

The contribution of infrastructure to the value added of the national economy: an international comparison over the years 1995-2016

In this cover article, which complements the Statistics Netherlands' study into the value added created by infrastructure in a selection of countries, over the years 1995-2016, Next Generation Infrastructures briefly explains why it commissioned this study, why the results are relevant, and why it wants to pursue a richer characterization of the value created by infrastructure in the future.

Next Generation Infrastructures (NGinfra) is a knowledge platform established by six major infrastructure providers in the Netherlands: Rijkswaterstaat (executive agency of the Netherlands Ministry of Infrastructure and Water Management), ProRail (operator of the Dutch national railway infrastructure), Port of Rotterdam Authority (owner and operator of the port of Rotterdam and other ports in the Netherlands), Royal Schiphol Group (owner and operator of Amsterdam Airport Schiphol and other airports in the Netherlands), Vitens (the largest drinking water provider in the Netherlands) and Alliander (one of the largest energy distribution network operators in the Netherlands).

The mission of NGinfra is to provide the Dutch infrastructure providers with the new knowledge they need in their operational and strategic decision making to account for interactions and interdependencies in the infrastructure system-of-systems. NGinfra accommodates knowledge exchange across infrastructure sectors, and stimulates interdisciplinary infrastructure systems research across the physical and engineering sciences, the social sciences and the humanities. It provides a platform for exchange of knowledge and good practices between its member organizations, it facilitates the articulation of joint knowledge needs and the set-up of collaborative research programmes, and it seeks to inform corporate and public policy makers with independent studies on the value that infrastructure generates for society.

In the latter vein, NGinfra commissioned the first exploration into the value added of infrastructure, executed by Statistics Netherlands in 2017¹. In this study we deviated from the traditional 'hard infrastructure' definition, which is restricted to the immovable physical infrastructure assets, such as roads, railway lines, cables and pipelines. Instead we defined infrastructure as 'the system that provides essential services for society and the economy', more specifically:

- Flood protection and water management;
- Energy (electricity, heat, transport and heating fuels);
- Transport of people and goods (overland, by air, sea and rail);
- Information and telecommunications, incl. digital communications (fixed and mobile);
- Provision of safe drinking water; and
- Sanitation and solid waste management.

¹ CBS, Toegevoegde waarde infrastructuur Nederland, 1995-2015, 31 oktober 2017. <https://www.cbs.nl/nl-nl/publicatie/2017/44/toegevoegde-waarde-infrastructuur-nederland-1995-2015>

The definition thus includes the entire supply chain for each one of the aforementioned essential services, including production and conversion facilities (e.g., oil refineries producing transport fuels from crude oil), the use of movable assets (e.g., trains) and the management and control systems (e.g., traffic management) without which safe and reliable services cannot be supplied. The system definition largely coincides with the definition of infrastructure used by the UK Office for National Statistics, which is pioneering infrastructure statistics.² However, the definition of infrastructure, as an asset class and as a system providing essential services for society and the economy, is still debated, also within the UK. Whereas the definition used by the UK National Infrastructure Commission is consistent with the one used by the UK Office for National Statistics, the UK Government's Infrastructure and Projects Authority includes the science and research infrastructure and housing in its definition of (economic) infrastructure.³ The services provided by the infrastructure system are not only essential for the economy. They are also denoted as essential services in article 20 of the European Pillar of Social Rights, which states: *'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.'*⁴ In the present study we have chosen to adhere to the infrastructure definition used in the 2017 study by Statistics Netherlands, which includes flood protection and water management services, as these are evidently of vital importance for the Netherlands, where the larger part of the population lives below sea level and in river flood plains. As in the 2017 study, financial services are excluded, as these depend on the provision of electricity and digital communication services and as such can be considered as a downstream segment of the economic infrastructure system as defined in this study.

For a capital-intensive system like infrastructure, which provides services that are critical to the functioning of the economy and society as a whole, it is quite astonishing that basic data are largely lacking. Infrastructure is not recognized as a distinct category in the standard industrial classifications like the NACE⁵ activity classification used by the European Union or the ISIC⁶ classification used by the UN. As a consequence, insight into the direct contribution of infrastructure goods and services to the national economy cannot be obtained unless it is constructed from the multitude of industrial activities which constitute the infrastructure system according to the comprehensive definition used in this study.

