital stock of civil engineering works that is owned by the government. This data is available in the NA.

The compensation of employees for public infrastructure related activities consists of activities such as waste management, road maintenance and water management. This information can be included using COFOG-data. Based on the primary services as defined in chapter 2, the following COFOG-functions are used to define infrastructural activities[16]:

- 4.3 Fuel and energy
- 4.5 Transport
- 4.6 Communication
- 4.7 Other industries
- 5.1 Waste management
- 5.2 Waste water management
- 6.3 Water supply
- 6.4 Street lighting

[16] The same functions, except 'other industries', have been considered by ONS in their article Experimental comparisons of infrastructure across Europe (2019).

COFOG 4.7 (other industries) is included because in the Netherlands it mainly consists of water management such as flood defenses.

The aforementioned COFOG functions relate to the *sector* government and not the *industry* government. The sector government consists of entities in the industry government, but also of entities in other industries like the waste management industry (NACE category 37-39). When these industries are already included in the study, the related VA will be included twice. Therefore, a correction is made using detailed government data compiled by Statistics Netherlands.

International approach
Similar to the Dutch approach, VA generated by the use of public infrastructure is approximated by the depreciation on capital stock of civil engineering works that is owned by the government. However, these data are not directly available in international databases. Hence, depreciation on capital stock of civil engineering works is calculated by applying a geometric rate of depreciation[17] to the capital stock of 'other building and structures'[18] owned by the general government. Data on the latter is available from Eurostat.

Regarding the compensation of employees for public infrastructure related activities, the same data and selection of COFOG-functions were used. The correction for the potential overlap between the sector government and other infrastructure industries could however not be made. Hence, there is some double counting in the international estimates[19]. Moreover, no information is internationally available on the contents of COFOG 4.7 (other industries), therefore it could potentially also contain other non-infrastructure items which might be more prevalent in other countries.

3.2.4 Retail and wholesale trade in fuels

This industry was not included in the previous study on the VA of infrastructure. The retail and wholesale trade in fuels is part of NACE 47.3 (Retail sale of automotive fuel in specialist stores) and NACE 46.71 (Wholesale of solid, liquid and gaseous fuels and related products). Data on the value added of these NACEs is not published in the NA. However, underlying NA data can be used to construct estimates for the retail sale of fuels for 1995 – 2016 and for the wholesale of fuels in 2015 and 2016. The year-on-year growth rates of value added in the SBS data from 1995 to 2015 are used to extend backwards the National Accounts data from 2015, to construct a full time series (see Box B for details).

The VA of retail sale of fuels needs to be adjusted for other sales at petrol stations, such as food and beverages, as we do not wish to include these shop sales. Earlier research by Statistics Netherlands for the National Energy Outlook has determined that approximately 36 percent of value added generated by petrol stations relate to fuel sales. In order to align with other publications by Statistics Netherlands, the same share will be used in this study.

[17] Calculation: 1/(average lifespan of 'other building and structures' in Europe) = 1/55 = 1.18 percent (CBS, 2017b).
55 years is the Eurostat recommendation for the life length of roads. It may not be suitable for all infrastructure assets. However, as most infrastructure owned by governments is roads, this average is most suitable in this case.
[18] The other buildings and structures category of non- financial, produced, tangible fixed assets consists of non-residential buildings and other structures, such as civil engineering works (ESA10).
[19] For the Netherlands, the average share that is excluded in order to prevent double counting is 19 percent.

International approach
NA-data on NACE 47.3 and 46.71 is not published in international databases (only NACE 46 and 47). However, for a number of European countries the value added of retail and wholesale trade in fuels can be derived from SBS- data. This was used to determine the fuels share of NACE 46 and 47. Information on the necessary correction for shop sales at petrol stations was not found. Therefore, the same correction factor as used for the Netherlands has been used. This is a rather weak assumption, but including the whole NACE 47.3 would be even worse.

3.2.5 Data processing, hosting and related activities

Companies engaged in Data processing, web hosting and other activities in the field of information (e.g. data centres) were not included in the initial study. Data processing, hosting and related activities are described by NACE 63.11. Data on value added for this specific NACE is not published in the NA of Statistics Netherlands and is also not available in the underlying data used for the compilation of the NA. Data on NACE 63 is available for the years 2015 and 2016, and for NACE 62-63 for 1995 – 2014. Labour data (number of employees) is available for NACE 63 and 63.11. Therefore, we can derive an employment share of NACE 63.11 in 63. Under the assumption that the ratio between employees and value added is the same for all businesses in NACE 63 this share is used to estimate the associated VA.

International approach
Since Eurostat publishes employment data for NACE 63.11, the Dutch approach can be applied to other European countries. As information on the share of Data processing, hosting and related activities is not available for each year for all countries, the average share over all years was used instead of a specific share per year. Moreover, a share of NACE 62-63 was taken instead of a share of NACE 63, because data is only available at a higher aggregated level.

3.3 Methodology: investment activities

VA created by investments in civil engineering works are included under investment activities. To determine this VA, the following steps were taken.

First, total investments in civil engineering (including major maintenance) were determined for the relevant exploitation activities. These investments were valued at purchasers' prices and must be converted into basic prices. A *price correction factor* was determined by taking the ratio between the supply at basic prices and the supply at purchasers' prices for construction related product-groups, according to the following formula (2):

$$CF_t = \frac{P_t^b}{P_t^a}, t \in \{1995, \dots, 2016\}$$

Where CF_t is the correction factor in year t, P_t^b is the supply of the Construction industry in basic prices in year t and P_t^a the supply of the construction industry in purchase prices in year t.
For the Netherlands, the correction factor for the investments in civil engineering is 1, so it does not have any impact on the valuation of investments.

In addition to the initial study, a specific *price correction factor* was estimated for investments in mineral exploration activities. Now, the extraction of minerals was chosen as the product group instead of the construction related product groups[20]. As the correction factor for exploration does differ from 1, it changes the valuation of investments from mineral exploration activities.

Investment for each industry in purchasers' prices is multiplied by the *price correction factor* to determine the investments in civil engineering at basic prices, according to the following formula (3):

$$I_t^{jb} = I_t^{ja} \times CF_t, t \in \{1995, \dots, 2016\}$$

where I_t^{jb} are the investments in basic prices of industry j in year t and I_t^{ja} are the investments in purchasers' prices of industry j in year t.

Next, for the construction industry, the VA per unit of production is determined. This ratio is multiplied by the investments, according to the following formula (4):

$$VA_t^j = I_t^{jb} \times \frac{VA_t^{construction}}{P_t^{construction}}, t \in \{1995, \dots, 2016\}$$

where $VA_t^{construction}$ is the VA for the construction industry in year t and $P_t^{construction}$ is the production for the construction industry in year t. For the investments in mineral exploration activities, VA per unit production is determined based on Mining and quarrying (NACE B) instead of the Construction industry.

This results in direct VA caused by investments in civil engineering by infrastructural related exploitation industries.

