DTU Wind and Energy Systems

An estimation of the local economic impacts of the Østerild Test Center project

Society, Market & Policy Section

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DTU Wind & Energy Systems is a department of the Technical University of Denmark with a unique integration of research, education, innovation and public/private sector consulting in the field of wind energy. Our activities develop new opportunities and technology for the global and Danish exploitation of wind energy. Research focuses on key technical-scientific fields, which are central for the development, innovation and use of wind energy and provides the basis for advanced education at the education.

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1 Sammenfatning

Denne undersøgelse belyser de lokale økonomiske virkninger af Østerild Testcenter i lokalområdet omfattende Thisted, Morsø og Jammerbugt kommuner. Der er anvendt en regional input–output-model, der tager højde for regionale handelslækager, kombineret med projektspecifikke efterspørgselsdata og eksplicitte antagelser om lokalt indhold. Der gives også en belysning af virkningerne af forbruget i området forårsaget af turister, som også besøger Østerild Besøgscenter.

I dette afsnit er givet en dansk sammenfatning af hovedresultaterne fra undersøgelsen. De vigtigste resultater fra undersøgelsen er:

- Undersøgelsen viser, at Testcenter Østerild i perioden 2020 til 2024 har medført en forøget efterspørgsel efter varer og tjenester på ca. 1,5 mia. DKK. Af det årlige gennemsnit på 300 mio. DKK genererer de løbende investeringer en øget årlig efterspørgsel på omkring 284 mio. DKK mens drift- og vedligeholdelse udgør de resterende 16 mio. DKK. Investeringerne omfatter primært bygning af fundamenter og installation og udskiftning af vindmøller.

- Af den samlede forøgede efterspørgsel på ca. 1,5 mia., udgør den lokale andel omring 500 mio. DKK, svarende til ca. 34 %, hvilket svarer til en stigning i den lokale efterspørgsel efter varer og tjenester på omkring 100 mio. DKK årligt. Af disse ca. 100 mio. DKK medfører investeringerne en øget lokal efterspørgsel på godt 90 mio. DKK, og drift- og vedligeholdelse en øget lokal efterspørgsel på knap 10 mio. DKK årligt. Det lokale indhold er 32% for investeringerne og 57% for drift- og vedligehold, mens resten indkøbes andre steder i Danmark eller i udlandet

- Den øgede lokale efterspørgsel medfører en øget aktivitet i lokalområdet. Testcenter Østerild medfører således en øget årlig lokal produktion på ca. 140 mio. DKK, en årlig bruttoværditilvækst på ca. 58 mio. DKK og en årlig forøgelse i den lokale beskæftigelse på godt 65 fuldtidsjobs.

- Der er en betydelig variation fra år til år i omfanget af den lokale øgede efterspørgsel. Eksempelvis varierer den øgede lokale årlige beskæftigelse fra omkring 26 til 89 fuldtidsbeskæftigede afhængig af omfanget af fundamentsbyggeri, udskiftninger af hovedkomponenter samt installation af nye vindmøller. Der er en tilsvarende variation fra år til år i forhold til den lokale produktion og brutoværditilvækst.

- Der er omkring 50.000 besøgende turister per år på Testcenter Østerild, hvilket også medfører en forøget lokal efterspørgsel efter varer og tjenesteydelser. Det er svært at kvantificere de turistmæssige effekter af de 50.000 besøgende på Testcenter Østerild i forhold til andre turistaktiviteter i Thy, men i rapporten er der lavet undersøgelser af turismes effekter på bl.a. lokal beskæftigelse.

- Resultaterne af undersøgelsen afspejler at den arbejdskraft, der kræves for at imødekomme den ekstra efterspørgsel, er til stede. Modellen tager ikke højde for mangel på arbejdskraft, manglende lokale kompetencer, pendling, løn- og prisreaktioner, produktionsbegrænsninger eller fortrængning fra andre sektorer.

2 Summary

This study assesses the local economic effects of the Østerild Test Center within Thisted, Morsø and Jammerbugt municipalities. It uses a regional input–output model calibrated to account for regional trade leakages, combined with project-specific demand data and explicit local-content assumptions. A supplementary estimate is also provided for expenditure within the area by visitors who also visit the Østerild Visitor Centre.

- **Modeled project demand totals approximately DKK 1,500 million over 2020–2024.** The annual average is **DKK 300 million**, comprising **DKK 284 million in CAPEX** and **DKK 16 million in O&M**. Under the baseline reconstruction, main-component replacements represent **62% of cumulative demand** and sustain CAPEX activity between foundation construction, turbine installation and turbine replacement periods.
- **Around one-third of project demand is sourced locally.** Approximately **34%**, or around **DKK 505 million** over the period, is retained locally, equivalent to an annual average of **DKK 101 million**. This comprises approximately **DKK 92 million in local CAPEX demand** and **DKK 9 million in local O&M demand** per year. Local content is **32% for CAPEX** and **57% for O&M**, while the remainder is sourced elsewhere in Denmark or abroad.
- **Local project demand supports local economic activity.** Under the baseline, it generates approximately **DKK 139.5 million in output**, **DKK 58.3 million in gross value added (GVA)** and **65.9 full-time equivalent (FTE) jobs** annually.
- **CAPEX accounts for most of the estimated effects.** It generates an annual average of **59.7 FTE jobs** and **DKK 52.7 million in GVA**, compared with **6.2 FTE jobs** and **DKK 5.6 million in GVA** from O&M. Annual CAPEX-related employment varies within **26–89 FTE jobs**, following foundation construction, turbine installations and turbine replacements.
- **Industrial effects reflect existing local capabilities.** CAPEX effects are concentrated in **construction** and **non-metallic mineral products**, particularly concrete-related manufacturing, with additional accommodation and food-service activity associated with project personnel. O&M supports accommodation and food services, machinery repair and installation, construction and other local services.
- **Estimates vary with the assumptions.** Across alternative local-content and main-component replacement assumptions, annual impacts range across **36–116 FTE jobs**, **DKK 31.6–103.1 million in GVA** and **DKK 74.9–250.1 million in output**. The results are more sensitive to local-content assumptions and represent alternative modeling cases rather than statistical confidence intervals.
- **Employment intensity is consistent with wind-sector benchmarks.** Per million EUR of total local output, CAPEX supports **3.4–3.6 FTE**, comparable to QBIS offshore-port estimates, while O&M supports **3.6 FTE**, similar to Esbjerg but at a lower absolute scale.
- **Visitor expenditure is associated with additional local activity.** Assuming **50,000 annual arrivals**, expenditure by visitors who also visit the Østerild Visitor Centre is associated with **65.9 FTE jobs**, **DKK 56.8 million in GVA** and **DKK 103.8 million in output** annually. Across assumptions of **25,000–75,000 arrivals**, employment ranges across **33–99 FTE jobs**. These figures do not establish how much tourism is caused by the Visitor Centre.
- **Employment estimates reflect the labor required to satisfy additional demand.** The model does not account for labor scarcity, skills mismatches, commuting, wage and price responses, production constraints or displacement from other sectors.

3 Introduction

The Østerild Test Center is Denmark's principal facility for full-scale testing of prototype wind turbines. Since opening in 2012, it has supported the development and verification of large turbine models designed for the wind-energy sector, including offshore-oriented prototypes tested under controlled onshore conditions. The facility therefore plays a strategic role in Denmark's wind innovation system and in the industrial development of increasingly large turbine technologies.

The facility is located in a sparsely populated area near the village of Østerild in Thisted Municipality, and its establishment involved visible landscape change, environmental assessment, forest clearance and compensatory reforestation. Local residents may experience visual, environmental or landscape-related costs, while part of the economic value generated by the facility may be captured by firms, workers and institutions outside the immediate host community. This makes the test center a rele-vant case for assessing whether nationally important green infrastructure also generates meaningful economic benefits for the surrounding local economy.

Estimating these local benefits requires a framework that can account for the openness of a small regional economy. National input–output multipliers are not directly appropriate for this purpose, because they implicitly assume that a much larger share of intermediate demand is retained within the economy. At the same time, detailed input–output tables are not available at the municipal level in Denmark. The empirical challenge is therefore to construct a regionalized input–output model that can approximate local supply-chain linkages while explicitly accounting for regional trade leakages.

This study addresses that challenge using the FLQ$^+$ non-survey methodology. Evidence from applications in Finland, Italy, South Korea and Argentina shows that FLQ-based regionalization produces more realistic regional multipliers than simple location quotients, particularly in small and open economies where interregional trade leakages are substantial (Bonfiglio & Chelli, 2008; Brondino et al., 2024; Flegg & Tohmo, 2019; Jahn et al., 2020; Tohmo, 2004). Empirical studies suggest that calibrated values of the parameter δ around 0.2–0.3 are appropriate for regions comparable in size and openness to Danish municipalities, while the augmented AFLQ method offers little improvement over a well-calibrated FLQ (Flegg & Webber, 2000; Flegg et al., 2021). FLQ$^+$ further refines this approach by integrating cross-entropy balancing and regression-based calibration of δ, making it a suitable and cost-effective option when survey-based regional input–output data are unavailable (Lamonica et al., 2020; Lamonica & Chelli, 2018).

This study combines Danish national input–output accounts, regional employment information, project-specific expenditure data and explicit assumptions on local content. The local area is defined as the combined territory of Thisted, Jammerbugt and Morsø municipalities: a semi-rural functional area of around 100,000 inhabitants with linked labour markets, supplier networks and visitor-service activities. This definition is broader than the immediate settlement affected by the facility, but narrower than the full North Jutland Region, allowing the study to preserve local relevance while capturing the main economic linkages through which impacts are likely to occur.

The study estimates the direct, indirect and induced local economic impacts of the Østerild Test Center over 2020–2024 in terms of output, gross value added, labour earnings and full-time equivalent employment. It considers three channels: project-related capital expenditure (CAPEX), operation and maintenance (O&M), and visitor-related tourism associated with the Østerild Visitor Centre. The analysis asks how much economic activity is plausibly retained within the local area and which sectors benefit the most. The resulting estimates inform both the local debate around Østerild and the broader question of how large-scale renewable-energy infrastructure should be evaluated when economic benefits and local costs are unevenly distributed.

4 Project overview

The Østerild Test Center has become a central site for the testing of large wind turbine prototypes by leading European and international manufacturers. In 2021, Vestas announced the installation of the offshore prototype V236-15.0 MW (Vestas Wind Systems A/S, 2021), a model that has since become central to the company's European offshore portfolio. More recently, Siemens Gamesa installed and tested its SG DD-276 prototype at Østerild, a 21.5 MW offshore-oriented turbine with a 276-meter rotor whose final blades were mounted in April 2025 (Ahmed, 2025). Other recent prototypes tested at the site include Vestas's V162-7.2 MW (Vestas Wind Systems A/S, 2023) and earlier Siemens Gamesa units such as the SG 11.0-193 DD (Russell, 2020). These prototype programs illustrate the continued industrial use of Østerild as Denmark's principal facility for full-scale turbine testing.

The center was established following a national planning process initiated in the late 2000s. The decision to create a new test facility was driven by the physical limits of the existing Høvsøre Test Center in Lemvig Municipality, which had been operational since 2002 but could no longer accommodate the scale of future turbine prototypes. Studies conducted by DTU Wind Energy and the industrial partnership Megavind concluded that larger hub heights and rotor diameters would require a new national test site. In 2009, the Danish Parliament approved the establishment of a national test center for large-scale wind turbines through a dedicated law (*Anlægslov*), giving the project a specific legislative and environmental framework.

The selection of Østerild in Thisted Municipality followed a technical screening of potential sites across Denmark. The chosen area met the relevant criteria: an average wind speed of at least 8 m/s at 100 m height, relatively simple terrain, sufficient distance from settlements and with limited conflicts with nature protected areas. The process also involved a full Environmental Impact Assessment and a Strategic Environmental Assessment in accordance with European Union directives. These studies addressed potential local effects on noise, wildlife, groundwater and landscape, and established compensatory measures such as reforestation to offset the clearance of 245 hectares of plantation. Public hearings were held over two months, and formal responses from residents, environmental organisations and other stakeholders were reviewed as part of the legislative process.

The law defined the Technical University of Denmark (DTU) as operator, with responsibility for operation, environmental monitoring and compliance with national noise regulations. The financial model was structured to be cost-neutral for the state, with users of the test center covering expenses related to land acquisition, construction and environmental compensation. The act establishing the test center was approved by Parliament in June 2010, and a subsequent amendment in 2018 extended the permitted turbine height from 250 m to 330 m. The project therefore reflects both industrial demand for larger turbine testing capacity and a regulated planning process shaped by environmental considerations.

4.1 Physical Setup

The Østerild Test Center is located near the village of Østerild, in Thisted Municipality, within the North Jutland Region (*Region Nordjylland*) of Denmark. The site lies a few kilometres inland from the North Sea, in an area of flat and open terrain with uniform surface and minimal obstacles. These conditions provide stable wind characteristics comparable to those found offshore. The center covers approximately 346 hectares and is divided into four functional zones: a protective area, an open wind field, a measurement area, and the main test area where the turbines are aligned.

The test area shown in Figure 1 was established in 2012 when Østerild began operation with seven test stands designed for turbines up to 250 meters in total height. In 2018, two additional stands were added, bringing the total to nine. Of these, five can accommodate turbines reaching up to 330 meters from ground to blade tip. The upgrade also included reinforced foundations, internal roads for heavy transport, and improvements to the site's measurement systems.

Figure 1: Nine wind turbine stands in Østerild Test Center, Thisted Municipality.

Two 250 meter masts are located at each end of the turbine row. They are equipped with radar-controlled aviation lights that operate only when aircraft are detected in the area, and they also function as meteorological towers collecting continuous data on wind speed, direction, turbulence, and temperature. These measurements allow the comparison of observed mechanical loads with theoretical design models during prototype testing.

Test stand	Turbine model	Manufacturer	Year	Tower (m)	Rotor (m)	Total (m)
1	SG 8.0-167 DD	Siemens Gamesa	2022	120	167	203.5
2	V150-6.0 MW	Vestas	–	154	150	227
3	V236-15.0 MW	Vestas	2022	163	236	280
4	V162-6.0 MW	Vestas	–	154	162	237
5	V155-3.45 MW	Vestas	–	140	155	213
6	SG 14-236 DD	Siemens Gamesa	2022	160	236	278
7	SG 14-222 DD	Siemens Gamesa	2021	160	222	270
8	SG 11.0-200 DD	Siemens Gamesa	–	140	200	240
9	GE 6.1-158 MW	GE Renewable	2021	118	158	195

Table 1: Erected wind turbines at the Østerild Test Center as of January 2024.
Note: Stand 1 was previously located at stand 6 and was relocated in 2022.
Source: Wikipedia contributors (2025).

DTU Wind Energy is responsible for the operation and maintenance of the facility in coordination with turbine manufacturers and public authorities. The companies currently operating in the center and their respective turbine types are listed in Table 1. Each manufacturer operates an individual test pad for prototype verification and performance measurement under controlled conditions. The layout ensures sufficient spacing between turbines to avoid interference from wake effects and to maintain accuracy in aerodynamic and acoustic measurements.

Testing at Østerild allows manufacturers to verify load models, measure environmental noise, and collect operational data used for turbine certification. Offshore prototypes are tested onshore because the onshore location allows continuous technical access for maintenance and instrumentation, which would be restricted at sea. Load measurements record the forces acting on key components such as blades, bolts, and welds to verify that they meet design expectations for a lifespan of at least twenty years.

According to Jørgensen et al. (2020), the construction of the test center required the clearance of 245 hectares of plantation, which was compensated by 393 hectares of new forest established else-where in Denmark, as required by the environmental provisions of the establishment law. The report also describes the visitor center managed by Thisted Municipality, which opened in 2017 adjacent to the test area, provides public information about wind technology, and receives approximately 50,000 visitors annually. The surrounding landscape has been partially reforested and maintained under an approved environmental management plan.

Together with the Høvsøre Test Center, which was expanded in 2018 to host seven turbines, Østerild provides Denmark with the capacity to test up to sixteen large-scale wind turbines simultaneously. These two sites form the principal testing infrastructure supporting industrial development and applied research within *Nordjylland Region*.

4.2 Local area definition

There is no universally agreed definition of "local area" in the literature on economic or environmental impact assessment. Broadly, three conceptual approaches are recognized—administrative, functional, and impact-based. The administrative approach defines the local area according to formal jurisdictions such as municipalities or counties, mainly for governance and statistical purposes (HM Treasury, 2022). The functional approach conceives it as a socially and economically integrated territory, typically delineated through indicators such as commuting flows, labor-market linkages, or patterns of service interaction (OECD, 2012; Office for National Statistics, 2015). The impact-based approach defines the local area according to the spatial extent of the project's significant physical, economic, or social effects (European Commission, 2017; International Finance Corporation, 2012).

The test center is located specifically next to Østerild Klitplantage, a coastal forest situated north of the village of Østerild, east of the town of Thisted, the administrative center of Thisted Municipality (see Figure 2). In studies mainly focused on environmental or community impacts, the "local area" is often defined as the immediate surroundings of the project—those communities that directly experience its externalities such as noise, visual change, or habitat disturbance. In other words, such studies rely on an impact-based definition of locality. If that same definition were applied here, the local economic impact of the Østerild Test Center would be very limited. The site is located in a sparsely populated landscape with little industrial or commercial activity nearby, and only a few scattered households are directly affected by its presence. Yet this definition, while appropriate for other types of studies, would be too narrow to capture the broader economic dynamics generated by the test center's operation. To understand its local economic significance, it is necessary to consider a wider functional area that reflects the actual geography of labor markets, suppliers, and service linkages connected to the facility.

On the other hand, including the entire *Nordjylland Region* in the analysis would certainly make it easier to obtain statistically significant results regarding the project's economic impact. However, doing so would also make the analysis meaningless in terms of local relevance. The region includes Aalborg and several eastern municipalities with very different economic structures and no direct exposure to the project's externalities. This illustrates the trade-off that must be managed: defining an area large enough to capture relevant economic effects, yet small enough to preserve its local meaning.

Figure 2: Study area and regional context in Denmark.

Note: The local area is shaded in red, the rest of the region in blue, and the red line indicates the location of the Østerild Test Center.

To address this issue, we define the local area as the combined territory of Thisted, Jammerbugt, and Morsø municipalities. Thisted was initially considered on its own, since it hosts the test center and is the administrative unit responsible for activities such as tourism promotion and tax collection related to the project. However, two problems arise with this approach. The first is methodological: although it is technically possible to apply our method using only Thisted, its relatively small population—around 45,000 inhabitants—would considerably reduce the robustness of the estimates, as discussed in subsection 6.2. The second is conceptual: the three municipalities are geographically close and economically interconnected, making the combined area more consistent with a functional definition of locality. It is likely that many workers and suppliers are based in neighboring areas, since Morsø hosts concrete and gravel manufacturers, and the test center itself lies near the border with Jammerbugt. In this sense, local labor and supplier networks clearly extend beyond administrative boundaries.

