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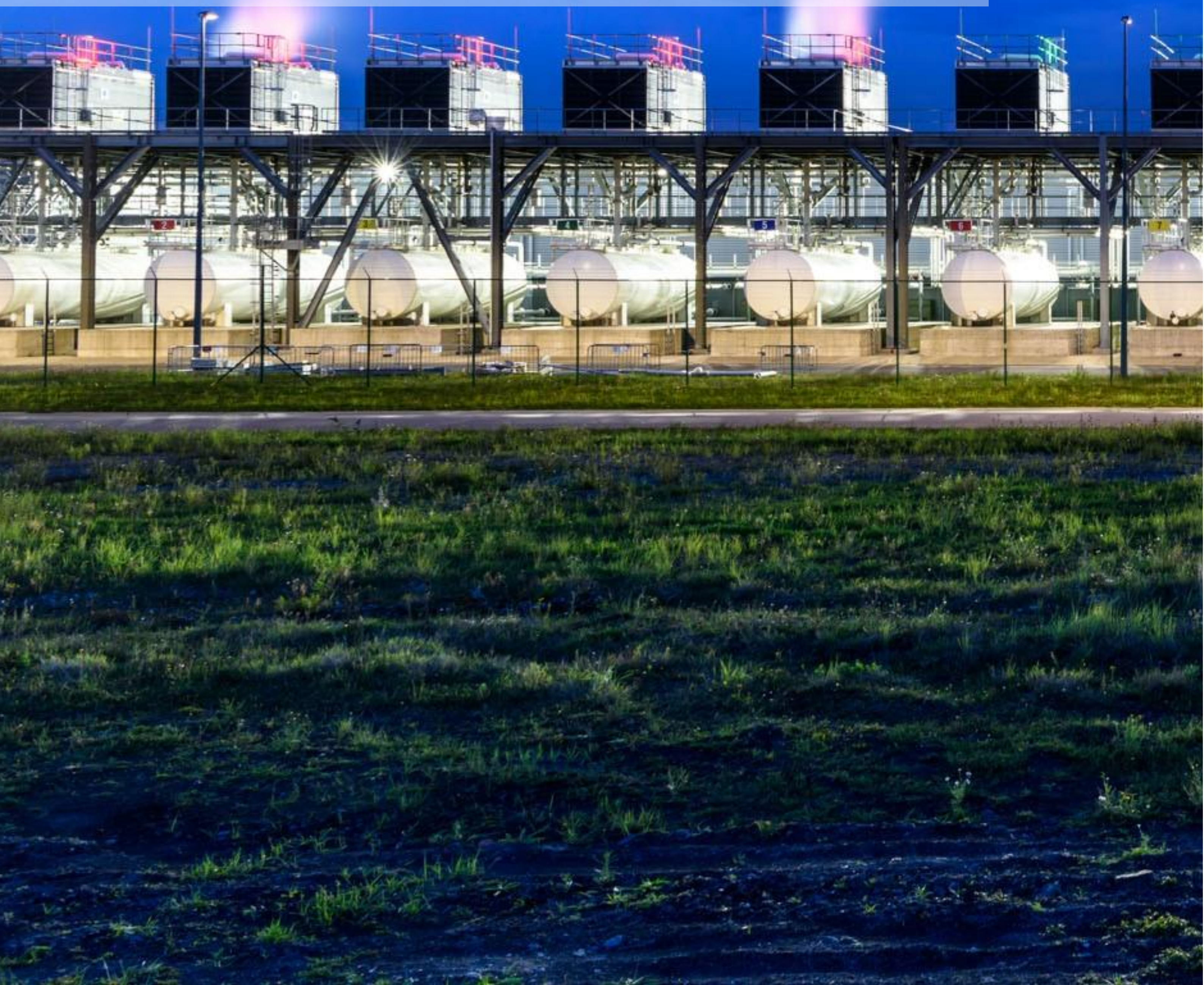
Copenhagen Economics

GOOGLE'S HYPERSCALE DATA CENTRES AND INFRASTRUCTURE ECOSYSTEM IN EUROPE

Economic impact study

Appendix



Methodology: Economic impact analysis

In this appendix, we outline the approach applied in the quantitative analysis of the economic effect of Google's expenditures on data centres and related infrastructures in Europe.

Data sources
The source data for our analysis is information received from Google on expenditures and employment at their data centres in Europe. More precisely, we have used data on Google's data centres in Belgium, Denmark, Finland, Ireland, and the Netherlands.

The Google data has not been sourced from audited financial statements (thus do not seek to represent a position of financial results), yet we understand it to be a precise characterization of the magnitude of the expenditure on data centres in Europe.

Further sources of data are the Eurostat input, via World Input-Output Database (WIOD) containing input-output tables, and input-output tables from national statistics.[1] We use the regional Input-Output tables from WIOD, as this enables us to assess the impact of all the data centres in Europe collectively, and thus account for the linkages between countries.

We have used this data to estimate the supported GDP and employment contribution of Google's data centres in Europe. Additionally, we estimate the supported GDP and employment from Google's site reliability engineering (SRE) and network expenditures.

Description of expenditure and effects
Google's expenditure can be split into construction expenditures and operation expenditures. Each type of expenditure has a distinct mix of inputs and pattern of impact throughout the European economy. Thus, we quantify the impact from each separately. Expenditures are split into purchases of foreign and domestic goods and services. Data centres' operational expenditure factored in the analysis includes, for instance, the annual wages for Google employees and contractors working at the data centres, costs of electricity and repair expenditures, while excluding servers, which is consistent with prior literature in this field.[2] Disregarding any EU manufactured server equipment relevant to the hyperscale data centres has the effect to keep results conservative and limited to only activity occurring with the data centre facility.