International approach

Internationally, data on investments in civil engineering are part of the investments in 'other buildings and structures'[21] and so civil engineering works (structures) are not separately identifiable. Therefore, the reported VA will be an overestimation compared to the Dutch estimation. Additionally, the price conversion factor between purchasers' and basic prices is not available internationally. As the ratio appeared to be equal to or near one, this correction is not made for the international estimates. Lastly, for the Dutch estimates only domestic exploration is included, since exports are not part of the Dutch infrastructure (export is shown as a memorandum item in the accompanied datasets[22]). The international estimates include total exploration activities (domestic and foreign), because there is no international information available to specify export and it is not at all likely that the Dutch breakdown is representative for the economic situation in other countries.

[20] This is an improvement on the previous study, where the same correction factor was used for all activities. This calculation is done for domestic exploration, which is included in the VA of infrastructure, and also for the export of exploration. The export of exploration is not included in the total VA of infrastructure in the Netherlands, since it is not part of the Dutch infrastructure, but noted as a memorandum item.

[21] Examples of 'other buildings' are offices, schools, hospitals, factories. It does not include dwellings (houses, flats, etc.).

[22] https://www.cbs.nl/nl-nl/maatwerk/2019/35/toegevoegde-waarde-infrastructuur-1995-2016

4. Results

The results of the updated Dutch estimates are presented here, as well as the international estimates. The latter places the results in an international context. The international approach also includes estimates for the Netherlands based on available international data in order to make a fairer comparison. Doing so provides an impression of the over- or underestimation of the estimates when compiled from the international database (see chapter 5). In addition to the results presented in chapter 4, more detailed tables are available to third parties for their own analyses[23].

4.1 Dutch estimates

4.1.1 Changes compared to initial study

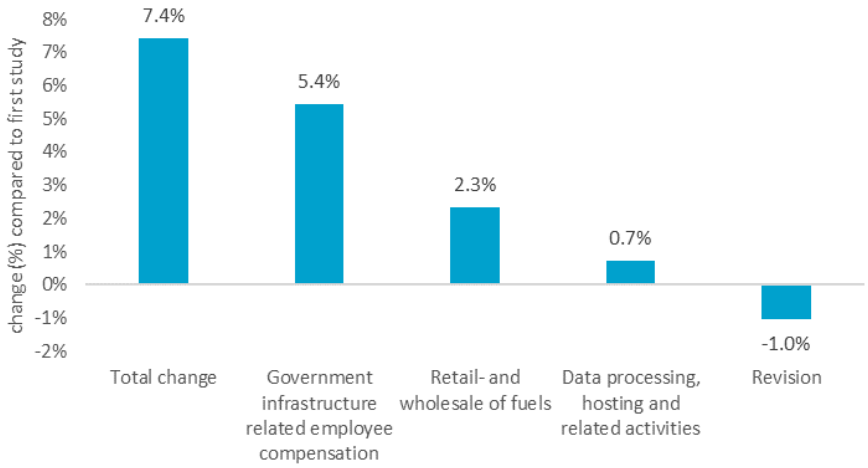
The results presented here slightly differ from those in the initial study. This is due to the increased scope and revision of NA. As already described in section 2.1, the scope has been extended with the following activities:

- Retail- and wholesale of fuels;
- Data processing, hosting and related activities;
- Compensations of employees for government infrastructure-related activities.

The 2015-revision of the National Accounts (see chapter 3.2) caused changes in the entire time series of all activities.

Figure 4.1 shows the impact of the revision and the newly included activities in this follow-up study. On average, the gross value added of infrastructure in the Netherlands has increased by 7.4 percent each year. This increase in level is relatively stable over the years and ranges from 5.8 to 9.4 percent. Government infrastructure related employee compensation causes the largest adjustment of 5.4 percent more VA compared to the previous study. The overall impact of the national accounts revision is negative (approximately -1 percent each year).

Figure 4.1 Impact of the revision and the additions to the previous study, average over 1995-2015.



[23] https://www.cbs.nl/nl-nl/maatwerk/2019/35/toegevoegde-waarde-infrastructuur-1995-2016

4.1.2 Macroeconomic perspective

The total value added of infrastructure in the Netherlands in 2016 came to 73.2 billion EUR. This means that infrastructure (the total of infrastructural activities contained within the definition used in this study) contributed 11.5 percent to the total value added of the Dutch economy (see figure 4.2). There have been some fluctuations in this contribution, mainly on account of the mining and quarrying industry. This industry is highly sensitive to price and volume fluctuations. When this industry (which by itself contributed 9 percent to the total VA of infrastructure in 2016) is not taken into account, the share is relatively stable over time and came to 10.5 percent in 2016. The decrease in value added in 2016 compared to the previous year is again mainly caused by the decrease in VA of mining and quarrying. This decrease is largely explained by the reduction of gas production in the Netherlands due to the production restrictions in the province of Groningen set by the Dutch government[24].

Figure 4.2 Contribution of infrastructure to the total VA of the Dutch economy.

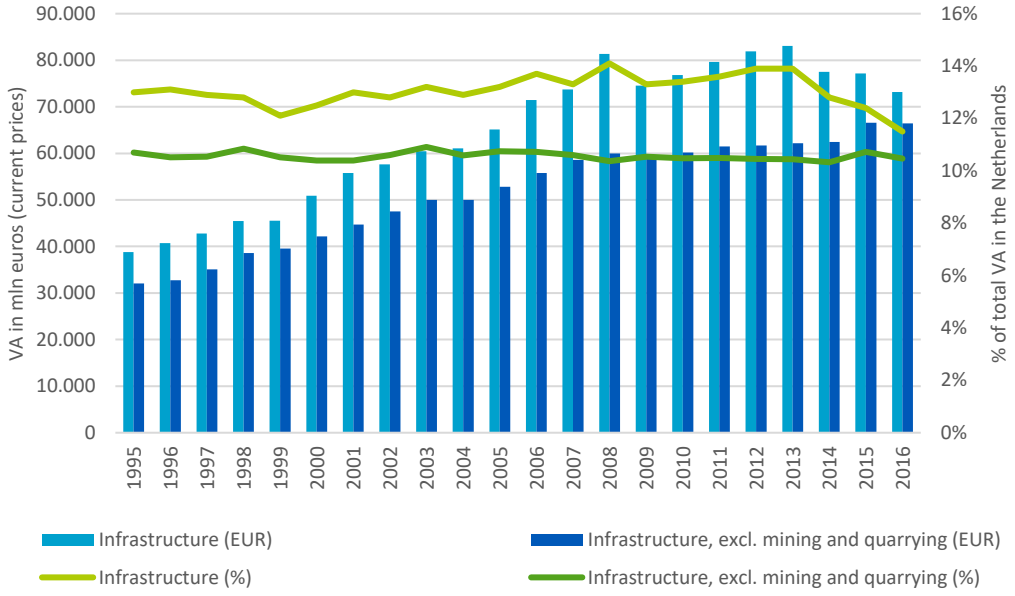
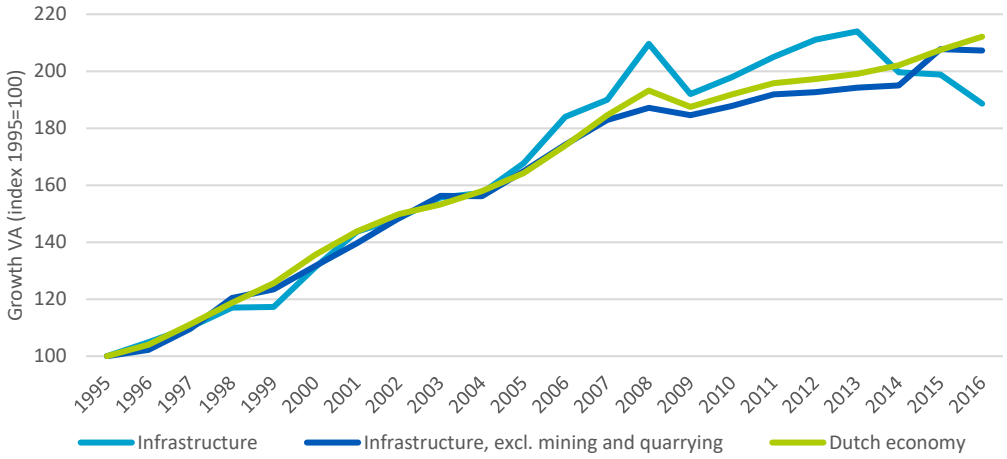