In addition, the three municipalities share significant economic and demographic similarities. They all exhibit a semi-rural character, with small urban centers, a mix of agricultural and light industrial land use, and limited connectivity to the rest of Denmark through three main corridors constrained by the Limfjord and the surrounding Brednings (see Figure 3). Moreover, this choice keeps the test center relatively equidistant from the borders of the selected area, taking into account the aforementioned geographical bottlenecks that define a relatively self-contained economic ecosystem.

For these reasons, the analytical definition of the ”local area” adopted in this study extends beyond the immediate settlement to include the municipalities of Thisted, Morsø, and Jammerbugt. This spatial scale captures the territory within which employment, supply-chain, and visitor-related effects are most likely to be retained, while excluding areas of the region that are unlikely to be directly influenced by the project’s externalities. Overall, this combined definition provides a balanced framework for assessing the test center’s local economic impact—broad enough to cover relevant functional linkages, but sufficiently delimited to preserve its local significance and policy relevance.

Figure 3: Local area around the Østerild Test Center.
Note: The red line shows the distribution of the test center, while the blue squares represent the connection points linking the area with the rest of the country.

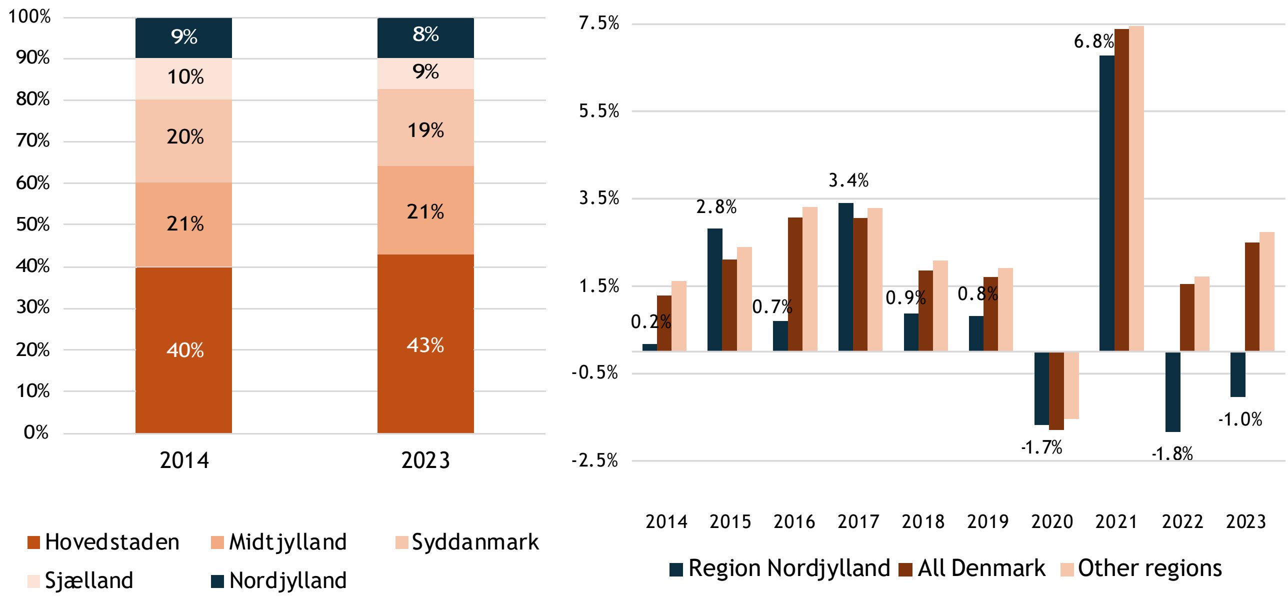
4.3 Socioeconomic and demographic profile

Statistics on output, GDP, gross value added, intermediate consumption and factor incomes are not available at the *kommune* level.[1] For this reason, the socioeconomic context is first assessed using indicators for the *Nordjylland Region*, before moving to municipality-level demographic and labor-market data for Thisted, Morsø and Jammerbugt. Where corresponding municipal indicators are unavailable, regional data provide the closest available evidence on the economic relationships applying to the local area.

The information available for constructing an economic model at the *kommune* level consists of the Danish national input–output tables and a limited set of local indicators: employment across 38 industries, enterprise counts for more detailed industries, unemployment, and demographic data. The available regional and local data are therefore examined below to first assess whether the assumptions applied later in the regionalization have empirical support: (i) labor productivity within each industry is assumed to be similar in the local area and nationally, allowing industry employment shares to be used as proxies for industry output shares; (ii) the relationships between output, gross value added, compensation of employees, gross operating surplus, employment, and enterprise counts are assumed to be similar between the local area and the national economy; and (iii) the production technologies of local industries are assumed to be similar to the national average, meaning that they use approximately the same mix of commodities and services as inputs per unit of output. National technical coefficients can therefore provide a reasonable starting point for the regionalization.

[1]The main accounting identities used in the analysis are: Output = Gross value added + Intermediate consumption; GDP = Gross value added + taxes less subsidies on products; and Gross value added = Compensation of employees + Gross operating surplus and mixed income + other taxes less subsidies on production.

The assessment begins with regional indicators, which provide the broadest available economic benchmark for the local area. As shown in Figure 4a, the *Nordjylland Region* has accounted for close to 9% of national output over the past decade, indicating a stable contribution to the Danish economy. Figure 4b shows that, despite year-to-year variation in GDP growth across regions, this relative posi-tion has remained broadly unchanged. The stability of these relationships over time indicates that the regional comparisons are not driven by conditions in a single year and supports the use of evidence from the full period.

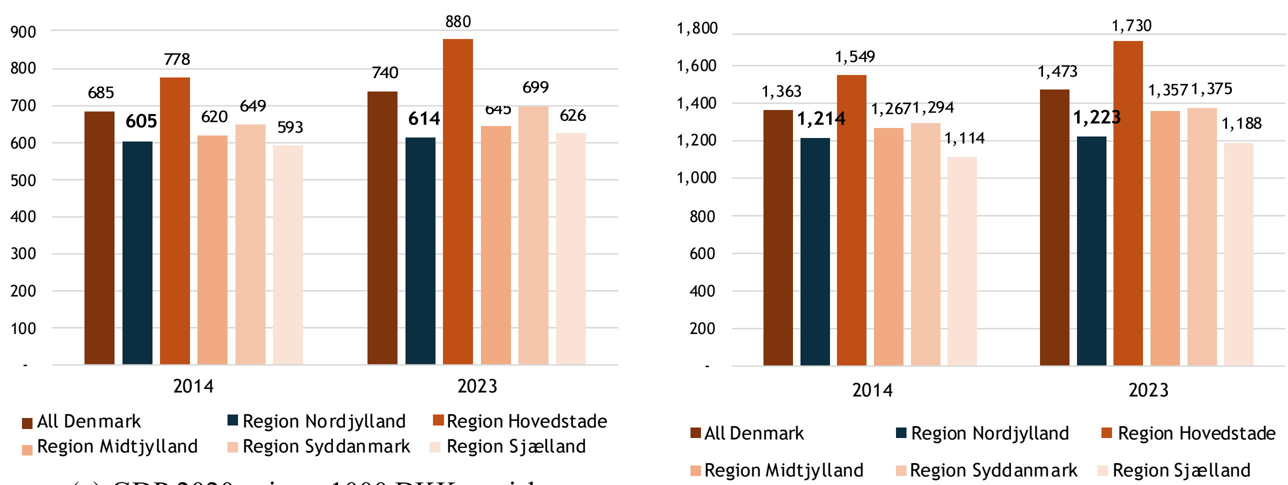


(a) Output share by region (% of national)

(b) GDP at 2020 prices, % change by year

Figure 4: Regional output and economic growth.
Source: Calculations based on Statistics Denmark (2025e).

Assumption (i) is examined through labor productivity, measured as GDP and output per job. As shown in Figure 5, these indicators in *Nordjylland* are approximately 12–17% lower than the national aggregate. However, the national figures are strongly influenced by the *Hovedstaden Region*, which includes Copenhagen and records distinctly higher productivity. Compared with the other Danish regions, *Nordjylland* remains close to the non-capital-region average.



(a) GDP 2020-prices, 1000 DKK per job

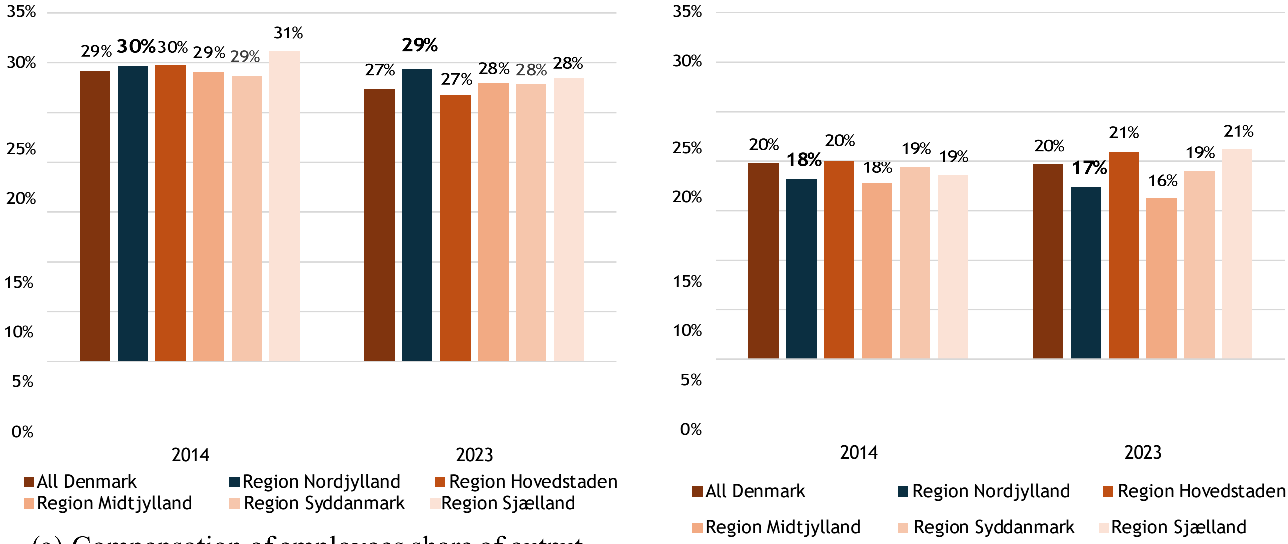
(b) Output 2020-prices, 1000 DKK per job

Figure 5: Regional productivity indicators.
Note: The left panel shows GDP per job and the right panel output per job, both at 2020 prices.
Source: Calculations based on Statistics Denmark (2025d, 2025e).

The differences observed outside the capital region are therefore relatively limited. At the aggregate level, this supports the assumption that labor productivity in the local area is similar to the national industry averages used in the model, allowing municipal industry employment shares to serve as proxies for output shares where municipal output is unavailable.

Assumption (ii) is examined through the distribution of output between labor and capital. As shown in Figure 6, compensation of employees accounts for roughly 30% of output in *Nordjylland*, while gross operating surplus and mixed income account for around 20%. These shares remain relatively stable over time and are similar to those observed nationally and in the other Danish regions.

This similarity supports the use of national accounting ratios where corresponding municipal values are unavailable. In particular, these ratios provide a basis for translating estimated municipal output into gross value added, compensation of employees, and gross operating surplus.



(a) Compensation of employees share of output

(b) Capital profits share of output

Figure 6: Regional labour and capital income shares.
Source: Calculations based on Statistics Denmark (2025e).

The available data do not permit a direct comparison of municipal and national technical coefficients. Nevertheless, the similarities in productivity and factor-income shares do not indicate a fundamentally different aggregate production structure in *Nordjylland*. They are therefore consistent with assumption (iii), under which national technical coefficients provide the initial representation of local production technologies. The regionalization methodology subsequently adjusts these coefficients to account for local supply capacity and inputs sourced from outside the local area.

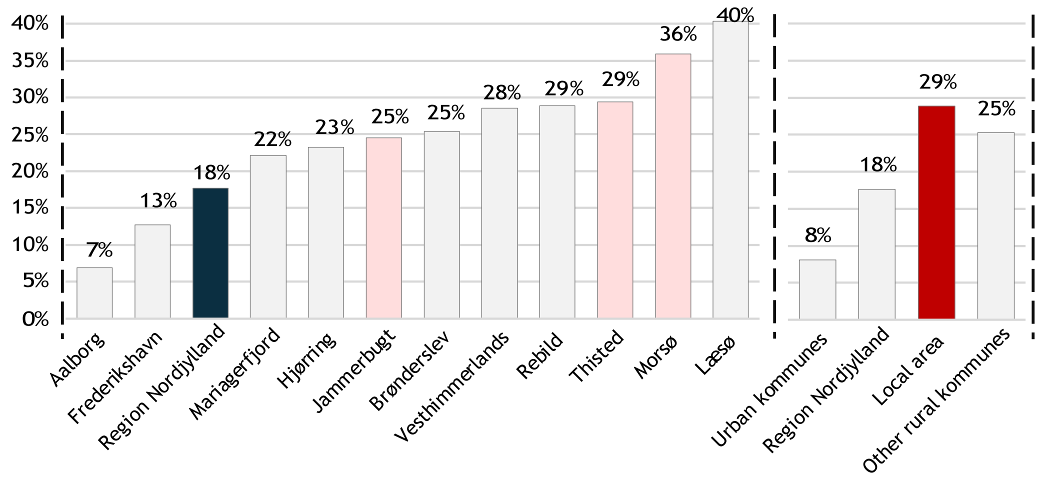
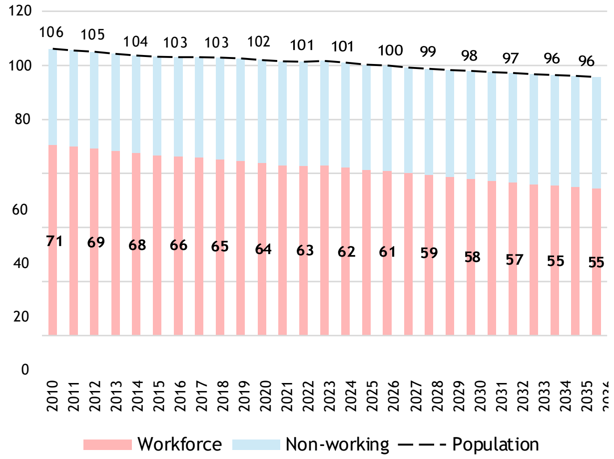


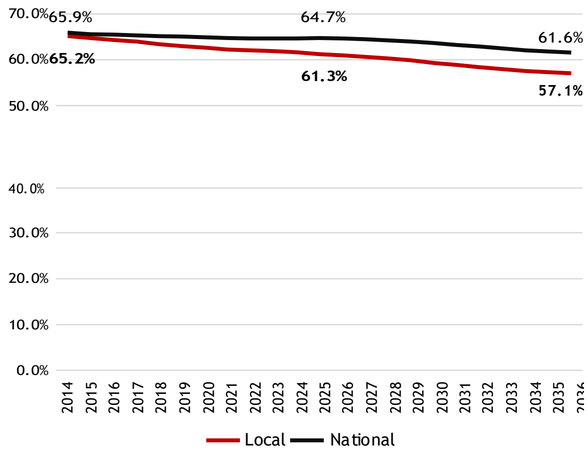
Figure 7: Rural population share by municipality and municipality group in Nordjylland, 2025.
Source: Calculations based on Statistics Denmark (2025b).

Following the regional assessment, the municipality-level indicators reveal three additional characteristics of the local area: a relatively high degree of rurality, a demographic trend that closely follows the national pattern, and labor-market conditions broadly comparable with those of other rural *kommuner* and the rest of Denmark.

Rural population shares vary substantially across *kommuner* in *Nordjylland*. In 2025, rural settlements accounted for approximately 18% of the regional population. As shown in Figure 7, the corresponding share was 8% in the urban *kommuner*, 25% in the other rural *kommuner*, and 29% in the local area. Within the local area, Morsø had the highest rural population share, at 36%, followed by Thisted at 29% and Jammerbugt at 25%. The local area is therefore more rural than *Nordjylland* as a whole and slightly more rural than the remaining rural municipalities in the region.



(a) Working-age population, thousands of persons



(b) Working-age population share (% of total population)

Figure 8: Local working-age population and population share.
Note: The left panel shows the total working-age population, while the right panel reports its share of the total population.
Source: Calculations based on Statistics Denmark (2025b).

This higher degree of rurality does not, by itself, imply that national productivity relationships are inappropriate for the local area. Rural municipalities tend to have a different sectoral composition, including a greater presence of agriculture, forestry, and hospitality-related activities. These structural differences will be captured through the observed distribution of local employment across industries. Once this sectoral composition is represented, rurality alone provides no basis for assuming systematically different productivity within the same industries.

The local area has a total population of around 100,000 inhabitants and a working-age population of approximately 62,000. As shown in Figure 8, the working-age population has changed both in absolute terms and as a share of the total population. This share is projected to decrease from 61% to 57% over the next decade. Historical changes have been concentrated among younger and prime-age groups, reflecting population aging and migration. However, the overall trajectory closely resembles the national demographic trend and does not indicate an exceptional aging pattern in the local area.

Unemployment provides a complementary indicator of local labor-market conditions. In the Danish context, municipal-level research has shown that higher local economic activity helps prevent long-term unemployment, making unemployment a useful proxy for local economic conditions (Hummelgaard et al., 2022). The local area is compared with the urban *kommuner* of Aalborg and Frederikshavn, the other rural *kommuner* in *Nordjylland*, and the rest of Denmark.

As shown in Figure 9, unemployment in the local area has followed the same broad cycle as in the comparison groups. Its level has been particularly close to that observed in the other rural *kommuner* and in the rest of Denmark, while generally remaining below that of the urban *kommuner*. The slight increase recorded in 2023 was also consistent with the wider labor-market trend. The unemployment series therefore does not point to markedly different local labor-market conditions.