In 2017, Statistics Netherlands explored and developed a methodology for measuring the value added generated by infrastructure in the Netherlands. The study published today was conducted (1) to improve the methodology and (2) to provide international reference material for the value added generated by infrastructure. In applying the improved methodology to other countries, the limited availability of public data turned out to be problematic. For none of the countries included in the international analysis did publicly available data for relevant industrial activities contain the same high level of granularity as the data available for the Netherlands. To arrive at the estimates of

² UK ONS, Developing new measures of infrastructure investment: July 2017, see: <https://www.ons.gov.uk/economy/economicoutputandproductivity/productivitymeasures/articles/developingnewmeasuresofinfrastructureinvestment/july2017>. See also: UK ONS, Developing new statistics of infrastructure: August 2018: <https://www.ons.gov.uk/economy/economicoutputandproductivity/productivitymeasures/articles/developingnewmeasuresofinfrastructureinvestment/august2018/>

³ See: <https://www.gov.uk/government/publications/national-infrastructure-and-construction-pipeline-2018>

⁴ European Commission, European Pillar of Social Rights, 17 November 2017. https://ec.europa.eu/commission/sites/beta-political/files/social-summit-european-pillar-social-rights-booklet_en.pdf

⁵ NACE: Nomenclature Statistique des Activités Économiques dans la Communauté Européenne

⁶ ISIC: International Standard Industrial Classification of All Economic Activities

infrastructure value added for other countries, assumptions have to be made, as a consequence of which the quality of the estimates deviates from the ones obtained for the Netherlands, where the data quality allowed for a more precise estimation methodology. As a control experiment, the value added by infrastructure in the Netherlands was therefore also determined on the basis of data available in Eurostat and OECD databases, leading to a slightly higher estimate of the contribution of infrastructure to the Gross Value Added of the national economy: 12.3% in 2016 (in comparison with 11.5% percent if the higher resolution data available for the Netherlands are used).

In the international comparison over the full range of the fifteen selected countries, Statistics Netherlands was confronted with several issues of missing data, especially concerning infrastructure investments (which in the case of the Netherlands contribute 5.8% of the total value added generated by infrastructure in 2016), which complicated the construction of consistent time series. If the results are adjusted to exclude mining and quarrying activities, which add substantial value added to the economy in resource rich countries like Canada and Norway, the value added generated by infrastructure, expressed as its contribution (%) to the Gross Value Added (GVA) of the national economy, turns out to be in the 10%-15% range for most of the selected countries. Notable exceptions are the US, with an infrastructure contribution of 8% to the national GVA, and Greece, Poland and Hungary, with an infrastructure contribution of more than 15% to the GVA of the national economy. In a more detailed comparison for a selection of EU Member States which provided higher resolution data, the contribution of infrastructure to the GVA of the national economy varies between 11% (France) and 17.4% (Greece). These results seem to confirm the hypothesis that, while the absolute value added of infrastructure may increase with economic development, its relative contribution to the national economy is likely to decline as an economy advances towards more specialized economic activities and more complex supply chains, such as in the transition from an agricultural to an industrial economy, and in the transition from an industrial economy to a post-industrial service economy.

It is quite remarkable that the share of infrastructure in the GVA of most countries included in this study is consistently in the 10%-15% percent range, despite huge differences in climate and geography, population density, spatial distribution of the population, economic structure, spatial dispersion of economic activities, and so forth. These differences between countries are to some extent reflected in differences in value added of infrastructure per capita and per square kilometer. It comes as no surprise that the Netherlands' infrastructure generates twice as much value added per km² as infrastructure in Germany, and more than 25 times as much as infrastructure in Finland per km².⁷ In the generation of infrastructure value added per capita, the Netherlands and Finland score roughly the same.⁸ However, a macro-economic indicator like value added does not shed any light on the causal mechanisms at work. The lower contribution of infrastructure to the Gross Value Added of the US economy cannot be attributed to a lower productivity of US infrastructure or to a more advanced economy in comparison with the other countries included in the analysis. Besides issues of missing data in the US analysis, the concept of value added is far too abstract to allow for such conclusions. For a deeper understanding of the mechanisms at play in the relationship between infrastructure and economic growth, a more detailed analysis of infrastructure requirements of specific industries would be needed as well as a deeper analysis of how specific infrastructure investments and services

⁷ Excluding mining and quarrying.