Figure 4.3 shows the growth in VA of infrastructure (including and excluding mining and quarrying) and the Dutch economy as a whole from 1995 onwards. This growth has not been adjusted for any price effects. The trend is different for infrastructure and for the Dutch economy. When excluding the mining and quarrying industry from infrastructure, the trend becomes similar. The growth of value added of the Dutch economy still slightly outpaces the growth of the value added of infrastructure in nominal terms (excl. the mining and quarrying industry).

[24] https://www.reuters.com/article/us-netherlands-groningen-gas/netherlands-to-halt-gas-production-at-groningen-by-2030-idUSKBN1H51PN

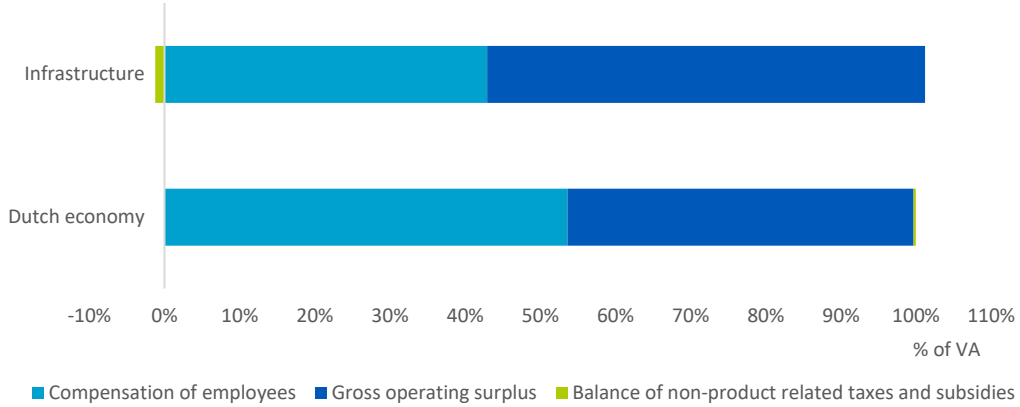
Figure 4.3 Growth VA (in nominal terms) of infrastructure and Dutch economy, index (1995=100)[25]



4.1.3 Decomposition of value added

Infrastructure is more capital intensive compared to the rest of the Dutch economy, since the share of compensation of employees is relatively smaller for infrastructural activities compared to the Dutch economy as a whole (see figure 4.4). Within the infrastructure sector, there are some (small) differences between the economic activities when looking at the decomposition of gross value added[26] (e.g. air transport and data hosting are more labour-intensive than most other activities[27]). The biggest outlier is the mining and quarrying industry: with 91 percent of value added accounted for by gross operating surplus, it is relatively more capital-intensive than other activities.

Figure 4.4 Decomposition of value added, 2016



4.1.4 Exploitation versus investment activities

Most of the value added of infrastructure is generated by exploitation activities, 94.2 percent on average in the years analysed. This share is fairly stable over time and changes by only 1 percent

[25] Index is based on VA in current prices. Therefore, differences in price-effects might influence the trend of the categories compared.

[26] Gross operating surplus includes the income of self-employed people.

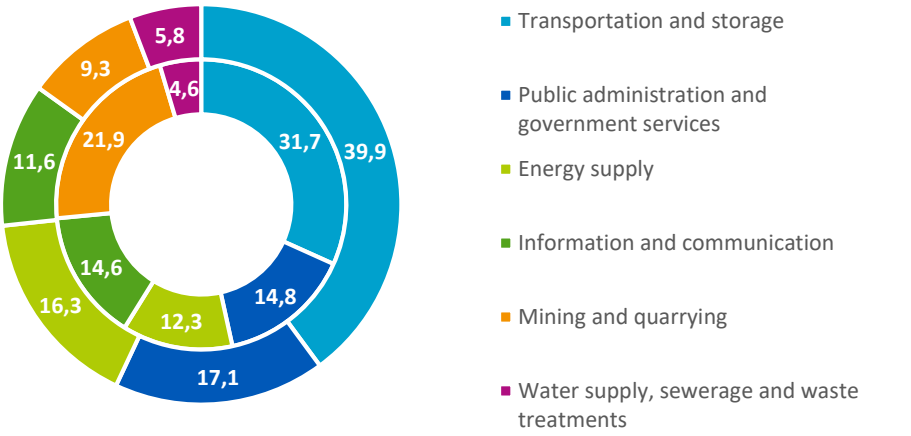
[27] See the more detailed tables available on the website of Statistics Netherlands.

when excluding the mining and quarrying industry. In absolute terms, VA generated by exploitation activities was 68.9 billion EUR in 2016 compared to only 4.3 billion EUR by investment activities. Exploitation activities make use of previously built infrastructure. Since there have been many investments in infrastructure in the past, it is not remarkable that the exploitation activities are much larger than the investment activities. For most infrastructural activities, the share of the investment activities is small except for public administration and government services, where investment activities account for 22 percent on average. This is because of the relatively large infrastructure investments made by the government. More than half of the VA of investment activities is induced by public administration and government services.

4.1.5 The underlying economic activities of infrastructure

When looking at the various economic activities[28] that fall within the scope of infrastructure as defined in chapter 2, the transportation and storage industry (NACE H[29]) creates most of the VA[30]. Figure 4.5 shows the contribution of VA of different economic activities in 2006 (inner circle) and 2016 (outer circle). When excluding the mining and quarrying industry, the contributions of the various activities are relatively stable. Though some shifts are still perceptible, such as an increased contribution of energy supply and transport and decreased contribution of information and communication activities. The industries Transportation and storage and Public administration and government services together are responsible for more than half of the VA of infrastructure in 2016.

Figure 4.5 Contribution value added per economic activity, 2006 (inner circle) and 2016 (outer circle).