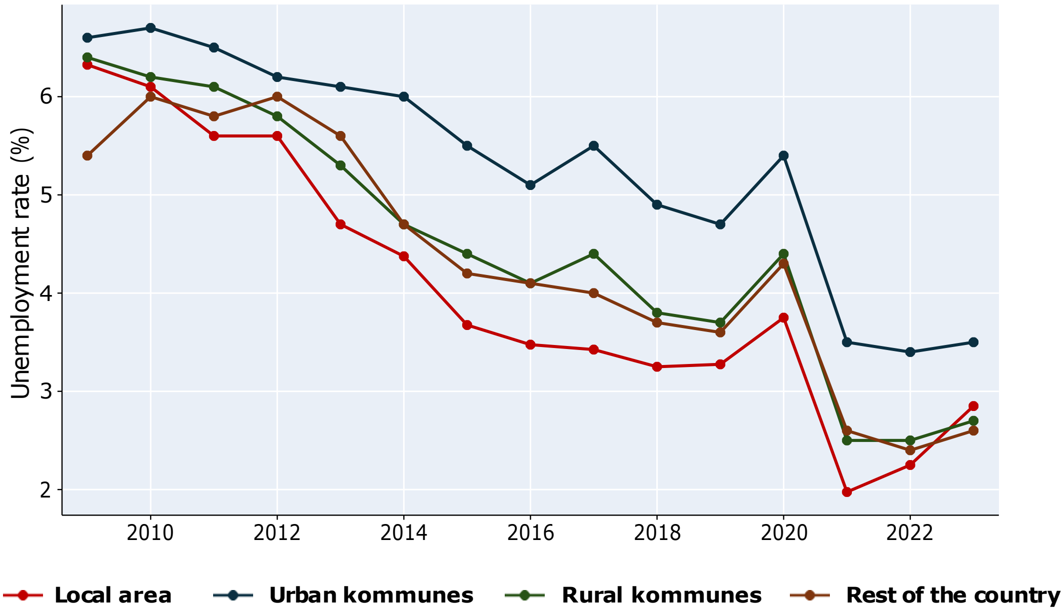


Figure 9: Unemployment rate, 2009–2023.
Source: Calculations based on Statistics Denmark (2025a, 2025f).

Taken together, the regional and municipality-level indicators do not reveal structural differences that would invalidate the use of regional and national economic relationships. The higher rural population share primarily reflects differences in sectoral composition, which are captured through local employment shares, while demographic and unemployment trends remain broadly aligned with national and rural benchmarks. Municipal employment can therefore be used to approximate the local distribu-tion of output, and national accounting ratios provide a reasonable basis for estimating gross value added and factor incomes. National technical coefficients likewise provide a suitable starting point for representing local production technologies, subject to the regional trade adjustments described in the methodology.

5 Methodology

5.1 Input-Output analysis framework

Input–Output (IO) analysis is a framework developed by Wassily Leontief to examine interrelationships between the productive sectors of an economy. Often referred to as the *Leontief model* or *interindustry analysis*, it remains one of the most widely used tools for assessing the economic impact of investment projects.

5.1.1 Theoretical assumptions

Despite the power of the IO framework and its widespread use in economic analysis, IO models rely on a number of assumptions that should always be considered when interpreting results and designing scenarios. In general, these models perform a *static* analysis of economic conditions and assume that, in aggregate terms, certain relationships remain fixed in the face of an external shock.

The main assumptions are:

1. *Constant returns to scale.* The relationship between input use and output production is proportional. If an industry doubles its output, it is assumed that it must also double the amount of each input used. Neither economies of scale (producing more with relatively fewer inputs) nor diseconomies of scale are considered.
2. *Fixed technical coefficients (static technology).* Each sector uses a fixed combination of inputs to produce its output. This means there is no substitution among inputs: for example, agriculture always requires the same proportion of labor, fertilizers, and machinery, regardless of price changes or scarcity.
3. *Homogeneity of output.* All output from a given sector is assumed to be identical. For instance, "the textile sector" is treated as if all fabrics were of the same quality and type, without varieties.
4. *No supply constraints.* Factors of production (labor, capital, natural resources) are assumed to be available in any required amount. If a demand shock equivalent to 50% of a region's GDP is simulated, the model does not consider that the region might lack workers, land, or resources to meet this demand.
5. *Treatment of imports.* The basic model is closed. In open-economy extensions, imports are included but treated with fixed coefficients, meaning that they are assumed to be always available in the same proportion, even under large demand shocks, without changes in international availability or prices.
6. *Absence of a price mechanism.* Any increase in demand is translated directly into a proportional increase in required inputs. The model does not consider that, in practice, demand pressure may lead to price increases, supply responses, or substitution effects. In other words, I–O models operate in physical (or constant-price monetary) terms and do not account for demand elasticities or relative price adjustments.

These simplifying assumptions allow IO analysis to clearly track inter-sectoral linkages and multiplier effects. However, they also imply that results should not be interpreted as precise predictions of how an economy will adjust under large or long-term shocks, but rather as indicative measures of structural interdependencies. For further details, see (Miller & Blair, 2009, Chapter 2).

5.1.2 IO matrices (X, Z, Y & V)

In its most basic form, an IO model is represented as a system of linear equations, where each equation describes how the production of a sector is distributed among the different sectors of the economy. Extensions to the classical model often introduce greater detail by incorporating temporal or spatial dimensions, adjusting to data availability, or linking with other economic analysis tools.

Building a Leontief model starts from observed economic data for a specific geographic region (for example, a country, region, or municipality). The approach focuses on a set of sectors that produce goods or services (*outputs*) and, at the same time, consume inputs from other sectors (*inputs*) to generate their own production. The level of sectoral disaggregation can range from a few broad sectors—for example, "manufacturing"—to detailed classifications with hundreds or thousands of specific categories.

The essential information for input–output analysis is organized into the *inter-industry sales matrix* Z. In this table, each row i represents the destination of sector i's production (to itself or to other sectors), while each column j details the composition of the inputs required by sector j to produce its output. The cells z_{ij} forming this matrix constitute the central part of the input–output accounting framework.

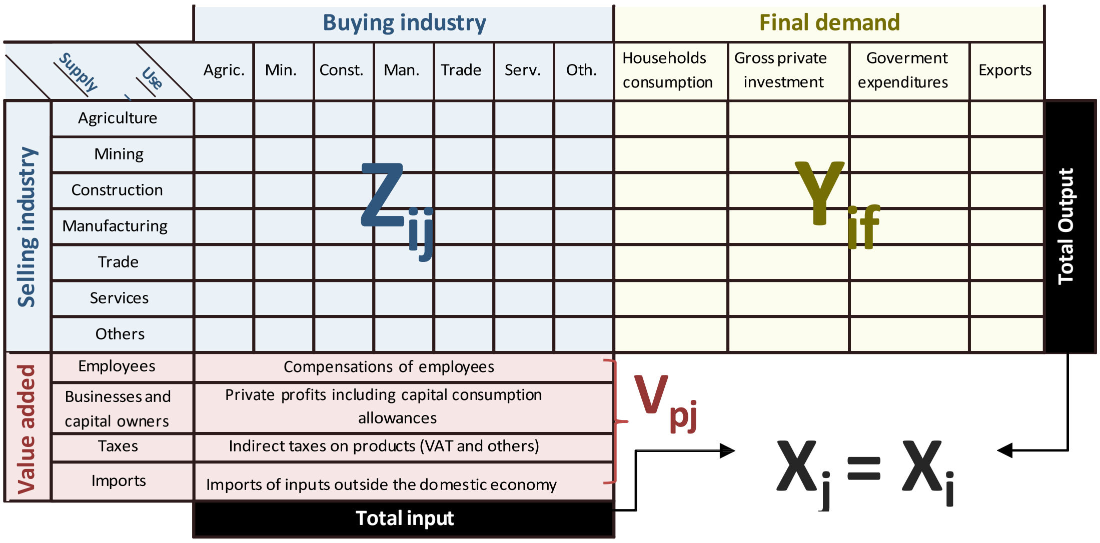


Figure 10: Basic structure of an Input–Output accounting framework.

In addition, the *final demand matrix* Y contains columns that record sales to non-productive destinations f, such as households, governments, investment, or exports from productive industries i. For example, electricity may be sold both to manufacturing companies (as an intermediate input) and to households (as final consumption).

On the other hand, the *value-added matrix* V contains rows p of primary inputs, which represent non-industrial elements used in the production of purchasing sectors j, such as labor, capital depreciation, indirect taxes, or imports.

The total output of sector i, denoted X_i, can be expressed as the sum of all intermediate deliveries to other sectors j and the sales to final demand categories f:

$$X_i = \sum_j Z_{ij} + \sum_f Y_{if}, \tag{1}$$

In turn, the total input for sector j, denoted X_j, is given by the sum of all intermediate purchases from sectors i and the acquisition of primary inputs p, which include elements not produced by domestic industries such as imports, labor, capital, or indirect taxes:

$$X_j = \sum_i Z_{ij} + \sum_p V_{pj}. \tag{2}$$

The main feature of this accounting process is to establish a balance that holds by definition. Since the output of each industry corresponds exactly to the payments made to all its suppliers (both intermediate and primary), the total output must equal the total input for every sector. Therefore, since the accounting balance implies $X_j = X_i$ whenever $j = i$, for each industry k:

$$X_k = \sum_j Z_{kj} + \sum_f Y_{kf} = \sum_i Z_{ik} + \sum_p V_{pk}, \qquad \forall\, k. \tag{3}$$

This equilibrium condition guarantees that the input–output accounting framework is internally consistent: the value of what a sector produces (distributed as intermediate sales and final demand) is always equal to the value of what it consumes (intermediate purchases and primary inputs).

The following matrix notation will be used in what follows:

$$X = \begin{bmatrix} X_1 \\ \vdots \\ X_n \end{bmatrix}, \quad Z = \begin{bmatrix} Z_{11} & \cdots & Z_{1n} \\ \vdots & \ddots & \vdots \\ Z_{n1} & \cdots & Z_{nn} \end{bmatrix}, \quad Y = \begin{bmatrix} Y_{11} & \cdots & Y_{1F} \\ \vdots & \ddots & \vdots \\ Y_{n1} & \cdots & Y_{nF} \end{bmatrix}, \quad V = \begin{bmatrix} V_{11} & \cdots & V_{1n} \\ \vdots & \ddots & \vdots \\ V_{P1} & \cdots & V_{Pn} \end{bmatrix} \tag{4}$$

Here, X denotes the vector of total sectoral outputs, Z the interindustry transaction matrix, Y the final demand matrix with F demand categories f (e.g., household consumption, government, investment, exports), and V the value-added matrix with P primary input categories p (e.g., labor, capital depreciation, taxes, imports).

The output and input balances can therefore be expressed in matrix form using the summation vector i, which is a column vector of ones of appropriate dimension. Post-multiplication of a matrix by i yields a column vector whose elements are the row sums of the matrix, while pre-multiplication of a matrix by row vector i' yields another row vector whose elements are the column sums of the matrix. Therefore, for the output and input balances we have:

$$X = Z \cdot i + Y \cdot i \tag{5}$$

$$X' = i' \cdot Z + i' \cdot V \tag{6}$$

5.1.3 Technical coefficients matrix (A)

We previously introduced the static technology assumption, which states that each industry requires a fixed combination of inputs to produce one unit of output. Under this assumption, there exists a constant matrix that links the output vector X with the inter-industry transactions matrix Z. In other words, each element of this matrix A represents the fixed proportion between the flow Z_{ij} and the total output of the purchasing industry X_j. Formally, $A = [a_{ij}]$ is called the *technical coefficient matrix* and is defined as:

$$a_{ij} = \frac{Z_{ij}}{X_j} \tag{7}$$

It is convenient to define the diagonal matrix of outputs $\hat{X}$:

$$\operatorname{diag}(X) = \hat{X} = X \cdot i' = \begin{bmatrix} X_1 \\ \vdots \\ X_n \end{bmatrix} \cdot \begin{bmatrix} 1 & 1 & \ldots & 1 \end{bmatrix} = \begin{bmatrix} X_1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & X_n \end{bmatrix}. \tag{8}$$

Therefore, the inter-industry sales matrix Z can be written as:

$$Z = A\hat{X} \quad \rightarrow\rightarrow \quad A = Z\hat{X}^{-1}. \tag{9}$$

Combining (9) with (5), and recalling that $i' \cdot i = 1$, we obtain:

$$X = A\hat{X} \cdot \mathrm{i} + Y \cdot \mathrm{i} = AX(\mathrm{i}' \cdot \mathrm{i}) + Y \cdot \mathrm{i} = AX + Y \cdot \mathrm{i}. \tag{10}$$

Therefore, X can be isolated on the left-hand side, which makes explicit the relationship between final demand and total output (10). Furthermore, the same equation can be expressed in differential form to evaluate the impact of a demand shock ΔY on total output.

$$(I - A)\, X = Y \cdot \mathrm{i} \quad \rightarrow\rightarrow \quad X = (I - A)^{-1}\, Y \cdot \mathrm{i} \quad \rightarrow\rightarrow \quad \Delta X = (I - A)^{-1}\, \Delta Y \tag{11}$$

5.1.4 Leontief matrix and multipliers

The Leontief matrix L plays a central role in input–output analysis, as it summarizes the total (direct and indirect) production requirements of the economy. From (11), L it is defined as:

$$L = (I - A)^{-1}. \tag{12}$$

Formally, $L = [l_{ij}]$. Each element l_{ij} represents the total amount of output from sector i required to satisfy one unit of final demand in sector j. This value includes not only the direct input from i to j, but also all the indirect contributions that arise through intermediate production chains. For example, if sector j demands machinery, and the machinery sector requires steel, electricity, and other inputs, all of these indirect needs are reflected in l_{ij}. In this way, L extends the interpretation of the technical coefficients matrix A, which only captures direct requirements.

An important application of the Leontief matrix is the computation of multipliers m, which measure how changes in final demand propagate through the economy. These multipliers quantify the total increase in output across all sectors resulting from an additional unit of final demand in a given sector. The output multiplier of sector j is defined as the sum of the j-th column of L:

$$m_j = \sum_{i=1}^{n} l_{ij}, \qquad j = 1, \ldots, n \tag{13}$$

The *Type I multiplier* (L_1) is already defined in (12), under the assumption that only inter-industry linkages are relevant. However, this approach excludes the feedback effects associated with household consumption. A broader analysis introduces the *Type II multiplier* (L_2), which extends the model by endogenizing households. This requires adding an extra row and column to A in order to represent labor income and household consumption.

Let $\bar{A}$ denote the augmented matrix of technical coefficients:

$$\bar{A} = \begin{bmatrix} A & h \\ \bar{w}' & 0 \end{bmatrix} \tag{14}$$

The column vector of household consumption coefficients h represents the share of final expenditure distributed across i industries. The row vector of labor income coefficients $\bar{w}'$ represents the share of input labor provided to each purchasing industry j.

The elements of h and $\bar{w}'$ are defined as:

$$h_i = \frac{Y_{ic}}{\sum_{i=1}^{n} Y_{ic} + \sum_{i=1}^{p} Y_{pc}}, \qquad \bar{w}_j = \frac{V_{wj}}{X_j} \tag{15}$$

The household consumption of sector i is denoted as Y_{ic}, while V_{wj} denotes the labor income generated in sector j. The Type II Leontief matrix is then defined as:

$$L_2 = (I - \bar{A})^{-1}. \tag{16}$$

In this way, L_2 incorporates the feedback loop between production and household demand, typically with larger multiplier values than L_1.

5.1.5 Impact effects: direct, indirect & induced

Lets define a demand shock ΔY as a column vector which can represent any additional expenditure over the domestic economy across different j industries.

$$\Delta Y = \begin{bmatrix} \Delta Y_1 \\ \vdots \\ \Delta Y_n \end{bmatrix} \tag{17}$$

The total impact on domestic output can be obtained from the Leontief system as:

$$\Delta X = L_2 \, \Delta Y. \tag{18}$$

The decomposition of this effect is straightforward. The *direct effect* corresponds to the initial increase in production in the industries directly affected by the shock, ΔY. The *indirect effect* reflects the inter-industry linkages, as additional intermediate inputs are required along the supply chains; mathematically, it is given by $(L_1 - I)\,\Delta Y$. Finally, when households are endogenized in the Type II model, an additional *induced effect* arises from the increase in labor income that generates further consumption demand. This effect is measured as the difference between the Type II and Type I outcomes, $(L_2 - L_1)\,\Delta Y$.

In sum, the total impact of a demand shock can be expressed as the sum of its three components:

$$\Delta X = \Delta Y + (L_1 - I)\,\Delta Y + (L_2 - L_1)\,\Delta Y = L_2\,\Delta Y \tag{19}$$

5.1.6 Impact indicators: output, value added, labour income & jobs

The impact ΔX measures the increase in gross output generated by a change in final demand. While this indicator captures the total production response, economic impact analyses usually report additional indicators that translate output changes into value added, labour income, and employment effects. The four indicators used in this study are summarized in Table 2.

Effect	Total	Multiplier
Output	$\Delta X = 1^\top L \Delta y$	$m_j^x = 1^\top L e_j$
GVA	$\Delta V_b = (\% v_b)^\top L \Delta y$	$m_j^b = (\% v_b)^\top L e_j$
Labour income	$\Delta V_w = (\% v_w)^\top L \Delta y$	$m_j^w = (\% v_w)^\top L e_j$
Employment	$\Delta E = \left(\frac{E}{X}\right)^\top L \Delta y$	$m_j^e = \left(\frac{E}{X}\right)^\top L e_j$

Table 2: Impact indicators and multipliers

Note: e_j is a selection vector with a one in the entry corresponding to sector j and zeros otherwise; 1 is a vector of ones.

To do so, we define *primary input coefficients* as the share of each value-added component in sectoral output:

$$\% v_{pj} = \frac{V_{pj}}{X_j}, \tag{20}$$

where $p \in \{w, g, t\}$ indexes compensation of employees (w), gross operating surplus (g), and net taxes on production (t). Thus, $\% v_{pj}$ measures euros of primary input p generated per euro of output in sector j.

The *gross value added effect* (ΔV_b) is obtained by applying the gross value-added coefficient to the output change:

$$\% v_{bj} = \frac{V_{bj}}{X_j}, \qquad \Delta V_b = \% v_b \cdot \Delta X, \tag{21}$$

where $V_{bj} = V_{wj} + V_{gj} + V_{tj}$ denotes gross value added in sector j. Hence, ΔV_b captures the value added generated through labour income, operating surplus, and net taxes on production.

The *labour income effect* (ΔV_w) is computed by applying the compensation-of-employees coefficient to the output change:

$$\% v_{wj} = \frac{V_{wj}}{X_j}, \qquad \Delta V_w = \% v_w \cdot \Delta X. \tag{22}$$

To express impacts in terms of jobs, sector-specific average wages are defined as compensation per full-time equivalent (FTE) employee:

$$w_j = \frac{V_{wj}}{E_j}, \tag{23}$$

where E_j denotes FTE employment in sector j. Combining this definition with % $v_{wj} = V_{wj} / X_j$ gives the employment intensity:

$$\frac{\% \, v_{wj}}{w_j} = \frac{V_{wj}/X_j}{V_{wj}/E_j} = \frac{E_j}{X_j}. \tag{24}$$

The *employment effect* (ΔE), measured in FTE jobs, is therefore obtained by applying the sectoral employment intensity to the output change:

$$\Delta E = \frac{E}{X} \cdot \Delta X. \tag{25}$$

In this way, the input–output framework translates output responses into distributive and employ-ment effects: value added is measured through gross value-added coefficients, labour income through compensation-of-employees coefficients, and jobs through sectoral FTE employment intensities.