⁸ These results are largely in line with the comparison of infrastructure stock between countries in Europe, as reported by the UK Office for National Statistics in: Experimental comparisons of infrastructure across Europe: May 2019

(<https://www.ons.gov.uk/economy/economicoutputandproductivity/productivitymeasures/articles/experimentalcomparisonsofinfrastructureacrosseurope/may2019>).

contribute to indirect economic effects, such as spillovers and agglomeration and proximity effects. It is good news that the International Transport Forum (ITF) is considering setting-up a satellite account for transport infrastructure in close connection with the System of National Accounts.⁹ It would be even better if this initiative could be expanded to encompass the wider system of economic infrastructure for all OECD countries. This would provide an opportunity to integrate the estimation method developed in this study into a supply and use table framework, which provides much more detailed information on how the economic value of infrastructure is built up, and thus provides more explanatory power.

Then what is the relevance of this study? First, this study shows that infrastructure makes a substantial contribution to our national economies. This conclusion may not be surprising, as all of us intuitively understand that economies depend on the essential services provided by infrastructure. The results of this study confirm this understanding and quantify the importance of infrastructure in terms of its contribution to the Gross Value Added of the national economy. Some critics may argue that the contribution as quantified in this study, although substantial, grossly underestimates the importance of infrastructure for the national economy, as ultimately all economic activity depends on the essential services provided by infrastructure. Others may argue that the contribution of infrastructure is exaggerated, because of the comprehensive definition of infrastructure used in our analysis. However, the definition used in this study is just comprehensive enough to define infrastructure as a functional system that actually supplies essential services. It does not include higher value-added services which are provided further on in downstream segments of the supply chain, such as content services which build on the provision of telecommunication and information infrastructure capacity services. Most controversy is likely to arise because of the inclusion of mining and quarrying, which generates substantial value added in natural resource rich countries. However, without the production of coal, oil and natural gas, we would not be able to supply the essential energy services needed in present day economies, whether in terms of transport and heating fuels or electricity. Excluding the mining and quarrying activities (which are included only for the parts that matter for the selected essential services) reflects to some extent a potential future scenario where all economies will only rely on renewable resources.¹⁰

Second, the comprehensive definition of infrastructure used in this study extends across infrastructure sectors and thus includes the many interactions and interdependencies between specific infrastructures in the infrastructure system-of-systems. This is especially relevant in the perspective of the ongoing convergence of infrastructure systems, most notably the convergence of energy, transport and information and telecommunication infrastructure. For example, in future scenarios for an energy system based on renewable energy resources, electric vehicles (whether fueled by electricity or hydrogen) are considered as active components of the energy infrastructure which are expected to respond to time and/or location dependent electricity price signals, enabled by information and telecommunication infrastructure. It will thus be increasingly difficult and increasingly meaningless to delineate specific infrastructure systems or sectors. This development, however, is not yet acknowledged in the disconnected practice of infrastructure policy making and regulation.

Third, the detailed analysis for the Netherlands shows that the 'most' essential infrastructure services generate less value added than other essential infrastructure services which depend on

⁹ See also: Peter van de Ven, Developing Thematic Satellite Accounts: The example of a thematic satellite account for transport, SDD Working Paper (forthcoming), OECD Statistics Working Paper series, 2019.

¹⁰ It must be noted though that also renewable energy requires intermediate outputs and substantial investments in production facilities, which cannot be accomplished without mining and quarrying activities.

them. In the Netherlands, flood protection and water management can be seen as the ‘most’ essential infrastructure service without which half of the country would be uninhabitable. However, this service constitutes only a minor part of the contribution of ‘public administration and government services’ to the value added generated by infrastructure.¹¹ The provision of energy services, information and telecommunication services, water, sanitation and waste management services combined contributes less to the value added created by infrastructure (33.7% in 2016) than transportation and storage services (39.9% in 2016). It may be argued that, following flood protection at the top of the hierarchy of essential services, energy services (especially electricity) and information and telecom services are situated at the next level of the hierarchy, without which modern transportation and storage services would not be possible. In other words, transportation and storage may to some extent be seen as a downstream segment of energy infrastructure (providing e.g., the fuels) and the enabling information and telecoms infrastructure. In further downstream segments (which are not part of the infrastructure definition used in this study) providing e.g., advanced logistical services, even more value added is likely to be created.