The various economic activities of infrastructure show different growth patterns since 1995[31], see figure 4.6. Most activities show a steady and similar growth across the years, with the exception of the more instable mining and quarrying industry and infrastructure related public administration and government services which does not show a growth over the last 6 years.

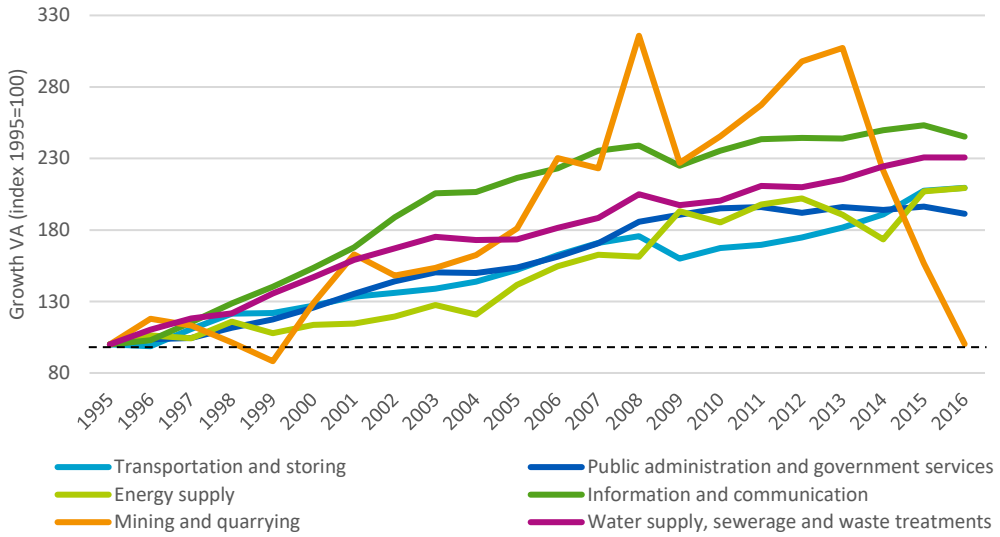
[28] The following aggregates are applied:
Transportation and storage = water transport, air transport, land transport, and warehousing and services for transport;
Energy supply = manufacture of coke and petroleum, energy supply, and retail and wholesale of fuels;
Information and communication = telecommunications, and data processing, hosting and related activities;
Water supply, sewerage and waste treatments = water collection, treatment and supply, and sewerage and waste treatment.

[29] Excluding postal and courier activities (NACE H.53).

[30] Especially warehousing and services for transport.

[31] Not corrected for price-effects (inflation).

Figure 4.6 Growth VA per economic activity, index (1995=100)[32]



4.2 International estimates

The economic system (and structure) of a country and geographical situation play an important role in the outcomes of the international results on VA of infrastructure. For instance, the Netherlands has a big port in Rotterdam which will have a positive effect on the results and Norway possess significant gas reserves which highly boost the estimates on VA of infrastructure when including Mining and quarrying. In general VA of infrastructure cannot be isolated from characteristics of a country like the geography, resources and policies of the countries (like central planning, and public intervening), therefore the results need to be carefully interpreted.

For most countries, a consistent time series could be constructed for 2012 – 2016 (when excluding use of public infrastructure services this could be done for 2001 - 2016). Data is scarce for the investment activities, and especially for the countries Poland, Belgium, Canada and USA[33]. Totals are nonetheless provided in this chapter for all countries and all years, even though there might be missing data across the years or for certain economic activities. Hence, the estimates need to be interpreted with caution when comparing between countries and over time. Despite the lack of detailed data at international level, the necessary assumptions, missing data and the limited choice of countries, the international results do provide some interesting insights in the differences of the structure of VA of infrastructure between countries and development over the years. This chapter mainly focuses on relative estimates; absolute estimates can be found in the supplemental datasets. Box C presents results based for countries where we had complete sets of data, and so are directly comparable based on the same concepts and data availability.

[32] Index is based on VA in current prices. Hence, differences in price effects might influence the trend of the categories compared.

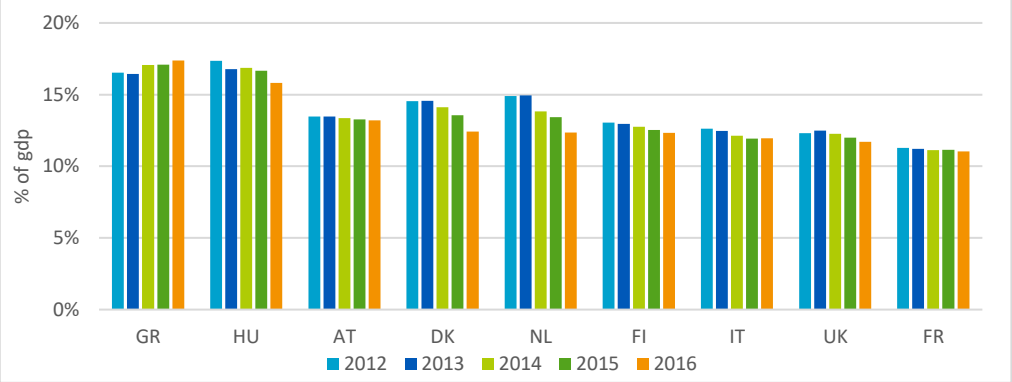
[33] Regarding the latter two, for some parts we had to rely on data from Eurostat which is not available for USA and Canada.

Box C. VA infrastructure of countries with same kind of data availability, 2012-2016

The following countries contain no (substantial) missing data on the estimation of VA infrastructure for 2012-2016: Austria, Denmark, Finland, Italy, Greece, Hungary, United Kingdom, the Netherlands and France[34].

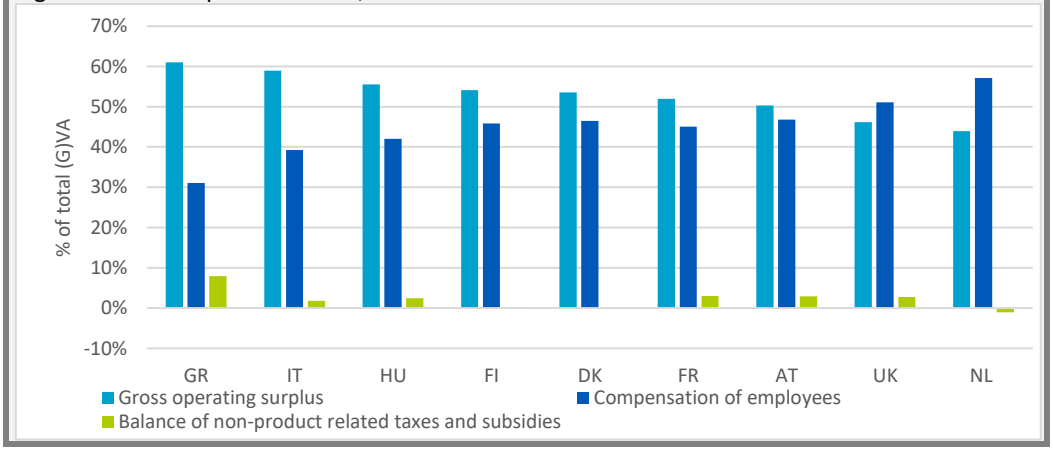
The contribution to total VA of a country varies between 11 and 17 percent (see figure C.1) and decreases over recent years for almost all countries (except for Greece). The share of investment activities in total infrastructure varies between 6 and 10 percent.