5.2 Regional estimation

5.2.1 Survey & non-survey methods

In the context of regional IO analysis, two main approaches can be distinguished: survey and non-survey methods. Survey methods rely on the direct collection of information from firms and households to construct detailed regional tables, which ensures high accuracy but is also extremely resource-intensive and costly. By contrast, non-survey methods use secondary data, proportionality assumptions, and econometric adjustments to regionalize national input–output tables, offering a more feasible alternative when detailed surveys are not available.

In the case of Denmark, and particularly at the kommune level, there is a scarcity of official data that could reliably capture interregional trade flows. Conducting large-scale surveys is not a viable option for the present work due to the costs involved. For this reason, it becomes relevant to apply non-survey techniques and toolboxes—already tested in other countries—to develop regionalized input–output frameworks and enable impact analysis at the subnational scale.

5.2.2 Location quotients: SLQ, CILQ & FLQ

The process of estimating a regional IO model ultimately leads to a formulation such as:

$$X^r = (I - A^r)^{-1} Y^r = L^r Y^r \;\; {}_2 \tag{26}$$

Here, Y^r denotes the final demand in region r, which acts as the exogenous shock. The variable X represents the total regional output, i.e., the endogenous response we aim to capture. Thus, the central challenge for the regional analyst is to estimate A^r, the *regional technical coefficient matrix*.

Recall that the fixed-coefficient assumption implies that, at the national level, each industry requires a given mix of inputs in fixed proportions. This technological relationship is taken as given. A naive starting point would then be to apply the national coefficients directly at the regional level:

$$A^r = A^n = [a_{ij}] \tag{27}$$

However, such a direct transfer tends to overestimate the true regional coefficients. The reason is not a change in technology -which is assumed the same for all the country-, but rather the fact that regions typically exhibit a much stronger propensity to trade. Inter-regional trade faces no tariffs or major barriers, and regions are often highly interconnected. Therefore, many of the inputs required by industries in region r are actually purchased from outside the region rather than produced locally.

Consequently, the task is to adjust the national matrix $A^n = [a^n_{ij}]$ in order to obtain a consistent regional version $A^r = [a^r_{ij}]$. A general way of expressing this adjustment is:

$$a^r_{ij} = t_{ij} \cdot a_{ij} \tag{28}$$

Where t_{ij} is the *regional trade coefficient*, a parameter that measures the proportion of input i required by industry j that can be supplied by firms within the region. By definition, $0 \leq t_{ij} \leq 1$. Thus, a^r_{ij} preserves the static technology assumption from the national level, while discounting the share of inputs that are effectively imported—i.e., obtained from other regions.

Location quotients (LQs) are essentially estimates of $\hat{t}^r_{ij}$, used to approximate the degree of regional self–sufficiency in supplying industry i. The central idea is to employ them as indicators of the extent to which a region is specialized in a given industry relative to the national economy. The most ba-sic and intuitive formulation compares the regional employment share of industry i with its national counterpart:

$$SLQ_i = \frac{\%E^r_i}{\%E^n_i} = \frac{E^r_i / \sum_{k=1}^{n} E^r_k}{E^n_i / \sum_{k=1}^{n} E^n_k} = \frac{E^r_i}{E^n_i} \cdot \frac{\sum_{k=1}^{n} E^n_k}{\sum_{k=1}^{n} E^r_k} \tag{29}$$

This formulation, known as the *Simple Location Quotient* (SLQ), measures whether industry i is rela-tively more or less concentrated in the region compared to the nation. In practice, $SLQ_i > 1$ indicates that the region is more specialized in industry i, whereas $SLQ_i < 1$ suggests the opposite. Following the standard adjustment rule, if $SLQ_i \geq 1$, the industry is assumed to be able to satisfy regional de-mand (so $\hat{t}^r_{ij} = 1$); if $SLQ_i < 1$, the national coefficient is scaled down by SLQ_i (so $\hat{t}^r_{ij} = SLQ_i$). The general concept of the LQ can be traced back to the 1940s, when it began to be applied systematically to disaggregate national input–output tables into state or substate levels. (Isard, 1960)

However, the SLQ adjusts uniformly by supplying industry, which limits its realism. In the 1970s, the *Cross–Industry Location Quotient* (CILQ) was introduced as the first major refinement. (Morrison & Smith, 1974; Round, 1978)

The CILQ is calculated for each cell (i, j):

$$CILQ_{ij} = \frac{SLQ_i}{SLQ_j} = \frac{E^r_i / E^n_i}{E^r_j / E^n_j} \tag{30}$$

This ratio compares the regional share of supplying industry i with that of purchasing industry j. If $CILQ_{ij} \geq 1$, the national coefficient is retained; if $CILQ_{ij} < 1$, it is adjusted downward by $CILQ_{ij}$. The CILQ allowed analysts to capture phenomena such as *cross–hauling* — the simultaneous import-ing and exporting of the same good by a region — and represented the first significant refinement of the method (Harrigan et al., 1980).

However, for the special case where $i = j$, the CILQ reduces mechanically to one, regardless of the size of the regional industry. This limitation was explicitly noted by Morrison and Smith (1974, p. 66). To address it, we adopt an *extended* definition that distinguishes $i = j$ from $i \neq j$, and we will refer to it simply as $CILQ_{ij}$ in what follows:

$$CILQ_{ij} = \begin{cases} SLQ_i & \text{if } i = j \\ \dfrac{SLQ_i}{SLQ_j} & \text{if } i \neq j \end{cases} \tag{31}$$

Studies during the 1980s and 1990s showed that both SLQ and CILQ tended to overestimate regional multipliers, especially in small regions. An important conceptual advance came from Round (1978), who argued that the relevant trade coefficient t_{ij} should be expressed as a function of three variables:

- the relative size of the supplying sector i,

- the relative size of the purchasing sector j,
- the relative size of the region.

He noted that SLQs incorporate the first and third factors, while CILQs incorporate the first and second but omit the third. Round proposed a logarithmic formula combining all three factors, offering a more general specification of trade coefficients (Round, 1978). However, his approach implied the counterintuitive assumption that smaller regions would generate higher regional technical coefficients.

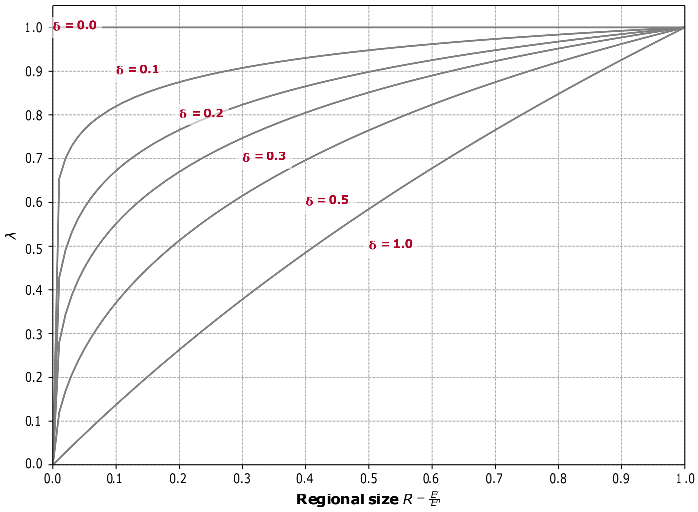


Figure 11: Relationship between λ and regional size R across different δ values.

This limitation motivated later refinements, most notably the *Flegg's Location Quotient* (FLQ). This method introduced an adjustment factor that depends explicitly on regional size:

$$FLQ_{ij} = CILQ_{ij} \cdot \lambda, \qquad \lambda = [\log_2(1 + E^r/E^n)]^\delta \tag{32}$$

The FLQ retains the structure of the CILQ but penalizes small regions by forcing them to import more, thereby avoiding the overestimation of multipliers. As with previous approaches, if $FLQ_{ij} \geq 1$, the national coefficient is retained, whereas if $FLQ_{ij} < 1$, it is adjusted downward by FLQ_{ij}. Using data for Scotland and other regions, it was demonstrated that the FLQ yielded far more realistic estimates (Flegg et al., 1995). Later, the formula was refined and the calibration of the parameter δ was discussed (Flegg & Webber, 2000).

The inclusion of the parameter δ in the FLQ formula refines the function $\log_2(1 + E^r/E^n)$ by altering its degree of convexity. Its value is bounded between $0 \leq \delta \leq 1$. A higher value of δ decreases the adjustment factor λ, thereby reducing the estimated trade coefficient t_{ij} by forcing the region to import more (see Figure 11). Conversely, when $\delta = 0$, $FLQ_{ij} = CILQ_{ij}$, meaning that regional size plays no role in the adjustment. From an econometric perspective, δ serves to calibrate the extent to which regional size influences the propensity to trade, which is at the same time determined by "all other" factors beyond size, such as geographical location, infrastructure quality, market openness, or historical trade patterns.

The FLQ has been criticized for its inability to account for cases of very high regional specialization, where it is plausible that a^r_{ij} could even exceed the corresponding national coefficient a^n_{ij} (McCann & Dewhurst, 1998). To address this limitation, the *Augmented FLQ* (AFLQ) was proposed (Flegg & Webber, 2000). This variant modifies the FLQ by incorporating an additional factor that depends on the purchasing industry's simple location quotient SLQ_j:

$$AFLQ_{ij} = FLQ_{ij} \cdot \begin{cases} \log_2(1 + SLQ_j), & SLQ_j > 1 \\ 1, & SLQ_j \leq 1 \end{cases} \tag{33}$$

The AFLQ thus reduces estimated imports for industries where both supplier i and purchaser j are strongly represented in the region, making it possible for a^r_{ij} to exceed a^n_{ij} under conditions of pronounced specialization. Nevertheless, as will be argued below, this adjustment is not the most suitable for small *kommunes*, which constitute the focus of our analysis.

5.3 FLQ+ approach: calibrating δ

The central difficulty in applying both FLQ and AFLQ methodologies lies in the choice of the parameter δ. Although previous research has shown that FLQ outperforms the SLQ and CILQ methods, it still requires prior knowledge of δ. For instance, in the case of the small open economy of Keski-Pohjanmaa, a region of about 68 thousand inhabitants, SLQ and CILQ were found to overestimate multipliers by 15% and 13%, respectively, whereas the FLQ adjustment formula successfully corrected this bias (Tohmo, 2004). In addition, Bonfiglio and Chelli's Monte Carlo simulations confirmed that both FLQ and AFLQ performed better than alternative methods, but remained highly sensitive to the choice of δ (Bonfiglio & Chelli, 2008).

The debate on how to select an appropriate value of δ has been ongoing since the early 2000s. Early empirical contributions often proposed ad-hoc solutions, recommending fixed values such as δ = 0.3 when no region-specific information was available (Bonfiglio & Chelli, 2008; Flegg & Webber, 2000). As noted by Pereira-López et al. (2021), this convention became widespread because values below this threshold tend to overestimate multipliers, whereas higher ones tend to underestimate them. Subsequent studies, however, showed that a single constant is unsatisfactory: for example, $\delta \approx 0.25$ in Finland (Flegg & Tohmo, 2013; Tohmo, 2004) and $\delta \approx 0.3$ in South Korea (Flegg & Tohmo, 2019; Jahn et al., 2020). Even within the same country, estimates vary widely, since reported figures usually reflect an expected value with potentially high variance across regions. This implies that case-specific calibration remains necessary for accuracy.

In order to address this challenge, recent contributions have focused on estimating δ directly from the data. The most notable advance is the FLQ+ approach, a hybrid method that combines the Modified Cross-Entropy (MCE) technique with a simple regression model to obtain region and country specific estimates of δ (Flegg et al., 2021). This estimated parameter is then used within the FLQ framework to derive regional input coefficients and multipliers. Using a South Korean survey-based interregional table for 2005, Flegg et al. (2021) show that FLQ+ performs much like the FLQ with an optimal δ.

The FLQ+ methodology can be summarized in three main steps:

1. Estimate a preliminary regional matrix $\hat{A}^r$ from the national coefficients A^n, constrained by observed regional output totals x^r.
2. Use $\hat{A}^r$ to calibrate the optimal value of $\hat{\delta}$ through a regression.
3. Construct the final regional matrix A^r by applying the calibrated $\hat{\delta}$ to A^n.

Formally, the starting point is the national technical coefficients matrix A^n:

$$A^n_{mce} = \begin{bmatrix} a^n_{1,1} = \frac{Z^n_{1,1}}{X^n_1} & \cdots & a^n_{1,k} = \frac{Z^n_{1,k}}{X^n_k} & a^n_{1,k+1} = \frac{\sum_{f=1}^{F} Y^n_{1f}}{X^n_{k+1}} \\ \vdots & \ddots & \vdots & \vdots \\ a^n_{k,1} = \frac{Z^n_{k1}}{X^n_1} & \cdots & a^n_{kk} = \frac{Z^n_{kk}}{X^n_k} & a^n_{k,k+1} = \frac{\sum_{f=1}^{F} Y^n_{kf}}{X^n_{k+1}} \\ a^n_{k+1,1} = \frac{\sum_{p=1}^{P} V^n_{p1}}{X^n_1} & \cdots & a^n_{k+1,k} = \frac{\sum_{p=1}^{P} V^n_{pk}}{X^n_k} & a^n_{k+1,k+1} = 0 \end{bmatrix}, \tag{34}$$

where the last column corresponds to the sum across all F categories of final demand (households, government, investment, exports, etc.), while the last row aggregates the P categories of primary inputs (compensation, profits, imports, and taxes), with X^n_{k+1} denoting the total domestic production sold to all components of final demand.

The formulation problem consists in estimating the regional matrix A^r that minimizes the deviations from the national coefficients according to the cross-entropy criterion, where each term $a^r_{ij} \ln \frac{a^r_{ij}}{a^n_{ij}}$ measures the information loss of replacing the national coefficient a^n_{ij} (taken as prior) with its regional counterpart a^n_{ij} (Kullback & Leibler, 1951):

$$\min_{A^r \geq 0} M(A^r \| A^n)_{mce} = \sum_i \sum_j a^r_{ij} \ln \left(\frac{a^r_{ij}}{a^n_{ij}} \right) \tag{35}$$

Subject to basic feasibility constraints that keep the matrix balanced and consistent with regional outputs x^r:

$$\sum_j a^r_{ij} x^r_j = x^r_i, \quad \forall i \tag{36}$$

$$\sum_i a^r_{ij} = 1, \quad \forall j \text{ such that } x^r_j \neq 0. \tag{37}$$

This constrained optimization problem yields a feasible regional matrix $\hat{A}^r$ that is consistent with regional output totals while remaining as close as possible to the national structure.
In the second step, $\hat{A}^r$ is used to estimate the parameter δ through the FLQ adjustment formula. Defining $\beta = \log_2\left(1 + \frac{E^r}{E^n}\right)$, the adjustment when $\text{FLQ}_{ij} < 1$ can be written as:

$$a^r_{ij} = \begin{cases} a^n_{ij} \cdot \text{SLQ}_i \cdot \beta^\delta, & i = j, \\ a^n_{ij} \cdot \text{CILQ}_{ij} \cdot \beta^\delta, & i \neq j. \end{cases} \tag{38}$$

Defining $\alpha_{ij} = \text{CILQ}_{ij}$ if $i \neq j$ and $\alpha_{ij} = \text{SLQ}_i$ if $i = j$, we obtain:

$$\hat{a}^r_{ij} = a^n_{ij} \alpha_{ij} \beta^\delta \tag{39}$$

For those pairs (i, j) such that $\alpha_{ij}\beta^\delta < 1$ it follows that $\hat{a}^r_{ij} \leq a^n_{ij} \alpha_{ij} \beta^\delta \leq a^n_{ij} \alpha_{ij}$ which implies $y_{ij} \leq 0$.

This condition indicates that the restriction is binding, and in this case taking logarithms yields:

$$\log \left(\frac{\hat{a}^r_{ij}}{a^n_{ij} \alpha_{ij}} \right) = \delta \log(\beta) + \varepsilon_{ij} \tag{40}$$

In the non-binding case, when $\alpha_{ij}\beta^\delta \geq 1$, it follows that $\rightarrow \hat{a}^r_{ij} = a^n_{ij} \rightarrow \log \frac{a^n_{ij}}{a^n_{ij} \alpha_{ij}} = -\log(\alpha_{ij})$

which carries no information about δ. Therefore, such observations are excluded from the regression.
By taking expectations across industries, the optimal δ for the region can be consistently estimated as the ratio between the mean of the regressand and $\log(\beta)$. This provides a systematic calibration of δ.

$$\hat{\delta} = \frac{\bar{y}}{\log(\beta)}, \qquad \bar{y} = \frac{1}{N} \sum_{(i,j)} \log \left(\frac{\hat{a}^r_{ij}}{a^n_{ij} \alpha_{ij}} \right). \tag{41}$$

Finally, this calibrated $\hat{\delta}$ is applied to A^n to obtain the regional matrix A^r.

5.4 Method justification

For the present application we rely on the FLQ+ methodology. The choice is motivated by both data availability and empirical performance. On the data side, we have a national IO table for 69 industries in Denmark covering the full study period, together with employment and enterprise data for the local area. However, public statistical sources such as Statistics Denmark do not provide single-region or multiregion IO tables for Denmark. This rules out the direct use of regional IO models and makes FLQ+ the most feasible non-survey alternative, as it requires only basic regional size indicators while providing a systematic calibration of the key parameter δ (Lamonica et al., 2020; Lamonica & Chelli, 2018).

Applications of FLQ can be found in the literature for small-area economies, which are comparable to Danish municipalities in terms of scale and openness to trade.

- *Italian regions*. Monte Carlo evidence shows that FLQ and AFLQ with δ in the 0.2–0.3 range outperform SLQ and CILQ when evaluated against simulated "true" multipliers (Bonfiglio & Chelli, 2008). More recently, using national accounts and non-linear programming, Socci et al. (2025) endogenously estimate region-specific δ instead of fixing it. Based on their estimates, feasible values range from 0.14 to 0.90 across 20 regions, mostly within 0.2–0.4, with an average of approximately 0.35. Regions with lower participation in national GDP tend to have smaller δ, while larger or more peripheral regions show higher values.
- *Keski-Pohjanmaa, Finland*. Using survey-based regional tables as benchmark, SLQ and CILQ overstate multipliers, whereas FLQ with $\delta \approx 0.25$ corrects the bias and aligns with the small, open character of the region (Tohmo, 2004).
- *South Korean regions*. Analyses using survey-based benchmarks show that higher δ values, around 0.30–0.38, can be required in more interdependent local economies, and that FLQ-based regionalization improves substantially over simpler location quotients (Flegg & Tohmo, 2019; Flegg et al., 2021; Jahn et al., 2020).
- *Gran Santa Fe metropolitan area, Argentina*. A recent peer-reviewed municipal application constructs an intraregional IO coefficient matrix by regionalizing the national table with local employment. In that application, LQ-based regionalization, including FLQ, is central to the strategy and yields plausible local multipliers and linkages (Brondino et al., 2024).