These findings should prompt us to put the concept of value added and the way in which it is measured into perspective. The economic concept of value added does not reflect the ‘real’ value added for society. Whereas the value added generated by essential and critical infrastructure services like flood protection, energy, telecommunication and information services, is only modest in economic terms, these infrastructure services evidently do generate immense value for society and the economy. Service disruptions in these (and other) parts of the infrastructure system bring huge negative externalities and cause societal disruption. This may lead us to reconsider the way investments in infrastructure, whether in new infrastructure or in maintenance and expansion of established infrastructure, are budgeted and justified. It might be argued that public investments in the construction and maintenance of essential infrastructure may well be the best use governments can make of public funds in countries with budget surpluses and declining state deficits, like the Netherlands, which can afford to invest.¹²

The fact that the provision of essential services generates comparatively little value added in economic terms, seems to be one of the reasons making infrastructure a theme that is generally not very popular with politicians. If there is any public debate on infrastructure, it is mostly triggered by service interruptions, time or budget overruns on infrastructure investment projects, hindrance caused by maintenance and construction works, or public resistance to new infrastructure projects. This leads to a public debate fueled by negative emotions, with a risk of eliciting reactive rather than proactive policy interventions. Given the capital intensity and accordingly long lifespan of most physical infrastructure assets, infrastructure policy needs a strategic forward-looking perspective with a long-time horizon. Too often though, infrastructure is used to patch up budget deficits, as postponing infrastructure maintenance will usually not have immediate repercussions for the reliability and quality of services provided. However, as shown especially in the USA and the UK¹³, the recurrent practice of postponing infrastructure maintenance and other infrastructure investments

¹¹ The total contribution of public administration and government services to the value added generated by infrastructure in the Netherlands amounts to 17.1% in 2016.

¹² This discussion could be extended to intangible infrastructure, like research and innovation infrastructure, and social infrastructure (e.g., housing, education, health care). However, these are beyond the scope of this article.

¹³ See for example: American Society of Civil Engineers, 2017 Infrastructure Report Card [<https://www.infrastructurereportcard.org/americas-grades/>]; Mauro Pisu, Barbara Pels and Novella Bottini, Improving Infrastructure in the United Kingdom, OECD Economics Department Working Papers No. 1244, ECO/WKP(2015)62, 6 July 2015.

does erode infrastructure service performance. Even the Netherlands, which is the best performing EU Member State in terms of overall infrastructure performance¹⁴, should be wary of this risk. In a recent audit, the Dutch Court of Auditors criticized the Dutch government for the deteriorating availability of its inland waterway system for freight shipping¹⁵, as a consequence of overdue maintenance. The volume of overdue maintenance works accumulated over the years now exceeds the annual budget available for management and maintenance of the inland waterway infrastructure. Apparently, the budget available for adequate infrastructure maintenance is consistently too tight, as the Dutch Court of Auditors drew the same conclusion in its previous audit of the maintenance budget for the Netherlands' highway infrastructure.¹⁶

Too many advanced economies have come to see the essential services provided by infrastructure as a given, used as we are to the omnipresent availability of infrastructure services of good quality. Especially in advanced economies the dialectics of progress are kicking in. In the fifty years or so since the construction of most of their physical infrastructure assets, technologies and standards have rapidly evolved. Without explicit awareness of the criticality of infrastructure service provision for the economy and society, the whole economy may be put at risk like the proverbial giant standing on feet of clay, as we are lagging behind in maintaining, substituting and innovating our legacy infrastructure. In the UK, this awareness has resulted in the creation of a National Infrastructure Commission which is required to carry out an overall assessment of the UK's infrastructure needs once every five years, the first one published in July 2018.¹⁷ The UK national infrastructure assessment has a time horizon of 10 to 30 years and builds on extensive cross-sector infrastructure system analytics, such as presented in the National Needs Assessment for UK infrastructure.¹⁸ Infrastructure Australia, which published the first Australian Infrastructure Plan in 2016¹⁹, is a similar statutory body as the UK National Infrastructure Commission, which is part of the Australian Government. In Canada, the awareness of the need to safeguard infrastructure performance is apparent from the so-called core public infrastructure survey conducted by Infrastructure Canada and Statistics Canada.²⁰

The substantial value added generated by infrastructure for our national economies, as quantified in the present study, may help to create more appreciation for infrastructure in the public debate. Value added, however, is only part of the story of the value that infrastructure creates for society. The provision of safe drinking water, sanitation and waste management creates evident value for society in terms of public health. These services enable us to live in densely populated cities. It is obvious that public health has large economic significance, even though its economic contribution

¹⁴ World Economic Forum (2018). The Global Competitiveness Report, WEF, Geneva.