Figure C.1 Contribution infrastructure to total VA



Infrastructure-related activities in Italy, Greece and Hungary seem to be more capital-intensive than in the other countries (see figure C.2), and does not vary much between 2012 and 2016. However, different rates of return on capital could also cause these differences. On the other hand, infrastructure is more labour-intensive in the Netherlands (compared to other countries). The contribution of gross operating surplus and compensation of employees is almost equal in the United Kingdom. The relative larger share of Information and communication activities in total infrastructure could partly explain this picture (see paragraph 4.2.4). Even though the decomposition depends on the kind of underlying economic activities, the overall picture (by looking at all countries) still provides meaningful insight as the missing data is mostly related to the relative smaller economic activities.

Figure C.2 Decomposition of VA, 2016

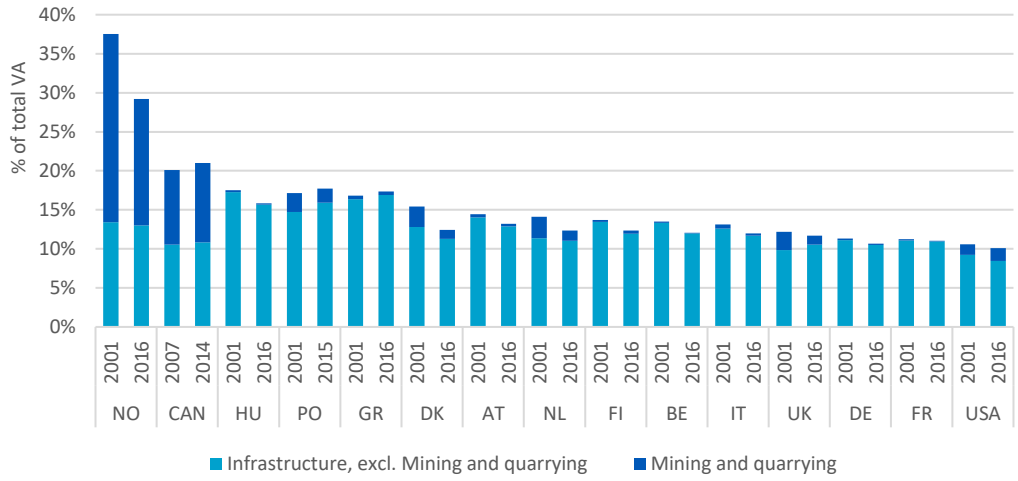


[34] For the Netherlands and France there is no data available in the international databases on the investments of retail- and wholesale of fuels. Since this is a very small omission in the total estimation of VA of infrastructure, both countries are included in this comparison.

4.2.1 Macroeconomic perspective

In general, the contribution of infrastructure to GVA seems to diminish between 2001 and 2016, see figure 4.7. As already noted in chapter 4.1, the mining and quarrying industry is different from other industries within infrastructure in the sense that it creates high value added, as the 'input' can be considered 'free' (i.e. from nature) and the output is valuable. This economic activity has a big impact on the VA of infrastructure, both in economic size as well as in volatility (as price-developments and volume-changes over time are volatile). Hence, the inclusion of Mining and quarrying has a big positive effect on the results for relative natural-resource-rich countries like Canada, Norway, and the Netherlands. The diminishing contribution of infrastructure is still evident when excluding mining and quarrying. Only Greece and the United Kingdom show slight increases in the share of infrastructure (excl. mining and quarrying) between 2001-2016[35].

Figure 4.7 Total value added of infrastructure as % of total VA, 2001 and 2016[36]



Expressing VA of infrastructure as a percentage of the size of the national economy[37] has several advantages. Firstly, it suppresses[38] any effect of inflation on the trend of VA (which is estimated in current prices) across time. Secondly, it places the absolute size of the VA of infrastructure in perspective, thereby enabling a better comparison between countries. Another way to compare the VA of infrastructure between countries is to express VA per capita or by land surface area (excluding the area below inland bodies of water such as major rivers and lakes)[39], see figures 4.8 and 4.9. These results shed light on the differences between countries. Of the European countries included in this study, the Netherlands has an average share of VA of infrastructure to total VA (see figure 4.7), but it has one of the highest VA of infrastructure when controlling for land area and population size. Greece on the other hand has an above-average contribution of infrastructure to total VA, but it has a relatively low VA of infrastructure when country and

[35] An increase can also be seen in the case of Canada, however its time series is much shorter and therefore not mentioned here.

[36] Be aware of the different time series for Canada (2007-2014) and Poland (2001-2015) due to data-availability. Moreover, 2001 data on 'use of public infrastructure' for Italy, Greece and Poland is imputed based on the average of capital stock owned by the government between 2012-2016.

[37] GDP is the common indicator for the size of the entire economy. As we look at VA of infrastructure, we choose to compare this to the sum of VA of all industries in an economy. As a result, the balance of product related taxes and subsidies is not included in this analysis.

[38] It is important to note that it does not completely remove the effects of inflation, as there can be differential price movements between infrastructure activities and the economy as a whole.

[39] This is what has been done in this study. There are of course many other indicators one can think of, depending on what needs highlighting or checking.

population size are taken into account. The inclusion of Mining and quarrying does not change this overall picture much.