Taken together, case studies and simulation exercises suggest that FLQ generally outperforms SLQ and CILQ, especially when δ is appropriately calibrated. The literature commonly reports accurate values around 0.2–0.3, although higher values may be required for more interdependent regional economies (Bonfiglio & Chelli, 2008; Flegg & Tohmo, 2019; Flegg et al., 2021; Jahn et al., 2020; Tohmo, 2004).

Regarding the augmented version AFLQ, empirical work using Scottish data shows that the inclusion of a measure of regional specialization in LQ-based formulae does not necessarily yield more accurate estimates of regional coefficients, and that FLQ outperforms SLQ and CILQ (Flegg & Webber, 2000). Similar conclusions are reached in simulation studies and later applications, where AFLQ provides little or no gain over a well-calibrated FLQ (Bonfiglio & Chelli, 2008; Flegg et al., 2021). This is consistent with our case, since only a few sectors of relevance display marked specialization, and the main purpose of using FLQ is precisely to avoid the systematic overestimation of impacts produced by SLQ and CILQ.

FLQ+ extends this approach by combining FLQ with cross-entropy balancing and regression-based calibration of δ (Lamonica et al., 2020; Lamonica & Chelli, 2018). This avoids arbitrary parameter choices and is consistent with evidence that calibrated FLQ-based methods improve predictive accuracy over simpler location quotients (Flegg et al., 2021). Given the absence of survey-based IO data at the kommune level in Denmark, FLQ+ is adopted here as a robust and cost-effective non-survey solution. This choice is supported by evidence that calibrated FLQ-based methods perform well in small and regional economies, with practical δ benchmarks commonly around 0.2–0.3 (Bonfiglio & Chelli, 2008; Flegg et al., 2021; Lamonica et al., 2020; Lamonica & Chelli, 2018; Tohmo, 2004).

6 Data and model construction

6.1 Regional IO model construction workflow

Figure 12 summarizes the workflow used to construct the regional IO model. The procedure follows six main steps. The first step defines the input data required for the model: the national IO system, regional employment, national and regional population, and the classification mappings used to align the different sources. The national IO source tables (NAIO1F/3F/4F) provide intermediate transactions, final demand, primary inputs, imports, and total output at the 69–industry level for each year in the period 2008–2024. The 69–industry classification is reported in Appendix Table A2. Regional employment is required at the same resolution, but observed municipal employment from KAS301 is available only at the broader 36a2/38–industry resolution, reported in Appendix Table A1.

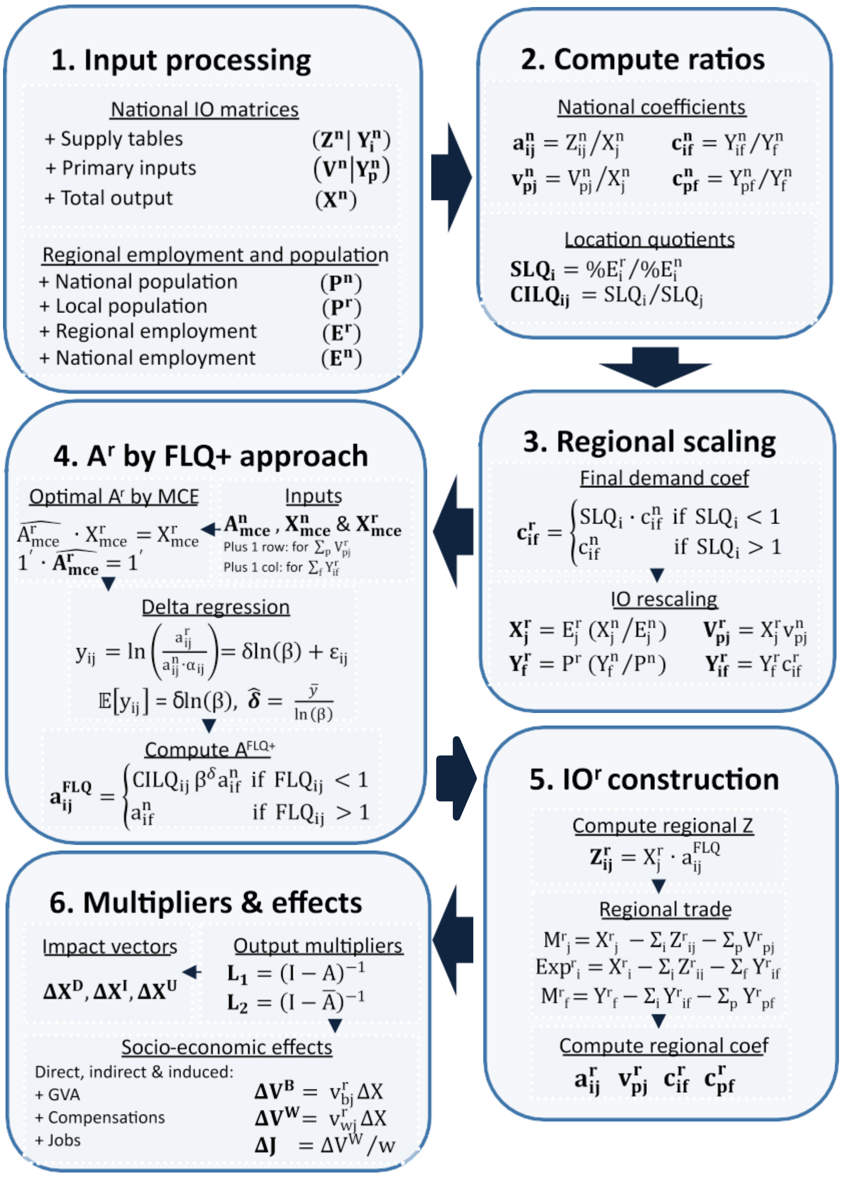


Figure 12: Diagram of model construction.

The construction of calibrated 69–industry regional employment vectors is therefore treated as part of the input-preparation stage and described separately in Subsection 6.2.

The second step computes location quotients from the calibrated regional employment vectors and uses them to regionalise the national IO structure. Regional output is scaled using employment ratios, while final-demand totals are scaled using population ratios and adjusted by local specialization.

The third step applies the FLQ^{+} procedure to calibrate the regional adjustment parameter δ. This provides a data-driven adjustment to the location-quotient regionalisation and avoids imposing an arbitrary value for the regional size parameter.

The fourth step estimates the regional interindustry transaction matrix from the calibrated regional technical coefficients and regional output. This yields the domestic intermediate transaction block of the regional IO table.

The fifth step recovers regional trade residuals. Any difference between total regional requirements and locally supplied inputs is assigned to interregional trade, ensuring that the regional accounts remain consistent with the estimated local supply capacity.

The sixth step balances the final regional IO accounts and recomputes the final coefficient matrices. The completed regional IO system is then used to compute output multipliers and the associated impact indicators.

Table 3 summarizes the public datasets used in the construction of the model. The study region is built by aggregating Thisted, Morsø, and Jammerbugt into a single functional area, denoted by L.

Type	Dataset	Variables	Notation	Geography	Sectoral resolution
IO tables	NAIO1F	Intermediate transactions	Z^{n}_{ij}	National	69
		Final demand	Y^{n}_{if}	National	69
	NAIO3F	Compensations	V^{n}_{wj}	National	69
		Gross operating surplus	V^{n}_{gj}	National	69
		Net taxes on production	V^{n}_{tj}	National	69
	NAIO4F	Imports	V^{n}_{Mj}	National	69
		Total output	X^{n}_{j}	National	69
Employment	ERHV1	Gross employment	E^{n}_{d}	National	742
		Employees only	$E^{n,e}_{d}$	National	742
	NABB69	Hours worked	H^{n}_{k}	National	69
		Employees only	$E^{n,e}_{k}$	National	69
	KAS301	Gross employment	E^{r}_{h}	Local	36a2
		Employees only	$E^{r,e}_{h}$	Local	36a2
Population	FT	National population	P^{n}	National	–
	BY2	Local population	P^{r}	Local	–
Businesses	GF12	Enterprise counts	B^{n}_{d}	National	742
		Enterprise counts	B^{r}_{d}	Local	742

Table 3: Public data from Statistics Denmark used for national IO construction, regionalisation, and auxiliary demographic and employment indicators.

The main data constraint is the mismatch between the national IO classification, observed regional employment, and detailed enterprise counts. The following subsection therefore describes how regional employment is first brought to the 69–industry resolution required for IO regionalisation.

6.2 Synthetic employment at 69 industries

The location-quotient regionalisation requires regional employment at the same 69–industry resolution as the national IO model. Location quotients are commonly computed using employment data, but they can also be computed from enterprise counts when employment is not available at the desired sectoral detail. This alternative is useful because enterprise data are often available at a more detailed industrial resolution than employment data, partly because employment tables are more affected by confidentiality restrictions. However, enterprise-based LQs must be used with caution. The reliability of location quotients depends on both the number of industries considered and the size of the local economy. In small areas, enterprise-based LQs are sensitive to firm-size differences: for instance, a restaurant and a cement plant each count as one enterprise, even though their production scale and employment differ substantially. This can distort specialization measures when industries are very detailed (Pominova, 2021). Previous studies further show that with broad groups of about 20 industries, LQs remain stable in towns with as few as 10,000 residents and in counties of about 25,000. By contrast, for detailed groupings of around 100 industries, stable estimates require populations of at least 1 million (Pominova, 2022).

In this study, observed regional employment is available only at the broader 36a2/38–industry resolution, which has less sectoral detail than the 69–industry national IO model. At the same time, enterprise counts are available at the detailed 742–industry level. The hybrid procedure therefore estimates expected detailed regional employment using national employment-per-enterprise ratios. The underlying assumption is that, within each detailed industry, the average number of workers per enterprise observed nationally is a reasonable proxy for the corresponding local ratio. Since the national ratio is computed over a much larger number of enterprises, it provides a more stable scale factor than a ratio computed directly from a small local economy.

Under this assumption, the number of local enterprises in each detailed industry implies an expected level of local employment, based on the average employment generated by enterprises in the same industry at the national level. These expected employment estimates are not used directly as final regional employment totals. Instead, they are used to compute detailed-industry employment shares within each observed 36a2/38 category. The observed employment totals are then distributed across 742 industries using these shares.

This approach could, in principle, be used to construct regional employment at several levels of sectoral detail, including 117 industries or even the full detailed classification. However, the literature warns that location quotients become increasingly unstable when very detailed industry classifications are applied to small local economies. With about 100,000 residents, the composite local area is therefore not treated as suitable for a direct enterprise-based LQ approach at very detailed resolution. For this reason, the synthetic employment estimates are converted to the 69–industry classification, matching the national IO model while remaining more cautious than a fully detailed enterprise-based regionalisation.

The procedure consists of five steps:

1. Sum the detailed enterprise counts of the municipalities in the study area.
2. Estimate expected detailed local employment by combining national employment-per-enterprise ratios with local detailed enterprise counts.
3. Compute detailed-industry employment shares within each observed 36a2/38 category.
4. Distribute the observed employment totals across detailed industries using these shares.
5. Convert the resulting detailed employment estimates to the 69–industry classification.

The detailed implementation is reported in Appendix A.3. The appendix defines the variables used in the procedure, describes the aggregation of municipal enterprise counts, and reports the equations used to construct the 742-industry employment shares and distribute the observed employment totals. The resulting total-employment vector at the 69–industry level is used to compute the SLQ/CILQ location quotients. The same procedure is also applied to employee-only employment to obtain the employee-based vector used for checks and FTE employment indicators.

6.3 Local specialisation

As described in Section 4.3, the study area has a larger share of rural territory than the region and the country as a whole. This is reflected in its employment structure, which differs clearly from the regional and national profiles (Table A3). The most distinctive feature of the local economy is its strong primary-sector and manufacturing base. Together, agriculture, forestry and fishing, and manufacturing account for almost 12 percentage points more of local employment than at the national level. Primary activities represent 7.6% of local employment compared to 2.3% nationally (LQ = 3.4), while manufacturing reaches 17.1% locally compared to 10.7% nationally (LQ = 1.6).

Tertiary activities account for a smaller share of local employment: 67.9% locally compared to 80.0% nationally (LQ = 0.8). This is consistent with a rural and production-oriented area. Services linked to corporate headquarters, specialised consultancy, finance, ICT, and R&D tend to concentrate in larger urban labour markets. Accordingly, information and communication (LQ = 0.3), financial services (LQ = 0.6), other business services (LQ = 0.6), consultancy activities (LQ = 0.4), and R&D activities (LQ = 0.1) have relatively low local employment shares. Locally embedded services, including retail, accommodation, care, construction-related activities, and operational services, remain more present in the local economy.

At the detailed 69–industry level, location quotients remain relatively stable over the period of analysis. For this reason, only the year 2024 is presented here to illustrate the detailed local economic structure, as shown in Figure 13. Additional detail is provided in Table A4, which reports enterprise counts and location quotients at the 117-, 69-, and 36a2-sector resolutions for Denmark, Nordjylland Region, and the municipalities of Thisted, Morsø, and Jammerbugt in 2023.

The strongest local specialisations (SLQ > 2) are found in agriculture and horticulture (01000), fishing (03000), and several manufacturing industries: food products, beverages and tobacco (10120), wood products (16000), paper products (17000), printing (18000), and non-metallic minerals (23000).

The area is also specialised (1.2 < SLQ ≤ 2) in forestry (02000), mining and quarrying (06090), fabricated metal products (25000), electrical equipment (27000), machinery (28000), furniture and other manufacturing (31320), repair and installation of machinery (33000), owner-occupied dwellings (68204), renting of non-residential buildings (68300), rental and leasing activities (77000), and residential care (87880). Moderate specialisation (1 < SLQ ≤ 1.2) appears in basic metals (24000), construction (41430), retail and repair of motor vehicles (45000), retail sale (47000), accommoda-tion and food service activities (55560), employment activities (78000), education (85202), arts and entertainment-related activities (90920 and 93000), and activities of membership organisations (94000).

Several activities remain less locally concentrated than nationally (SLQ ≤ 1), including electronic components (26000), motor vehicles and related parts (29000), sewerage and waste management (37390), wholesale trade (46000), land transport (49000), support activities for transportation (52000), travel agency activities (79000), architectural and engineering activities (71000), consultancy activities (69700), IT and information services (62630), and scientific research and development (72001/72002).

These specialisation patterns are directly relevant for the local impact analysis of the wind turbine test centre. The area has local industrial capacity in non-metallic minerals, repair and installation of machinery, electrical equipment, machinery, fabricated metal products, and construction. It also has local service capacity in retail, accommodation and food services, arts and entertainment, rental and leasing, care, and other locally embedded activities. These sectors provide potential channels through which operational expenditure and visitor-related demand may generate local spillovers. The extent of those spillovers will depend on procurement practices, firm capabilities, and project-specific requirements.

6.4 Local IO construction

6.4.1 Local output, final demand, and primary inputs

For each year $t \in \{2008, \ldots, 2024\}$, the national IO source tables (NAIO1F/3F/4F) are mapped and assembled using the common classification tables described in the methodology. This yields the national IO matrix IO^n_t and the associated coefficient matrices A^n_t, C^n_t, and v^n_t.

0 1 2 3 4 5 // 9

01000: Agriculture and horticulture	3.45
02000: Forestry	1.41
03000: Fishing	8.55
06090: Mining and quarrying	1.66
10120: Manufacture of food products, beverages and tob...	2.12
13150: Textiles and leather products	0.71
16000: Manufacture of wood and wood products	7.28
17000: Manufacture of paper and paper products	3.16
18000: Printing etc.	3.37
19000: Oil refinery etc.	0.00
20000: Manufacture of chemicals	0.49
21000: Pharmaceuticals	0.00
22000: Manufacture of rubber and plastic products	0.75
23000: Manufacture of non-metallic minerals	2.66
24000: Manufacture of basic metals	1.08
25000: Manufacture of fabricated metal products	1.48
26000: Manufacture of electronic components	0.73
27000: Electrical equipment	1.94
28000: Manufacture of machinery	1.93
29000: Manufacture of motor vehicles and related parts	0.85
30000: Manufacture of ships and other transport equipment	0.68
31320: Manufacture of furniture and other manufacturing	1.40
33000: Repair and installation of machinery	1.53
35000: Electricity, gas and other utilities	0.81
37390: Sewerage and waste management	0.81
41430: Construction	1.09
45000: Retail and repair of motor vehicles	1.02
46000: Wholesale	0.64
47000: Retail sale	1.18
49000: Land transport and transport via pipelines	0.74
50000: Water transport	0.64
51000: Air transport	0.00
52000: Support activities for transportation	0.64
53000: Postal and courier activities	0.69
55560: Accommodation and food service activities	1.00
58000: Publishing activities	0.46
59600: Motion picture and television programme prod.,...	0.73
61000: Telecommunications	0.13
62630: IT and information service activities	0.18
64000: Financial service activities, except insurance...	0.84
65000: Insurance and pension funding	0.28
66000: Other financial activities	0.17
68100: Buying and selling of real estate	0.64
68203: Renting of residential buildings	0.41
68204: Owner-occupied dwellings	1.51
68300: Renting of non-residential buildings	1.62
69700: Head offices activities; consultancy	0.42
71000: Architectural and engineering activities	0.48
72001: Scientific research and development (market)	0.15
72002: Scientific research and development (non-market)	0.00
73000: Advertising and market research	0.57
74750: Other professional, scientific and technical ac...	0.73
77000: Rental and leasing activities	1.23
78000: Employment activities	1.04
79000: Travel agent activities	0.50
80820: Services to buildings and landscape	0.67
84101: Rescue service etc. (market)	0.00
84202: Public administration etc.	0.64
85101: Education (market)	9
85202: Education (non-market)	3
86000: Human health activities	0
87880: Residential care	0
90920: Arts and entertainment; libraries, museums and...	0

: Arts, entertainment and cultural activities 94000:
Activities of membership organisations