¹⁵ Algemene Rekenkamer (2019). Resultaten Verantwoordingsonderzoek 2018 Ministerie van Infrastructuur en Waterstaat, rapport bij het Jaarverslag 2018, mei 2019, Den Haag: Sdu

¹⁶ Algemene Rekenkamer (2014). Instandhouding hoofdwegenet. Bijlage bij kamerstuk 34 000 A, nr. 8. Tweede Kamer, vergaderjaar 2014-2015. Den Haag: Sdu.

¹⁷ National Infrastructure Commission (2018). National Infrastructure Assessment, NIC, UK Government, July 2018. See: https://www.nic.org.uk/wp-content/uploads/CCS001_CCS0618917350-001_NIC-NIA_Accessible.pdf

¹⁸ Institution of Civil Engineers (2016). National Needs Assessment: A vision for UK infrastructure, ICE, UK, October 2016. See: [https://www.ice.org.uk/getattachment/news-and-insight/policy/national-needs-assessment-a-vision-for-uk-infrastr/National-Needs-Assessment-PDF-\(1\).pdf.aspx#_ga=2.11036212.1807526661.1561920195-1561389397.1556711691](https://www.ice.org.uk/getattachment/news-and-insight/policy/national-needs-assessment-a-vision-for-uk-infrastr/National-Needs-Assessment-PDF-(1).pdf.aspx#_ga=2.11036212.1807526661.1561920195-1561389397.1556711691)

¹⁹ Infrastructure Australia (2016). Australian Infrastructure Plan: Priorities and reforms for our nation's future. Report, February 2016. See: https://www.infrastructureaustralia.gov.au/policy-publications/publications/files/Australian_Infrastructure_Plan.pdf

²⁰. Statistics Canada and Infrastructure Canada (2017). Canada's Core Public Infrastructure Survey 2017. See: <https://www.infrastructure.gc.ca/plan/ccpi-ipecc-eng.html>

cannot be captured in the indicator of direct value added. Moreover, and perhaps more relevant, is the value of safe drinking water and sanitation as contributing to our personal health and wellbeing. Too often, the social value of infrastructure services is overlooked in the assessment of infrastructure investments. Transportation infrastructure services, for example, are not only relevant for commuting between our homes and work places or for commercial purposes. They are also enabling us to visit family and friends, to join our clubs, reach schools and enjoy cultural events, in other words, to engage in social interactions and to participate in society. The importance of universal access to reliable and affordable infrastructure services for an inclusive society cannot be overestimated. Besides the social dimension of the value of infrastructure, many other dimensions can be identified, such as cultural-historic and aesthetic value in the case of infrastructure heritage and iconic infrastructure works, which often contribute to a sense of place and belonging for local residents. In its pursuit of the value infrastructure creates for society, NGinfra will explore new methods and approaches for characterizing this value beyond the purely economic dimension.

With the present study two milestones have been reached. First, it presents a validated estimation method for the value added generated by infrastructure, as a system providing essential services, which fits within the System of National Accounts and which may inspire the development of an international standard method. If integrated into a supply and use table framework, as a satellite account of the national accounts, it will provide much more detailed insights. We sincerely hope that the OECD might take this idea forward, possibly building on the ITF initiative of developing a transport satellite account. Second, the international comparison of the value added that infrastructure contributes to the Gross Value Added of the national economies of fifteen EU and OECD member states is the first of its kind. The results should be treated with the utmost caution, as the macro-economic indicator of value added provides no clues to explain the differences observed between countries. However, the results do show that infrastructure makes a substantial contribution to the total Gross Value Added of all fifteen economies. For the Netherlands, throughout the years 1995-2016, infrastructure consistently contributed 13.1% (on average) to the total value added of the national economy. This is a fact that is highly relevant for the public debate on infrastructure, if it is properly contextualized, enriched with narratives and augmented with a social value perspective. These are the tasks which NGinfra has set out to pursue for the sake of a new public debate on the future of infrastructure.

NGinfra would like to acknowledge Luc Soete, Arnoud Boot, Josh Martin, Roger Vickerman and Peter van de Ven for sharing their insights and providing critical comments on draft versions of the Statistic Netherlands' report and this cover article.

Delft, 29 August 2019

Prof.dr.ir. Margot P.C. Weijnen,

Next Generation Infrastructures, Scientific Director