Figure 4.8 VA of infrastructure per capita (only Eurozone countries), 2016

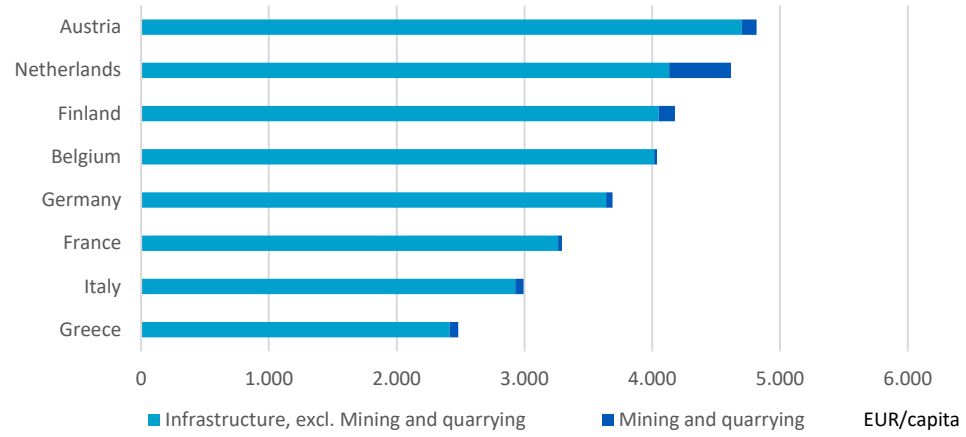
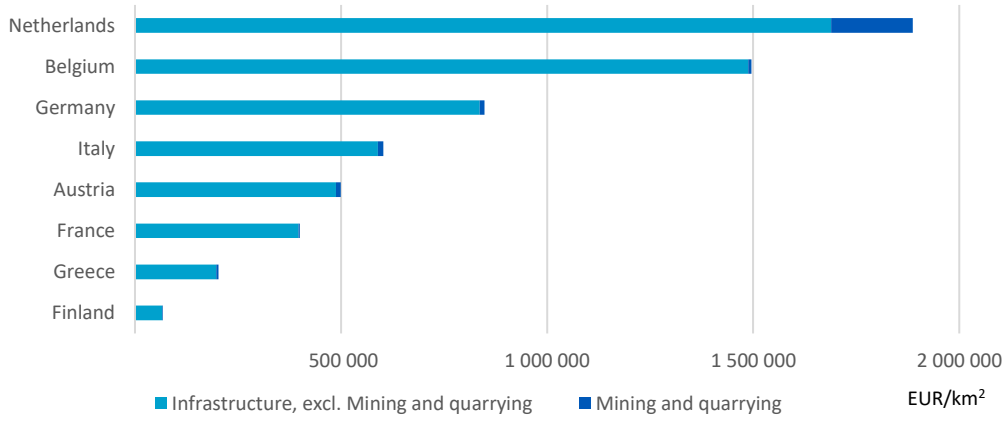


Figure 4.9 VA of infrastructure per squared km land use[40] (only Eurozone countries), 2016



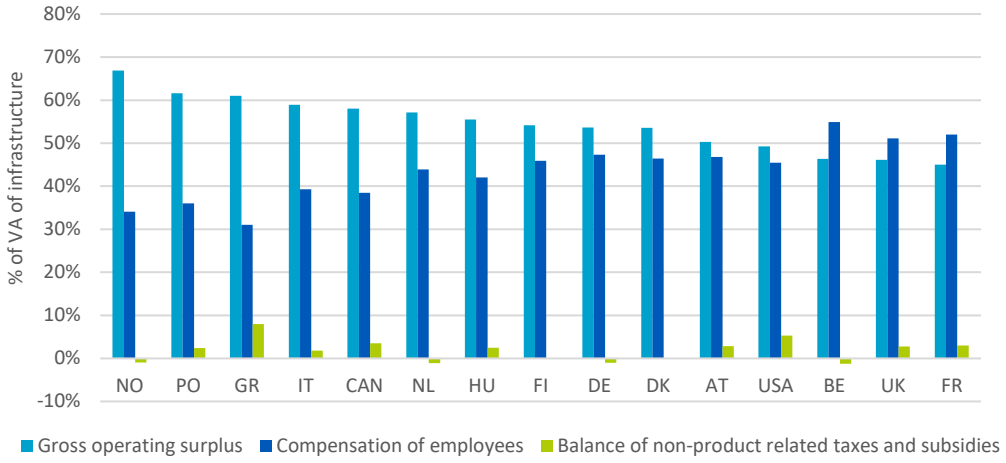
4.2.2 Decomposition of value added

Decomposing VA depicts differences in the capital-intensity of infrastructure related activities between countries, see figure 4.10. Belgium, France and the United Kingdom have a relatively labour intensive infrastructure sector, while Norway and Greece rely more heavily on capital or have a high return to capital. The inclusion of mining and quarrying reflects in relatively higher capital-intensities of the more resource-rich countries. Differences in the contributions of the various kind of economic activities influence the capital/labour ratio between countries.

Moreover, further analysis sheds light on the contributions of the balance of non-product related taxes and subsidies. Positive shares mean relatively more taxes, and negative shares reflect more subsidies. Hence, it seems that certain countries support industries related to infrastructure more so than others, and that it reflects differences in public policy measures (regarding infrastructure) between countries. However, one has to be very careful in drawing such conclusions as there are many other ways to support economic activities which is not reflected in VA decompositions.

[40] Land use is based on 2015 data.

Figure 4.10 Decomposition of value added of infrastructure, 2016[41].



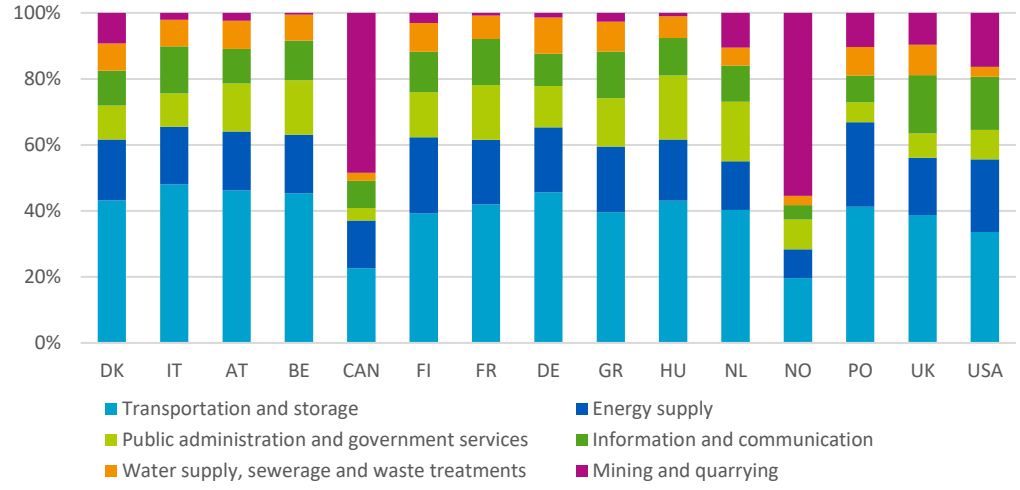
4.2.3 Exploitation versus investment activities

It is meaningless to compare the share of investment activities between countries, as in this case the influence of missing data on the results is too great. As mentioned in box C, the share of investment activities of the countries without missing data in 2016 varies between 6 and 10 percent.

4.2.4 The underlying economic activities of infrastructure

In general, the industry with the largest contribution is Transportation and storage with a share between 19 and 44 percent (see figure 4.11). In Norway and Canada, the contributions of the underlying economic activities are predominantly made by Mining and quarrying, with shares of respectively 53 and 49 percent. The economic structure of infrastructure does not change much between 2001 and 2016, therefore only 2016 data are displayed here to give an impression of the composition of the VA of infrastructure in different countries.

Figure 4.12 Contribution value added per economic activity, 2016[33]



[41] Due to data availability the results for Canada relate to 2014 instead of 2016, and for Poland to 2015.

5. Comparison of Dutch and international estimates

The approach developed in the initial study, using data available at Statistics Netherlands and which was refined in this follow-up study, was replicated for the international estimations. Data was extracted from the OECD database, however not all necessary data was available at the desired level of aggregation. Therefore, additional assumptions had to be made in order to compile a first explorative international overview of the value added of infrastructure. Despite the assumptions that have been made, the compiled dataset still lacks data for certain economic activities and years. The scale of the missing data differs between countries. Through the comparison of the two estimates for the Netherlands, the influence of missing data is elaborated further on in this chapter.