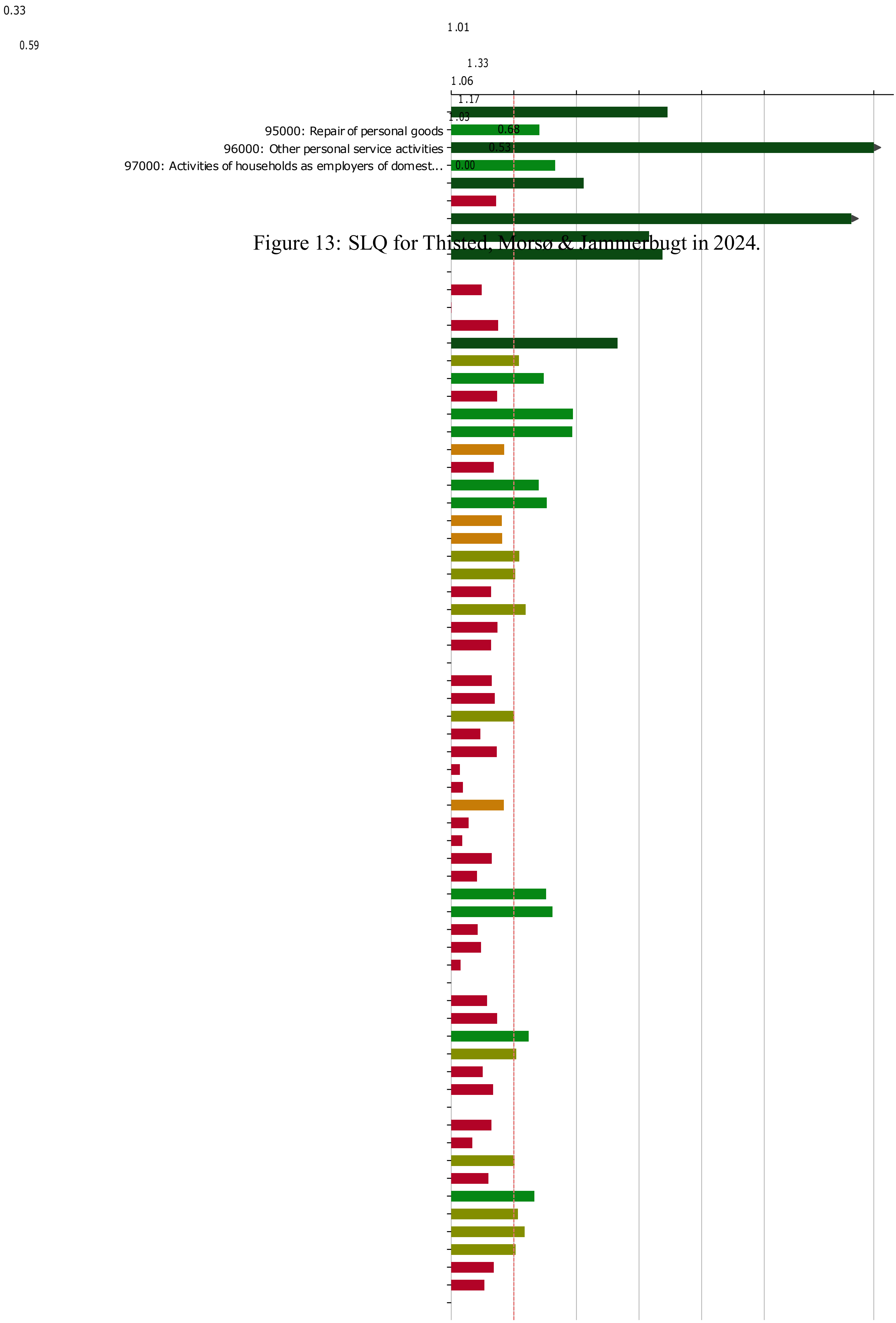


Figure 13: SLQ for Thisted, Morsø & Jammerbugt in 2024.

The calibrated local employment vectors are then used to compute the location quotients required for localisation. These quotients determine how much of the national input structure can be retained locally and how much must be adjusted downward to reflect limited local supply capacity.

The calibrated local employment vectors and population totals are used to scale the national IO accounts to the local economy. Industry output is scaled by local employment, while aggregate final-demand totals are scaled by local population:

$$x^r_j = E^r_j \frac{x^n_j}{E^n_j} \quad \forall j \qquad \text{and} \qquad y^r_f = P^r \frac{y^n_f}{P^n} \quad \forall f. \tag{42}$$

Here, E^r_j and E^n_j denote local and national employment in industry j, while P^r and P^n denote local and national population.

These assumptions are reasonable in the present setting. Figure 5b shows that local output and GDP per job are close to national levels, supporting the use of employment as a proxy for local output x^r_j. Moreover, consumption and related final-demand aggregates tend to track population more closely than the size of the workforce, which can differ markedly from population (see Figure 8b). Using population as the rescaling factor for final demand therefore allows the model to capture residential-area dynamics, where local consumption includes non-working populations, such as retirees, and can proportionally exceed local production relative to the national ratio.

The local final-demand pattern is adjusted using national final-demand coefficients and local specialization. The national final-demand coefficients c^n_{if} indicate, for each category f, the share of total final demand y^n_f supplied by sector i

$$c^n_{if} \equiv \frac{y^n_{if}}{y^n_f}. \tag{43}$$

Retaining national shares would be misleading when an industry has little or no local presence. For this reason, national final-demand shares are scaled by local specialization for under-specialized sectors, while sectors with at least national specialization retain the national coefficient:

$$c^r_{if} = \begin{cases} \mathrm{SLQ}_i\, c^n_{if} & \text{if } \mathrm{SLQ}_i < 1, \\ c^n_{if}, & \text{if } \mathrm{SLQ}_i \geq 1. \end{cases} \tag{44}$$

Combining c^r_{if} with the local final-demand totals gives final demand by supplying industry:

$$y^r_{if} = y^r_f\, c^r_{if}. \tag{45}$$

If $E^r_i = 0$, and thus $\mathrm{SLQ}_i = 0$, then $c^r_{if} = 0$ and $y^r_{if} = 0$. Hence, no local final demand is assigned to industries that are not present within the local area.

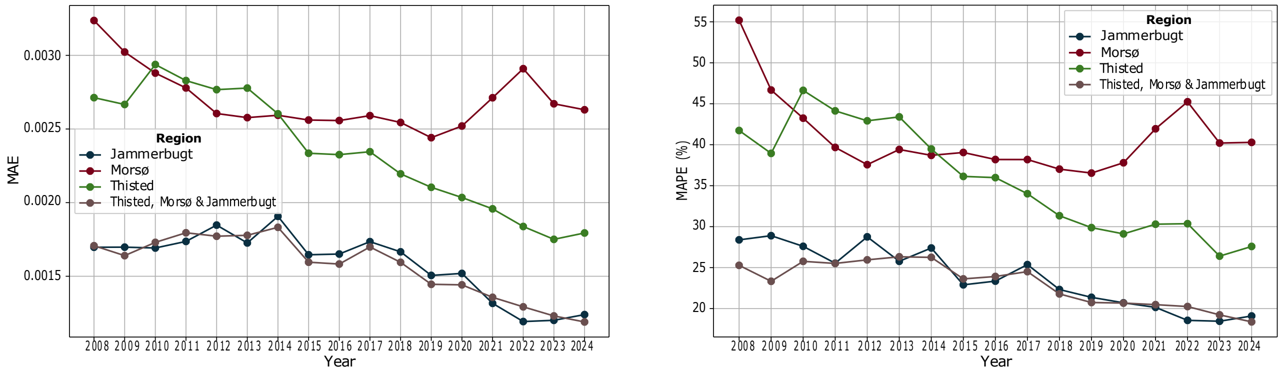
Primary-input shares are kept at their national levels. Local primary-input totals are then obtained by applying these national shares to local output and final-demand totals:

$$\begin{aligned} v^r_{pj} &= v^n_{pj} = \frac{V^n_{pj}}{x^n_j}, & v^r_{pf} &= v^n_{pf} = \frac{V^n_{pf}}{y^n_f}, \quad \forall p, j, f, \\ V^r_{pj} &= x^r_j\, v^r_{pj}, & V^r_{pf} &= y^r_f\, v^r_{pf}, \quad \forall p, j, f. \end{aligned} \tag{46}$$

At this point, the local accounts contain industry output x^r_j, final demand by supplying industry y^r_{if}, and primary inputs supplied to intermediate industries V^r_{pj} and final-demand categories V^r_{pf}. The remaining component is the local technical-coefficient matrix A^r, which is estimated using the FLQ+ procedure.

6.4.2 Delta calibration

As described in Subsection 5.3, the first step of the FLQ+ procedure is to estimate a provisional local coefficient matrix $\hat{A}^r$ that is consistent with local output and final-demand totals. For calibration, a consolidated national matrix $\hat{A}^{mce}_n$ is used, adding one row that aggregates all primary inputs and one column that aggregates total final demand. The primary-input entry in the final-demand column is set to zero.



(a) MAE of adjusted vs. target matrices

(b) MAPE of adjusted vs. target matrices

Figure 14: Cross-entropy estimation errors for technical coefficients.
Note: Error indicators are reported by year and municipality (Thisted, Morsø, Jammerbugt, and the combined local area) for the adjusted technical coefficient matrices (A_r).

On the local side, the target vector x^{mce}_r includes industry output x^r and one additional element corresponding to the total of final-demand components by supplying industry, $\sum_f y^r_{if}$. The optimization recovers the local matrix $\hat{A}^{mce}_r$ that satisfies the local accounting constraints while remaining close to the national prior.

The problem is solved with a reduced maximum cross-entropy routine in Python using cvxpy. The optimization was solved with the Splitting Conic Solver (SCS). All local-year cases reached convergence, and ex-post checks confirmed both column sums close to one and the balance condition. Figures 14a and 14b summarize the distance between local and national technical coefficient matrices. The Mean Absolute Error (MAE, Fig. 14a) measures the average absolute difference between coefficients, while the Mean Absolute Percentage Error (MAPE, Fig. 14b) expresses this deviation as a percentage of the national coefficients.

The results in Figure 14 show that both error measures are generally lower and more stable over time when the municipalities are aggregated, compared to treating them separately. This is especially clear in the most recent years. In practice, this means that fewer adjustments are required in the local technical coefficient matrix when working with the aggregated area. The results suggest that aggregation reduces variability across municipalities and provides a justification for continuing the analysis at this combined local level.

After computing $\hat{A}^r$, the δ estimates are obtained. Figure 15 shows that the estimated δ values are fairly stable and lie within the expected range of 0.20–0.30. The corresponding summary statistics are reported in Appendix A.4.

Of the 4.7 thousand observations in the 69×69 matrix, only about 1.6–1.7 thousand contribute to the estimation of δ. This is because many entries are zero and are therefore excluded from the regression.

The resulting optimal value, $\hat{\delta}$, is then applied to A^n to obtain the final local coefficient matrix A^r. The comparison between the traditional CILQ adjustment and the calibrated FLQ adjustment is reported in Appendix A.5.

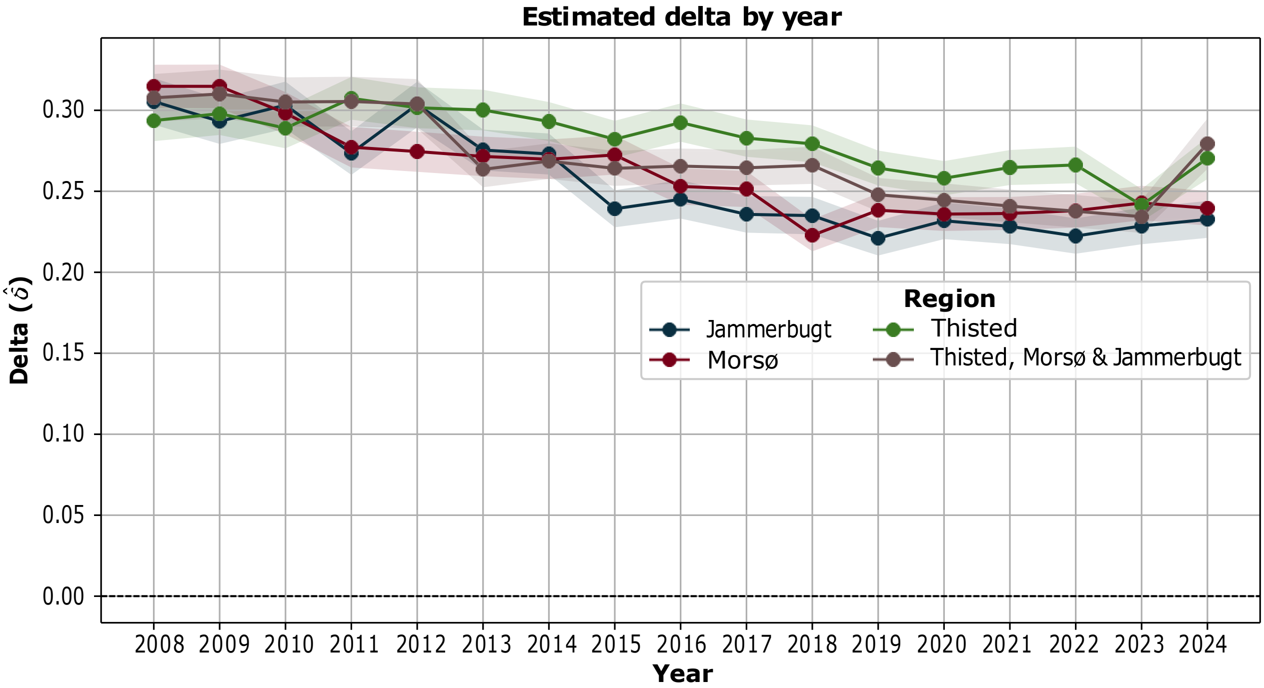


Figure 15: Optimal δ over time (FLQ+).
Note: Estimates are shown with confidence intervals for Thisted, Morsø, Jammerbugt, and the combined local area.

6.4.3 Final local accounts and trade residuals

To complete the local input–output matrix, interindustry transactions are computed from the estimated local coefficients and industry outputs:

$$Z^r_{ij} = X^r_j a^r_{ij}. \tag{47}$$

Together with the previously calculated Y^r_{if}, V^r_{pj} and V^r_{pf}, this delivers the domestic part of the local IO table. Because A^r and C^r are scaled downward to reflect limited local supply capacity, the shortfall to column totals is assigned to interregional trade by adding an imports row. For any given purchasing sector or final-demand category, what cannot be sourced locally is therefore met through interregional trade.

The residual trade balances in levels are computed as

$$\begin{aligned} M^r_j &= X^r_j - \sum_i Z^r_{ij} - \sum_p V^r_{pj}, \quad \forall j, \\ M^r_f &= Y^r_f - \sum_i Y^r_{if} - \sum_p V^r_{pf} \quad \forall f. \end{aligned} \tag{48}$$

Consequently, reductions in local domestic coefficients are absorbed by the import residuals, M^r_j and M^r_f in levels, or m^r_j and m^r_f in coefficient form. Once the local IO table is expressed in monetary terms, the final coefficients a^r_{ij}, v^r_{pj}, c^r_{if}, and v^r_{pf} are recomputed from the finalized accounts.

6.4.4 Multipliers and impact indicators

The completed local IO system is used to compute output multipliers and impact indicators. Output effects are obtained from the Type I and Type II Leontief inverses. Gross value added and labour-income effects are then computed by applying the corresponding primary-input coefficients to these output effects.

Employment effects are expressed in full-time-equivalent (FTE) jobs. The IO model first produces labour-income effects, measured in monetary units. These effects are then converted into employment effects by asking how many FTE jobs correspond to a given amount of labour income in each local industry. For this conversion, an estimate of wage per FTE is required.

The wage per FTE is computed from two elements: total compensation of employees and FTE employment. Compensation of employees refers to the total annual amount paid to employees in a given local industry, including wages, salaries, and employers' social contributions. Let V^r_{wi} denote compensation of employees in industry i and local area r.

Since local hours worked are not observed at the 69–industry level, local FTE employment cannot be measured directly. It is therefore imputed by assuming that, within each industry, local employees work the same average annual hours as national employees. Let H^n_i denote national hours worked by employees in industry i, and let $E^{n,e}_i$ denote the corresponding number of national employees. Since H^n_i is reported in thousands of hours, average annual hours per employee are computed as

$$h^n_i = \frac{1{,}000\, H^n_i}{E^{n,e}_i}. \tag{49}$$

These national hours-per-employee intensities are then applied to the local employee vector. Let $E^{r,e}_i$ denote the number of local employees in industry i. Imputed local employee hours are

$$H^{r,e}_i = E^{r,e}_i h^n_i.$$

To express these hours as FTE jobs, total annual hours are divided by $h^{FTE} = 1{,}740$, the number of annual hours corresponding to one full-time job. Local FTE employment is therefore

$$FTE^r_i = \frac{H^{r,e}_i}{h^{FTE}} = E^{r,e}_i \frac{h^n_i}{h^{FTE}} = E^{r,e}_i \frac{1{,}000\, H^n_i}{1{,}740\, E^{n,e}_i}. \tag{50}$$

The local wage per FTE is then given by

$$W^r_i = \frac{V^r_{wi}}{FTE^r_i}. \tag{51}$$

This wage-per-FTE vector provides the link between labour-income effects and employment effects. Let m denote the effect category, with

$$m \in M = \{\text{direct, indirect, induced}\}.$$

If $\Delta V^{m,r}_{wi}$ is the labour-income effect in industry i, local area r, and effect category m, the corresponding employment effect is computed as

$$\Delta J^{m,r}_i = \frac{\Delta V^{m,r}_{wi}}{W^r_i}. \tag{52}$$

Thus, employment effects are obtained by converting labour-income impacts into FTE jobs using an industry-specific local wage per FTE.

7 Model analysis

Figure 16 illustrates how the operation of the wind turbine test center generates economic effects within the local economy and how part of the expenditure leaks outside the area. The initial shock comes from the expenditure required to operate the test center, including activities such as foundations and piling, maintenance, site clearing and grubbing, access road construction, and accommodation and lodging paid by companies using the facilities. Only the share of this expenditure that is supplied locally enters the regional input–output model as direct local demand; the remaining expenditure is treated as external supply and therefore leaks to the rest of the country or abroad.

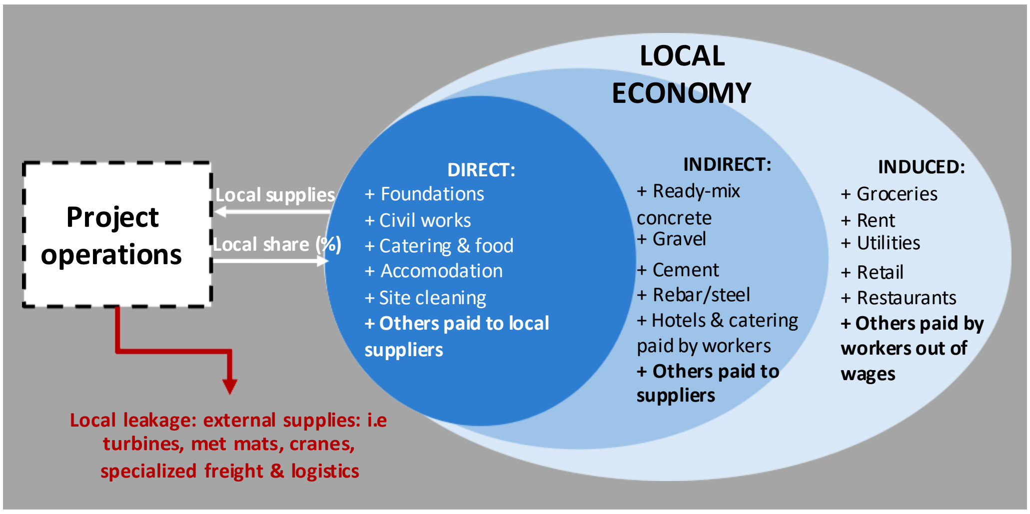


Figure 16: Diagram of different types of effects in a wind turbine test center.