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1 The WIOD is publicly available here: *www.wiod.org*.
2 BCG (2014) Digital Infrastructure and Economic Development; Oxford Economics (2018), Google Data Centers: Economic Impact and Community Benefit; RTI International (2018) The Impact of Facebook's U.S. Data Center Fleet; Copenhagen Economics (2018), European data centres.

We include expenditures from Site Reliability Engineering (SRE) and network connectivity expenditures. When considering these expenditures for the forthcoming period up to 2021, we do so on the basis of data tracking committed expenditures (in the case of SRE, despite a growth trend over time, we assume 2019-2021 expenditure to be set at a constant level, equal to 2018). As a result, we take an approach to forecasting that is likely to yield conservative estimates.

In this study, we estimate the effects in the entire EU, such that imports denote only services and products originating in non-EU countries. As imports from non-EU countries are factored out, all of the remaining Google expenditures support employment and GDP in Europe.

The economic impact of Google's expenditures is a result of the supported jobs at the data centre itself, at suppliers to the data centre and at firms throughout the economy, which benefits from the increase in economic activity. We call the effects *direct, indirect,* and *induced* respectively.

The *direct effect* includes the economic impact supported directly by the data centre and its key construction contractors. The directly supported jobs in operations include positions in management, mechanical and electrical maintenance, repair, IT and systems technicians, plumbing and water management and hardware operations.

The *indirect effect* reflects how expenditure at the data centre site on domestic goods and services support a contribution to GDP and employment through increased activity up the value chain of industrial and commercial activities that indirectly benefit from demand from the data centre site. The indirectly supported jobs include jobs in security, catering, cleaning and in the construction and supply industries, as well as at suppliers in upstream industries across the economy.

The induced effect includes the supported economic impact when salaries paid to employees at the data centre and its suppliers are spent throughout the economy. Induced jobs are supported throughout the economy and many jobs are supported in retail trade, transport, accommodation, restaurants, housing and finance.

In practice, displacement in the labour force can reduce the final effect realised. This depends on the skill base and degree of openness in the economy. The effects do not consider potential displacement impacts.

Our approach to estimate the economic impact

The effects in the EU from each data centre, the SRE expenditure and the network connectivity expenditure lead to the overall impact reported in chapter 2 of the report.. We estimate the direct, indirect and induced effects in two steps.

Firstly, the direct effects are calculated as the sum of wage expenditures at the data centres and the number of data centre staff reported to us by Google.

Secondly, we estimate the indirect and induced effects using an input-output model. Input-output models provide a consistent and intuitive way of measuring the economic effects of an activity in any given industry or company. The model uses input-output tables, which reflect how national statistical agencies track the interdependency between all the sectors of the economy. In the WIOD input-output table, it is reported how each of 35 industrial sectors:

i) relies on the other 34 sectors for inputs to their production; and
ii) supplies its products and services to each of the remaining 34 sectors.

We use the input-output tables to estimate economic multipliers, which are multiplied with the appropriate expenditures to give the economic effects.[3]

Due to the supply chain linkages across Europe, where producers of one good in one country is dependent on various inputs produced in other countries, the economic impact supported by data centres in Europe is larger when assessed for all the countries collectively than if it were to be assessed for each country separately. In other words, the multipliers will be larger, when assessed for all the countries together than would be the case for each country, as the share of imports to the total production is lower when a larger region is analysed.

Because of the underlying approach of this class of models, the results calculated by this method should however be regarded as approximations. Some of the assumptions are most likely to hold in the short run, and others are more appropriate for the long run. The results should thus be interpreted in the light of the following caveats.

First, we do not observe data on gross surplus for the direct effects (which under national counting rules is counted as part of GDP). In order to provide a conservative estimate, we do not include gross surplus in the operations when calculating the GDP contribution of the data centre. Including this would produce larger impacts.

Second, we assume that the technology and resource mix (ratios for inputs and production) is the same for all firms within each industry, i.e. within each of those 35 industrial categories reported by the different European national statistics agency's input-output table. As such, our analysis describes average industry effects.

Third, we assume fixed production and input ratios of companies and fixed consumption shares of households. We do not include extra effects from other investments or government spending.

Fourth, we assume that firms can increase their use of labour and capital as needed to meet the additional demand for their products from Google and their suppliers. Further, we assume that extra output can be produced in one area without taking resources away from other activities. This approach to considering no supply-side constraints is equivalent to an assumption of fixed prices and wages; indeed input-output models are referred to as *fixed-*

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3 In the literature, the ratio of (direct + indirect) to direct effects is called a *type 1 multiplier*, and the ratio of (direct + indirect + induced) to direct effects is called *type 2 multiplier*.

price models. We thus refer to our estimated impact as *supported effects*, because they indicate the potential effects in the situation where resources are readily available in the economy.

Last, we assume that the structure of the European economy remains unchanged, looking as in 2011 (the year of the input-output table from WIOD). Insofar as possible, we have relied also on more recent input-output tables at national level.[4] Any structural changes in the European economy since 2011 would therefore lead to changes to the multipliers – which could be implemented once the different official national statistics agencies in Europe release updated input-output tables. However, using 2011 multipliers ensures consistency as we cover the time period from 2007 to 2021.

4 Belgium is based on a 2010 national input-output table, Denmark is based on a 2016 national input-output table, Finland is based on WIOD from 2010, Ireland is based on WIOD from 2011 and the Netherlands is based on WIOD from 2011.

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