Table 5.1 presents the two macro-estimates for the Netherlands, where the underlying differences are also quantified for the exploitation and investment activities separately, because of the different methods applied for the estimation of these two types of activities. Based on the results for the Netherlands there is an overestimation of 7 percent when estimating VA of infrastructure by using available international data.

Table 5.1. Difference in VA between Dutch and international estimates, 2016

	Dutch estimate	International estimate	Difference
	million EUR		*percentage*
Total	73,201	78,396	7%
Exploitation activities	68,921	71,280	3%
Investment activities	4,280	7,116	66%

Table 5.2 gives insights into the order of magnitude of the missing data per country for the exploitation and investment activities. These estimates are the sum of the shares of the respective economic activities in the Dutch case and which are missing for that specific country. Negative percentages imply underestimation, because a certain economic activity is missing. Overestimations occur, either because a certain correction could not be made on the international data or the international approach overestimated a specific activity in the Dutch case due to the use of a different data source. Missing data in the database was particularly prevalent for countries such as Belgium, Canada and the USA.

Table 5.2 Estimates of the magnitude of missing data, 2016

	Total	Exploitation activities	Investment activities
DK	7%	4%	66%
IT	7%	4%	66%
AT	7%	4%	66%
BE	5%	4%	29%
CAN	-12%	-15%	56%
FI	7%	4%	66%
FR	7%	4%	66%
DE	7%	4%	57%
GR	7%	4%	66%
HU	7%	4%	66%
NL	7%	4%	66%
NO	6%	2%	65%
PO	7%	4%	57%
UK	7%	4%	66%
USA	-11%	-15%	58%

Table 5.3 presents the differences between the two estimates of VA of exploitation activities in infrastructure for the Netherlands in 2016, including a corresponding explanation. The largest difference occurs for the transportation and storage industry, as the whole NACE H was included in the international estimate (thereby including NACE H.53 which was excluded from the Dutch estimate).

Other minor differences can occur as different data sources had to be used and different types of corrections had to be made. For example, for manufacture of coke and petroleum (fuels only), the share of fuels was determined from a different source.

Table 5.3 Difference in VA between Dutch and international estimates of exploitation activities in the Netherlands, 2016

Exploitation activities	Dutch estimate	International estimate	Difference	Explanation
	mln EUR			
Total	68,921	71,280	2,359 (3%)	
Mining and quarrying	6,550	6,725	175 (3%)	Share of exploration (which is excluded from exploitation) was calculated using a different source.
Manufacture of coke and petroleum (fuels only)	1,145	1,157	12 (1%)	Share of fuels was determined using a different source.
Energy supply	7,781	7,781	-	
Water supply, sewerage, waste management and remediation activities	4,179	4,179	-	
Transportation and storage	28,839	30,969	2,130 (7%)	Whole NACE H is included in the international estimation, thereby including NACE H.53 (which was excluded from the Dutch estimate).
Telecommunications	7,192	7,192	-	
Public administration and government services, of which:	10,040	10,508	468 (5%)	
use of public infrastructure services	*6,434*	*6,433*	*-1 (0%)*	*For the international estimate, depreciation on capital stock of civil engineering works had to be calculated by applying a European averaged (geometric) rate of depreciation to the capital stock of civil engineering works owned by the general government. For the Dutch estimation, data on depreciation are available in the NA-database.*
Infrastructure- related employee compensation	*3,606*	*4,075*	*469 (13%)*	*No adjustment for double counting in the international estimate.*
Retail and wholesale of fuels	2,244	1,752	- 492 (-22%)	Different data source.
Data processing, hosting and related activities	951	1,017	66 (7%)	For the international estimate the share is an average over the years and based on a higher aggregated NACE.

Although missing data occur in many parts of the compiled international database, the most noteworthy instances of missing data concerning exploitation activities are as follows:

- For Canada data is available for the years 2007 – 2014 only;
- No COFOG-data are available, and therefore no estimation for infrastructure-related compensation of employees by the government, for the United States and Canada. For Belgium and Germany, this is only available from 2000 onwards and for Finland, Greece, Poland and Italy from 2001 onwards;

- Data on governmental capital assets (civil engineering works) in order to estimate VA of use of public infrastructure services is only available from 2012 onwards for Poland, Greece and Italy;
- No SBS data at Eurostat for the United States and Canada, hence it was not possible to estimate the size of Retail- and wholesale of fuel and Data processing, hosting and related activities for these countries based on the same approach;
- For Norway no information is available on the VA of the Petroleum industry.

The sum of the share of these missing items per country in the total VA of infrastructure in the Netherlands in 2016 are depicted in table 5.2. This gives an impression of the magnitude of the missing data, the consequence of using other data-sources, or different estimation approaches. However, it is important to keep in mind that these percentages are based on the Dutch situation and the size of a certain activity can be totally different in another country.

With regard to investment activities, the biggest difference between the Dutch and the international approach for all industries is the inclusion of buildings (such as shops, offices, schools and so on, not dwellings) in the data on investments in civil engineering works. Moreover, no adjustment was made for the difference between basic and purchasers' prices in order to estimate VA in basic prices. The correction factor applied in the Dutch estimate might however not be applicable to other countries. Table 5.4 shows additional differences in the two estimates for the Netherlands in 2016, including the corresponding explanation. The general overestimation of the inclusion of buildings in investments is not specifically mentioned as this is the case for all activities.

Table 5.4 Difference in VA between Dutch and international estimation of investment activities in the Netherlands, 2016

Investment activities	Dutch estimate	International estimate	Difference	Explanation
	mln EUR			
Total	4,280	7,116	2,836 (66%)	Inclusion of buildings, as well as civil engineering works, applies throughout.
Mining and quarrying	251	1511	1.260 (502%)	Export of exploration is included in international approach.
Manufacture of coke and petroleum (fuels only)	39	49	10 (26%)	
Energy supply	735	869	134 (18%)	
Water supply, sewerage, waste management and remediation activities	77	109	32 (42%)	
Transportation and storage	387	600	213 (55%)	Whole NACE H is included in the international estimation, so including NACE H.53 (which is excluded in the Dutch estimation).
Telecommunications	340	405	65 (19%)	
Public administration and government services	2,449	3,571	1,122 (26%)	
Retail- and wholesale of fuels	0	-	-	Missing data.
Data processing, hosting and related activities	1	3	2 (200%)	

Noteworthy instances of missing data concerning investment activities are:

- For Austria, Denmark, Finland, Greece, Hungary, Norway, the United Kingdom and the United States all data are available from 1997 onwards. In the case of Poland the 2016 data is missing, and for Canada there is data available for the years 2007 – 2014 only;
- There is almost no investment data available for Belgium, only for Mining and quarrying as well as Public administration and government services;
- Information on investment activities by Retail- and wholesale of fuels and Data processing, hosting and related activities is missing for the countries: Belgium, Canada, Germany, Poland and the United States. The Netherlands and France are only missing data on Retail- and wholesale of fuels;
- Information on investment activities within the telecommunications industry is missing for the countries: Belgium, Canada, Poland, Germany and United States.