The direct effect corresponds to the local production required to deliver the goods and services purchased for test center operations. This direct demand then generates indirect effects through local supplier chains. For example, local construction or maintenance activities may require ready-mix concrete, gravel, cement, rebar, steel, catering, hotels, and other inputs purchased from regional suppliers. These supplier purchases are captured through the type I Leontief inverse, denoted as L_1 in the diagram. The size of this effect depends on the local capacity to provide the required inputs: when specialized equipment, turbines, cranes, or freight and logistics services are not available locally, the associated expenditure leaves the region and does not generate further local supplier effects.

Finally, the workers employed directly and indirectly through these activities receive wages, part of which is spent in the local economy on groceries, rent, utilities, retail, restaurants, and other household services. These induced effects are captured through the extended multiplier, denoted as L_2 in the diagram. In the context of the test center, the induced channel is therefore not generated by the turbines themselves, but by the labour income associated with the local activities needed to operate, maintain, and service the facility. The diagram thus clarifies the distinction between local capture and leakages, which is central for interpreting the estimated direct, indirect, and induced impacts of the test center.

7.1 Relevant industries

The regional supply-chain analysis points to a relatively small group of sectors that are especially relevant for understanding how project-related demand may circulate within the local economy. Following the Rasmussen–Hirschman linkage approach (Hirschman, 1958; Rasmussen, 1956), sectors are classified according to whether they exhibit above- or below-average backward and forward linkages. This classification helps distinguish sectors that mainly demand inputs from the regional economy, sectors that supply inputs to many others, and sectors that do both.

Figure 17 shows that the main *Key* sectors in the local economy are Construction (41430), Wholesale

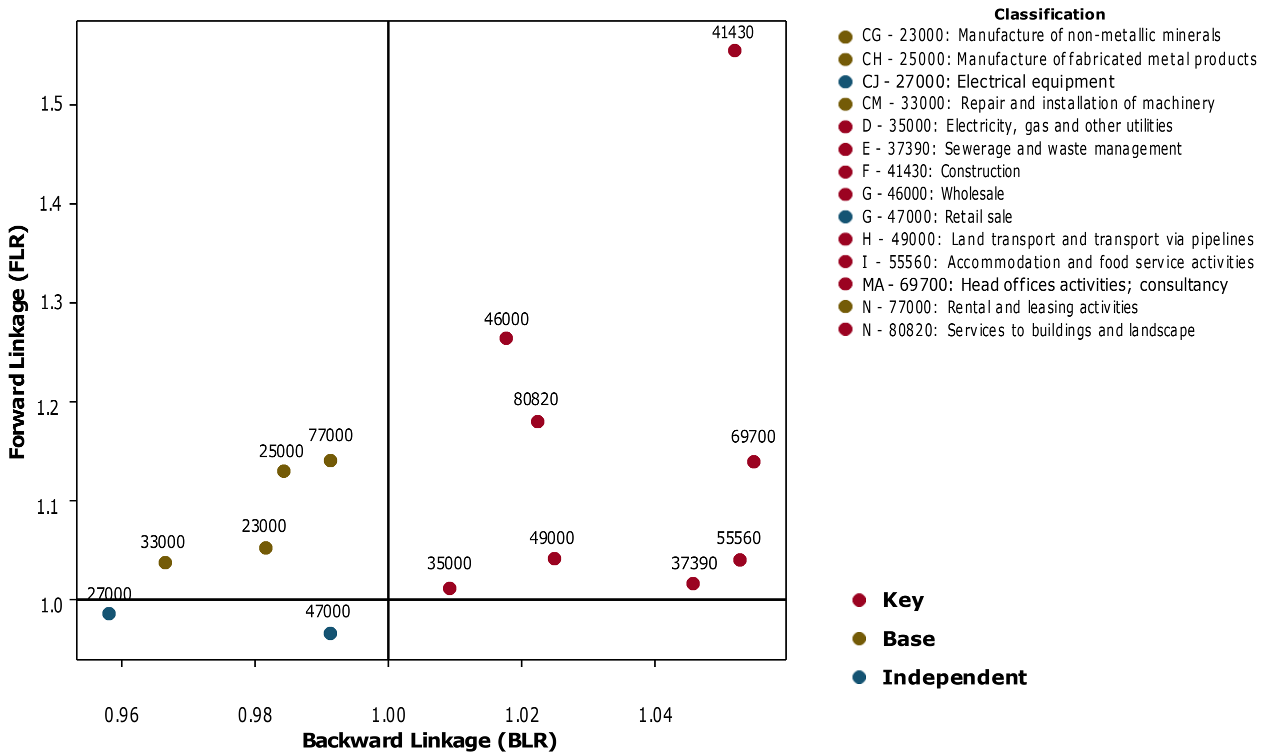


Figure 17: Sector classification by FLR and BLR for local area (2024).

(46000), Land transport and transport via pipelines (49000), Accommodation and food service activities (55560), Electricity, gas and other utilities (35000), Sewerage and waste management (37390), Head office and consultancy activities (69700), and Services to buildings and landscape (80820). These sectors combine above-average backward and forward linkages, meaning that they both rely on local suppliers and are connected to demand from other local sectors.

Several sectors appear as *Base* sectors, including Manufacture of non-metallic minerals (23000), Manufacture of fabricated metal products (25000), and Manufacture of machinery (28000) and Repair and installation of machinery (33000). These sectors have relatively strong forward linkages, suggesting that they provide inputs or services used by other parts of the regional economy, even if their own backward demand for local inputs is below average. Finally, Electrical equipment (27000), Retail and repair of motor vehicles (45000), Retail sale (47000), and Support activities for transportation (52000) are classified as *Independent* sectors in this framework.

This classification reflects the structural role of each sector, not its absolute size. A sector may be economically important in terms of employment or output while still displaying weak linkage indicators, and vice versa. For the purposes of this study, the classification is therefore used as a diagnostic tool to guide the interpretation of local supply-chain capacity and to identify sectors where procurement information would be especially valuable. In particular, the Key and Base sectors identified above provide the most relevant starting point for discussing potential local supplier relationships with DTU, turbine manufacturers, and local stakeholders.

Formally, the classification is based on normalized backward and forward linkage indicators. Let A be the technical-coefficients matrix and $L = (I - A)^{-1}$ the Leontief inverse. The backward-linkage ratio is computed from the column sums of L, while the forward-linkage ratio is computed from the row sums. Values above one indicate above-average linkages:

$$\mathrm{BLR}_j = \frac{\sum_i L_{ij}}{\frac{1}{n}\sum_i \sum_j L_{ij}}, \qquad \mathrm{FLR}_i = \frac{\sum_j L_{ij}}{\frac{1}{n}\sum_i \sum_j L_{ij}}. \tag{53}$$

Sectors with both indicators above one are classified as *Key*; those with only forward linkages above one as *Base*; those with only backward linkages above one as *Impulse*; and those with both indicators below one as *Independent*.

7.2 Local leakages

The FLQ+ regionalization produces a regional technical-coefficients matrix with lower inter-industry coefficients than the corresponding national matrix and than a matrix obtained with a simple CILQ adjustment, as shown in Figure A1. This result is consistent with the limited supply capacity of a small regional economy: part of the intermediate demand that would be supplied domestically at the national scale is treated as interregional imports at the local scale. Throughout this section, the Danish and EU27 results are *observed*, as they are computed directly from public datasets, whereas the local results are estimates produced in this study through the regionalisation procedure.

Figure 18 illustrates this mechanism for selected industries. At the local level, the domestic intermediate-input share is substantially lower than the national benchmark, often falling to around one half and, in some cases, to less than one third. By construction, value-added shares are held constant across the local and national specifications, so the main adjustment occurs through intermediate-input sourcing and the resulting leakages.

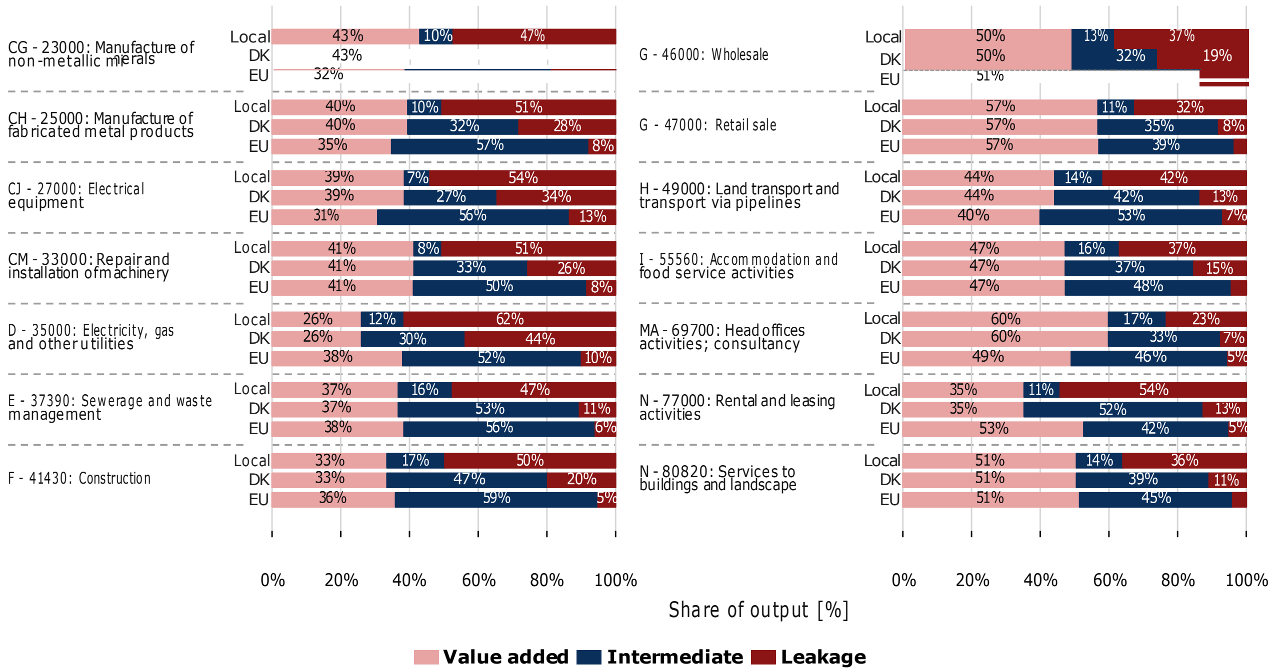


Figure 18: Value added, intermediate inputs, and leakages: local, Denmark, and EU27.
Note: Results are shown for the local area (2024), Denmark (2024), and the EU27 (2023).
Source: Calculations based on Eurostat, 2024.

These leakages directly affect the size of indirect and induced effects. Indirect effects are smaller locally because fewer supplier purchases are retained within the study area. This is particularly relevant for service and finance-related linkages, where the local economy has a thinner supplier base than the national economy. Induced effects are also more muted locally, because part of the additional household consumption leaks out through purchases of goods and services not supplied within the area. Nevertheless, induced effects remain relevant, since direct and indirect labour income still generates additional local consumption demand. Detailed sectoral effects are reported in Figure A2 in the Appendix.

7.3 Employment estimations

Employment multipliers, measured in FTE jobs and disaggregated by effect type for the local area, Denmark, and the EU27, are reported in Figure 19. The comparison shows the expected spatial pattern: direct employment effects are relatively similar across scales, while indirect and induced effects increase with the size and economic self-sufficiency of the reference economy.

The figure also shows clear differences in employment intensity across industries. Labour-intensive activities, such as retail, accommodation and food service activities, and services to buildings and landscape, display the highest total employment multipliers, at 7–10 FTE-years per million EUR once direct, indirect, and induced effects are included. Most manufacturing sectors, transport-related activities, construction, and professional or office-related activities generate lower multipliers, at 3–6 FTE-years per million EUR. The lowest values are found in the most capital-intensive activities, particularly utility-related sectors, with total effects of 2–3 FTE-years per million EUR.

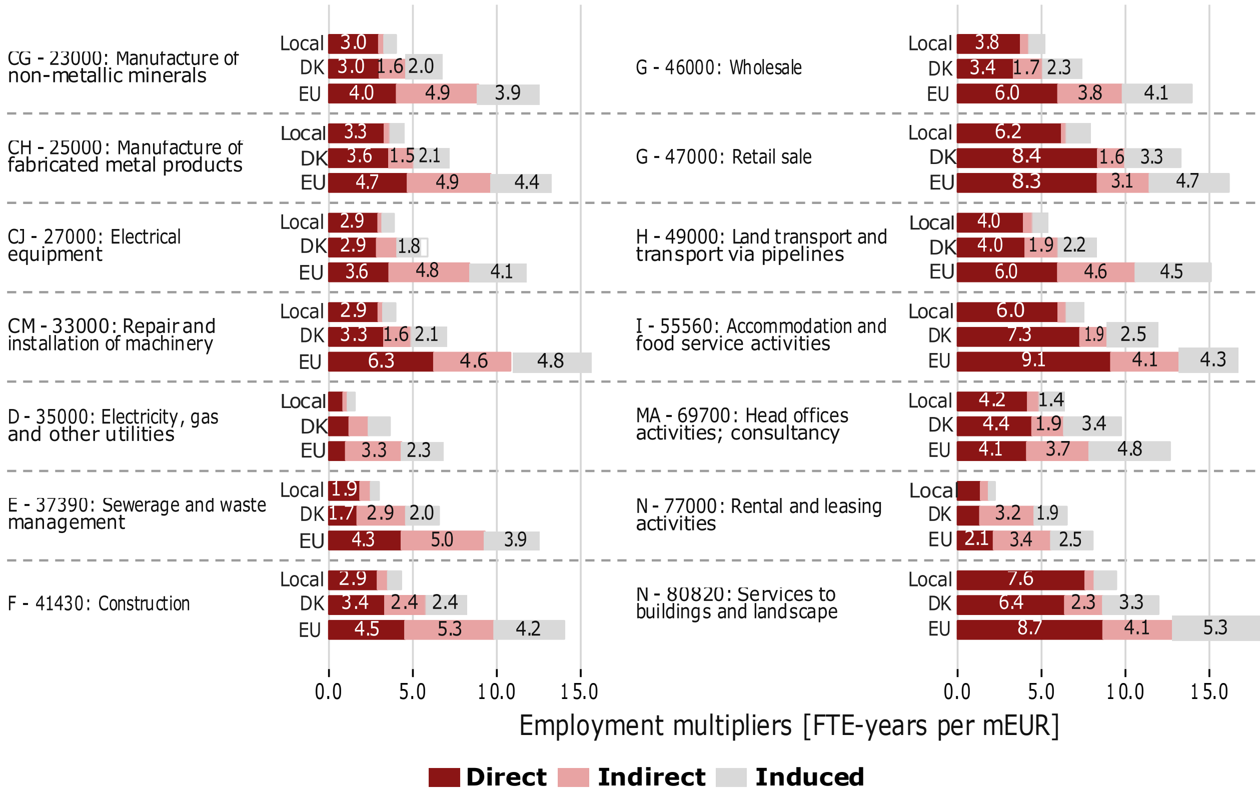


Figure 19: Employment multipliers by effect type and industry.
Note: Results are shown for the local area (2024), Denmark (2024), and the EU27 (2023).
Source: Calculations based on Eurostat, 2022, 2024.

Figure 20 complements this comparison by examining the local estimates in relative terms. It reports indirect and induced employment effects per direct job, together with their combined spillover ratio. This distinction is important because sectors with high employment multipliers do not necessarily generate the strongest spillovers relative to their direct employment base.

Electricity, gas and other utilities (35000) and Sewerage and waste management (37390) show the highest ratios in the figure, but these values partly reflect a base effect: both sectors create few direct jobs per million EUR of final demand, making spillovers appear large when expressed per direct job. The interpretation therefore focuses mainly on the remaining sectors.

For the rest of the local economy, total spillovers are concentrated in a relatively narrow range of 0.22–0.40 jobs per direct job. Construction (41430), Head office and consultancy activities (69700), and Architectural and engineering activities (71000) stand out above this range, reaching 0.50 additional jobs per direct job. This is consistent with the linkage classification in Figure 17, where these sectors are also identified among the strongest *Key* sectors. In contrast, supplier-related employment effects remain more constrained across manufacturing, retail, transport, accommodation, and other service-related activities.

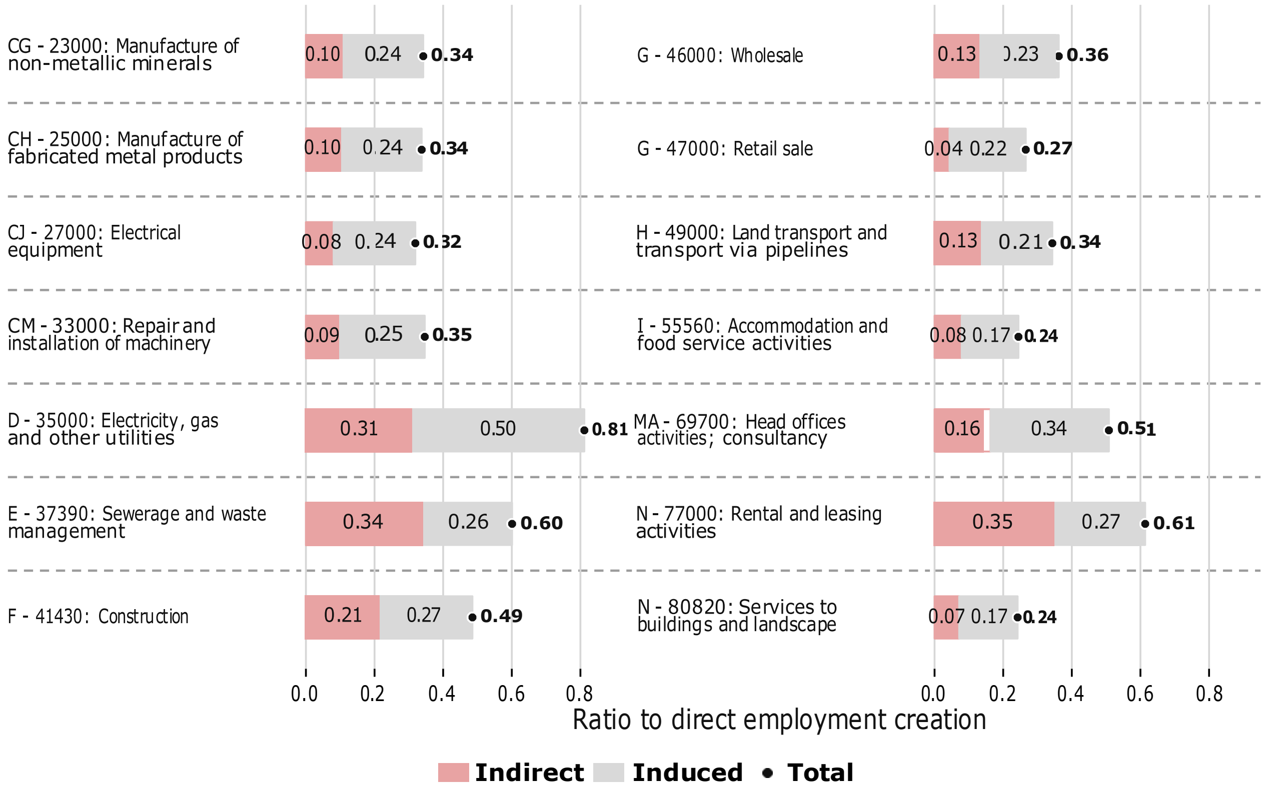


Figure 20: Ratios of indirect and induced to direct local employment effects by industry.
Note: Ratios are unitless and are computed from employment effects measured in FTE-years per million EUR shock.