6. Concluding remarks

6.1 Reflections

The main objective of this study is to place the estimates in an international perspective. Moreover, three activities were added to the operational definition. The approach developed in the first study was used for the international estimates. Data was extracted from the OECD database, which in some instances was available only at a higher aggregated level than desired. Hence, several stricter assumptions had to be made in order to compile a first explorative international overview of the value added of infrastructure in different countries. Despite the lack of detailed data at an international level, the necessary assumptions and data from a limited set of countries, the international results provide new insights into the differences of the structure of VA of infrastructure between countries.

The VA of infrastructure cannot be considered separately from the characteristics of a particular country, such as a country's geography (e.g., climate, natural resources), demography, spatial economy and economic structure, financial resources and policies. Hence, many factors play a role in the economic orientation on infrastructural activities within a country. This study only shows the different outcomes per country, without attempting to explain the root causes of these differences. The latter would need much more focused econometric modelling.

Data processing, web hosting and other activities in the field of information (e.g. data centres) have been included in this study as it includes the provision of infrastructure for hosting, data processing services and related activities. However, not much data is available at the required level. Therefore the following assumption was implemented to estimate the associated share of VA: the ratio between employees and value added is the same for all businesses in NACE 63 (Information service activities). This is a rather weak assumption given that it is a high-tech and diverse industry group, which make this estimate less robust than the other estimates.

6.2 Limitations

It is important to stress the fact that this study only concerns the direct economic and monetary value added of the infrastructure. Obviously, infrastructure also generates non-economic or social value. Although important, these issues are not quantified or integrated into this study. However, this study does trigger the discussions on the value of infrastructure, both economic and non-economic.

This study only includes direct effects of various relevant activities. Indirect effects are not included. Positive indirect effects for instance include the effect of investments in transport infrastructure on the attractiveness of certain locations for business activities, and the effect of clean drinking water and sanitation on public health. Negative indirect effects include air pollution and loss of nature. Moreover, the supply chain behind the relevant activities can also be seen as an indirect effect. After all, the infrastructure-related activities lead to intermediate consumption of goods and services for the manufacturing of products and the provision of services by other industries, which generate value added thanks to the essential services provided by infrastructure.

For the international estimations, not all necessary detailed data is available for most countries.

To compare trends over time between countries, either missing data would have to be imputed for some years and some countries (e.g. use of public infrastructure and telecommunications) or specific economic activities should be studied separately in more detail.

Data from lower-income countries and of non-European countries in particular are unavailable. However, it would be interesting to analyse the trends in VA of infrastructure in these countries as well, so as to obtain a more complete picture and compare these trends to the trends observed in this study. One may hypothesise structural differences between highly developed and less developed countries in the contribution of infrastructure to the total VA generated by the national economy, as advanced economies are likely to have developed longer, more complex supply chains behind the infrastructure supply chains, thus reducing the contribution of infrastructure to the overall value added generated by the national economy.

6.3 Recommendations

The VA of investment activities is based on investments in civil engineering works only and does not include other types of assets, such as transport assets. It would be interesting to explore some other types of assets in specific industries in the future (e.g. transport industry investing in trains and planes). For such an analysis, a general approach for estimating the investment activities cannot suffice, as the scope of investments in assets may vary between relevant economic activities.

As estimation of VA of investment activities is now based on investment data of exploitation activities, some additional calculations have to be done to convert these into value added estimations. Another approach could be to consider the output of the construction industry. This output is broken down into different types of goods and services, including housing, commercial buildings and infrastructure.

It would be insightful to have a longer time series, as most investments in established infrastructure were implemented before 1995. However, data availability remains a problem.

A suggestion made by the advisory group is to integrate the estimation-method into a supply and use table framework. This could provide more information on, and insights into, how the results are built up and thereby put less emphasis on a single indicator, i.e. value added. This approach is also known as a satellite account of the national accounts. Several satellite accounts already exist, such as the environmental accounts and tourism accounts. Moreover, the OECD is developing the framework for an *International transport satellite account*. The development of a satellite account is, however, comprehensive and very labour-intensive. It takes a long time to develop such a satellite account. Moreover, it requires detailed information and it is unlikely that this data is readily available. Consequently, an international comparison is unlikely to be feasible in the short term.

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Annex I. Definitions and abbreviations

Definitions

Balance of non-product related taxes and subsidies	Taxes and subsidies that are not directly related to the value or quantity of produced and sold products. Examples of non-product related taxes are the property tax, cleaning rights and sewerage fees paid by producers and consumers. An example of a non-product related subsidy are wage subsidies.
Civil engineering works	A civil engineering work is a construction other than buildings, for example railways, roads, bridges, highways, airport runways and dams.
Compensation of employees	Total compensation, in cash or in kind, that an employer owes to an employee for the hours worked during a reporting period. The compensation of employees is equal to the total of wages and social contributions at the expense of employers.
Economic activity	Collection of work activities aimed at the production of goods and services. This not only involves business activities but also activities from non-profit organisations and government. The economic activities are classified according to the Dutch standard industrial classification (SBI 2008).
Exploitation activities	Value added generated by operators using existing infrastructure.
Gross domestic product	Final result of productive activities of production units in a country. It equals the sum of value added in all sectors and industries, and includes some transactions that are not classified by sector of industry.
Gross operating surplus	The balance remaining after the value added at basic prices has been reduced by the remuneration of employees and the balance of taxes and subsidies on production and imports. For self-employed persons (who form part of the household sector) this balance is called mixed income because it also includes the remuneration for the work they have provided.
Investment activities	Value added generated by the producers of investments in infrastructure.

Kind-of-activity unit	A kind-of-activity unit is an enterprise, or a part of an enterprise, which engages in only one kind of (non-ancillary) productive activity or in which the principal productive activity accounts for most of the value added.
Value added	Income formed in the production process. The value added equals the production (in basic prices) minus intermediate consumption (in purchasers' prices). Value added is the income available to reward the production factors involved.

Abbreviations

CBS	Centraal Bureau voor de Statistiek (Statistics Netherlands)
COFOG	Classification of the Functions of Government
EUR	Euro
GDP	Gross Domestic Product
KAU	Kind-of-activity units
NA	National Accounts
NACE	Activity classification of the European Union (Nomenclature statistique des activités économiques dans la Communauté Européenne)
NGinfra	Next Generation Infrastructures
OECD	Organisation for Economic Co-operation and Development
SBI	Standard industrial classification
SBS	Structural Business Statistics
SUT	Supply and use tables
VA	(Gross) Value Added

Countries

AT	Austria
BE	Belgium
CAN	Canada
DE	Germany
DK	Denmark
FI	Finland
FR	France
GR	Greece
HU	Hungary
IT	Italy
NL	The Netherlands
NO	Norway
PO	Poland
UK	United Kingdom
USA	United States of America