The national ratios provide a useful reference for the scale of the adjustment from a national to a local analysis. In Denmark, the average ratios are 0.67 indirect and 0.70 induced jobs per direct job, equivalent to almost 1.4 spillover jobs per direct job. Compared with the local estimates, this im-plies a substantial downward correction when moving to the local area, consistent with the stronger supplier-demand and household-consumption leakages already reported in Figure 18. Less intermediate demand is retained by local suppliers, reducing local employment impacts.

The magnitude of this correction is large. For most local sectors, total spillovers are 0.22–0.40 jobs per direct job, meaning that the national benchmark is roughly three to six times higher than the local estimates. Even for the strongest relevant sectors identified above, where spillovers reach 0.50 jobs per direct job, the national benchmark is still almost three times larger. This confirms that applying national employment ratios directly to the local area would substantially overstate indirect and induced employment effects.

A reported benchmark used by Vordingborg Municipality for Klintholm Port assumes 0.6 indirect and 0.3 induced jobs per direct job (Hedetoft et al., 2023), equivalent to 0.9 additional jobs per direct job. Although this is below the national benchmark, it remains high relative to the local estimates obtained in this study, where typical total spillovers are closer to 0.3–0.5 jobs per direct job. In other words, the benchmark roughly doubles or triples the relative spillover effect estimated for the local economy. A dedicated application of the same method to Vordingborg would be needed for a direct comparison, but the benchmark appears too optimistic: Vordingborg has around 45,000 inhabitants, compared with about 100,000 in the local area analysed here, and the negative logarithmic effect of regional size in the FLQ+ methodology would likely imply even lower local spillovers. In this light, assuming almost one additional job per direct job is likely to overstate local employment impacts.

7.4 Delta sensitivity analysis

Appendix Table A5 reports the yearly FLQ+ estimates of δ for Thisted, Morsø & Jammerbugt. For 2024, the estimate is $\hat{\delta} = 0.2794$, with a 95% confidence interval of [0.2638, 0.2949]. This implies that, if the sensitivity analysis were restricted to the statistically plausible range around the 2024 estimate, only very limited variation in the results would be expected.

For this reason, Figure 21 instead considers the more illustrative boundary cases $\delta = 0$ and $\delta = 1$, together with the estimated value $\delta = \hat{\delta}$. The case $\delta = 1$ represents an extreme specification in which regional self-sufficiency is effectively absent: indirect effects disappear, all intermediate requirements are imported, and induced effects stem only from the direct effect. At the other extreme, $\delta = 0$ corresponds to the CILQ case and produces the largest indirect effects. Although this case is likely to overestimate local spillovers, it is useful as an upper bound on the magnitude of such effects.

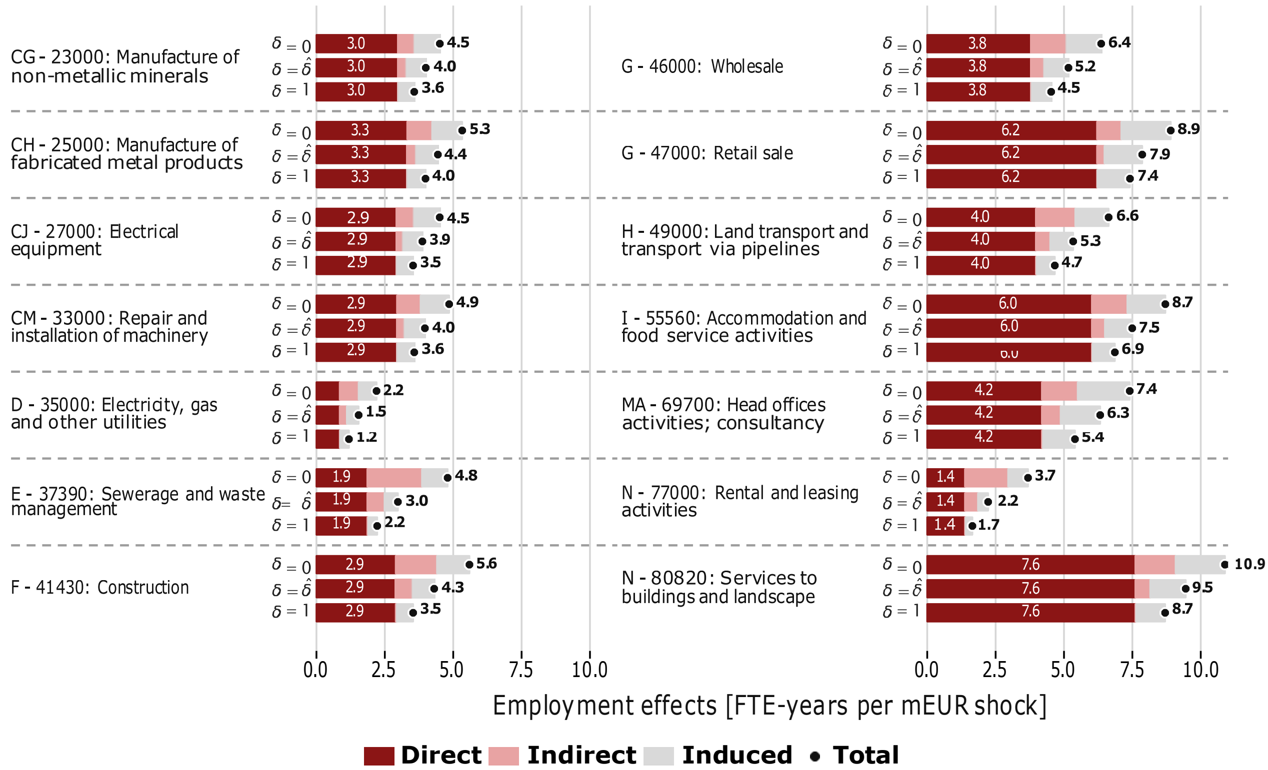


Figure 21: Local employment effects by industry under alternative δ values, 2024.

Direct effects remain unchanged across all three cases. This is because δ only affects the adjustment of the technical coefficients through equation (32), and does not alter the value-added coefficients. Hence, a given increase in local final demand is always translated into direct employment according to industry-specific labour productivity, as defined in equation (25). Overall, the figure suggests that, while the composition between indirect and induced effects changes somewhat across specifications, the estimated employment effects do not exhibit large deviations across plausible values of δ.

7.5 Final demand vector

To construct the demand shock vector by industry for the direct economic impact of the project, as defined in Equation 17, it is necessary to identify the cash flow generated by the project at the local level. In this study, the relevant variable is therefore not the total expenditure associated with the test center, but the share of expenditure, labour income and supplier activity that is actually captured by the local economy.

The supply-chain structure used for the impact estimation is presented in Figure 22. The figure illustrates the accounting logic used to decompose project operations into their main expenditure channels and to avoid double counting. DTU and the test-center users are treated as tier-0 project actors. Their activity generates direct local impacts through payments to local employees, purchases from local suppliers and visitor-related expenditure, while payments to suppliers outside the local area are treated as regional leakages.

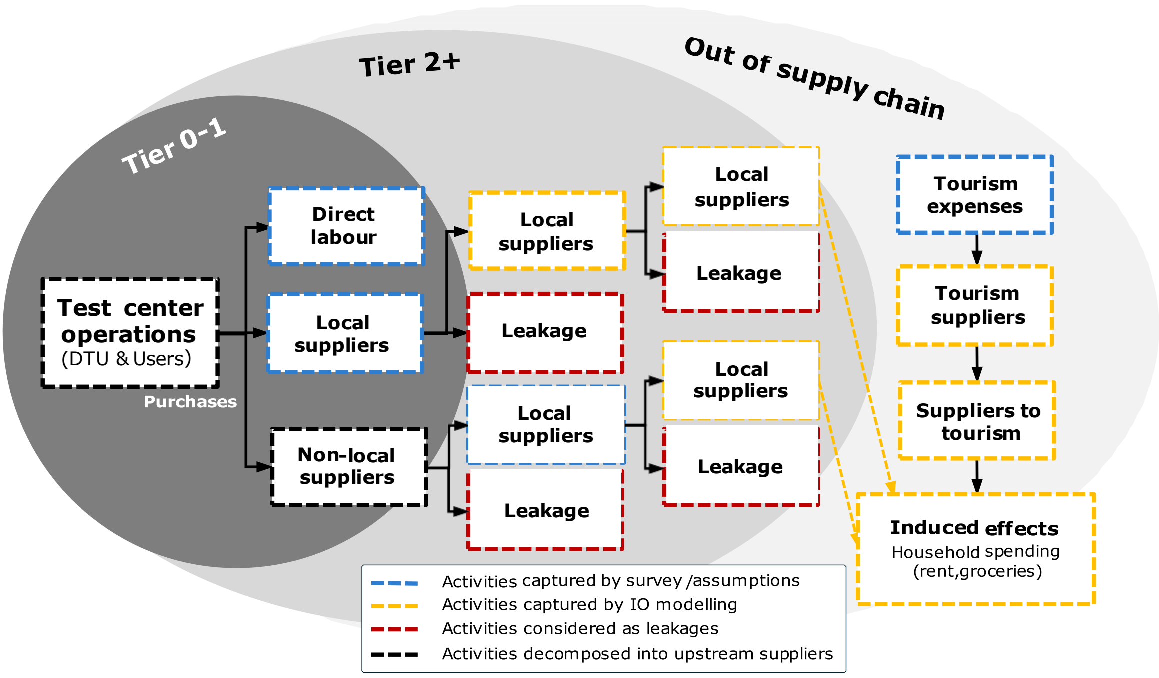


Figure 22: Local supply chain structure for impact estimation.

Only the expenditure captured locally enters the demand shock vector. Payments to local employees are treated as direct labour income, while purchases from local suppliers and visitor-related spending are allocated to the corresponding industries as direct local demand. Subsequent supplier effects and the induced effects generated by household consumption are estimated through the local input–output model developed in this research. Type I effects capture local supplier linkages generated by the initial shock, while Type II effects additionally capture wage-related household consumption. This approach allows the model to estimate additional local activity while avoiding the double counting of expenditure already observed in the primary data.

This distinction is central in the offshore wind impact literature. Large energy-related facilities may generate limited local effects if the main contracts, labour inputs and specialized services are sourced externally. Conversely, local impacts increase when local firms and workers are able to participate in the project supply chain (Sylvest, 2020). In this sense, local content depends not only on the existence of expenditure, but also on the availability, competitiveness and capacity of local suppliers and workers to meet project requirements.

Sylvest (2020) distinguishes between three types of local suppliers: primary, secondary and tertiary suppliers. This typology is useful for the Østerild case because it separates specialized wind-related activity from more general local service effects. Primary suppliers are firms directly involved in the core technical activity, such as turbine installation, inspection and specialized O&M providers. Secondary suppliers are firms outside the core wind sector whose services are required by project actors, such as equipment suppliers, electricians, fuel suppliers, cleaning services, inspection providers and other technical services. Tertiary suppliers have no direct role in the core technical activity, but serve workers, contractors and visitors through activities such as accommodation, restaurants, taxis, shops, catering and leisure services.

The ability of a local area to capture these effects depends on its existing industrial base and labour market. Evidence from offshore wind studies suggests that labour demand is often concentrated in technical occupations, including mechanics, electricians, blacksmiths and workers with vocational technical training (COWI, 2022). Although Østerild is not an offshore wind service port, this literature is relevant because it shows that local impacts depend on whether project-related demand can be matched by local skills, suppliers and facilities.

In addition to immediate expenditure effects, local impacts may also develop through longer-term mechanisms. Sylvest (2020) develops a theory of change in which immediate project outputs may evolve into broader local outcomes, such as improved supplier capabilities, new know-how, access to future markets, increased local visibility and economic diversification. For Østerild, this implies that the test center may generate local value not only through current expenditure, but also through learning effects, supplier upgrading and the strengthening of the local area's position within the wind-energy sector.

7.6 Primary data collection

The empirical estimation focuses on expenditure effects that can be quantified, assigned a local content assumption and allocated to industries. For this purpose, primary data were collected from the main actors involved in the operation and testing activities at the Østerild Test Center: DTU, Siemens Gamesa and Vestas. These sources provide three distinct inputs to the model. DTU data provide observed expenditure by cost type and industry. Siemens Gamesa data provide the main cost structure linking turbine and component activity to expenditure. Vestas data provide supplier-level and local expenditure information used to assess local-content assumptions and industry allocation.

The period of analysis covers the most recent five years, as the latest generation of turbines has mainly been installed during this period. Earlier turbine models were not considered fully comparable, since their cost structure, scale and operational requirements differ significantly from those of the current generation.

DTU Test Center accounting data were requested and classified according to the 14 industries used in the economic impact model. This classification was completed for two years of O&M and three years of CAPEX. In addition, DTU provided a qualitative rule-of-thumb estimate of the local share associated with each cost category. As a general criterion, expenditures were considered local when the supplier of the good or service was located within the defined local area.

DTU also provided total CAPEX and O&M figures for the period 2012–2024 in current DKK. Based on the available years with detailed industry classification, average industry shares and local-content shares were calculated separately for CAPEX and O&M. These shares were then applied to the annual total expenditure series in order to estimate industry-specific DTU costs for each year included in the analysis. The resulting DTU CAPEX and O&M series by industry and local content constitute a direct input to the demand shock vector used in the input–output model.

For test-center users, Siemens Gamesa provided the most complete cost information. Siemens Gamesa operates stands 1, 6, 7 and 8, as shown in Table 1. The information included costs related to turbine commissioning and decommissioning, main-component replacement, foundations and regular operations. These data are used as the main cost structure for linking the observed number of turbine installations, turbine removals and main-component replacements to expenditure.

Vestas operates stands 2, 3, 4 and 5. The information provided by Vestas was based mainly on expert judgement and internal experience from turbine projects at Østerild. These figures should therefore be interpreted with caution, as they are not systematically based on invoice-level or purchase-order data. Vestas also emphasized that turbine projects can vary considerably in scope and expenditure, and that any extrapolation of these figures to other projects, time periods or geographical contexts is the responsibility of DTU. For this reason, the Vestas information is not used as a complete cost model. Instead, it is used to assess the plausibility of local-content assumptions and to refine the allocation of expenditure across industries.

In addition to indicative cost estimates, Vestas provided names of specific local suppliers. This information made it possible to identify the industries most likely to receive each type of expenditure. Where supplier names were known, the closest industry category was assigned using company-level information from the Danish Central Business Register (CVR), including registered industry codes and industry descriptions where available.

7.7 Cost model elaboration

The cost model is constructed in three steps. First, physical activity at the test center is represented as a time series of turbine installations, turbine decommissioning events, and main-component replacements for each stand, as reported in Appendix Table A6. In this context, main-component replacements refer primarily to gearboxes, blades and generators. Second, this activity is linked to expenditure using the Siemens Gamesa cost model, complemented by the DTU CAPEX and O&M series described above. Third, the local content of each Siemens Gamesa cost category is estimated using Vestas input, local supplier information, and evidence on the local industrial structure.

The expenditure model combines the Siemens Gamesa cost structure with the Vestas information. The Siemens Gamesa dataset links project activity to cost categories, including commissioning, decommissioning, main-component replacement, foundations and regular operations, while Vestas provides more specific evidence on local expenditure. Together, they provide sufficient information to extrapolate the framework to the remaining stands, including GE Renewable Energy stand 9, for which no direct expenditure information was requested.

The Vestas and GE Renewable Energy stands were therefore assumed to follow a broadly similar cost structure, adjusted where relevant to reflect the known number of stands, turbine installations and component replacement activity during the period of analysis. Foundation costs for the Vestas and GE Renewable Energy stands were estimated using the average foundation cost reported in the Siemens Gamesa information.

The Vestas input was then used to estimate the local-content shares assigned to the Siemens Gamesa cost categories. Its observed local expenditure for selected categories complements the total cost estimates provided by Siemens Gamesa. The underlying assumption is that comparable cost items for Siemens Gamesa and Vestas in the 10–20 MW turbine category are of the same order of magnitude. Since the Vestas expenditure is observed as local, the implied local content share for each comparable Siemens Gamesa category is calculated as the ratio between the observed local Vestas expenditure and the corresponding Siemens Gamesa total cost estimate.

This procedure was applied to accommodation, catering and food, and contractor-related overhead costs, including equipment, site facilities, electrical services and utilities. The resulting local-content shares were then applied to the corresponding categories in variable O&M related to turbine and main-component commissioning and decommissioning.

For foundations, the local content share could not be inferred directly from the Vestas information. However, foundations are assumed to have a high local content because concrete represents an important part of the foundation cost and the local area has substantial capacity in concrete, gravel and sand-related activities. As shown in Table A4, the enterprise SLQ for *manufacture of concrete and bricks* (230020) is 2.0. At a more detailed level, there is also evidence of local specialization in *manufacture of concrete products for construction purposes* (236100), *manufacture of ready-mixed concrete* (236300), and *operation of gravel and sand pits, mining of clays and kaolin* (081200), with enterprise SLQs of 3.6, 4.8 and 5.7, respectively. Given both the size of foundation-related expenditure and the strong local specialization in these activities, foundations are likely to represent the main CAPEX spillover from the test-center operations.

Crane rental and mobilization/demobilization costs were treated more cautiously. Both the Siemens Gamesa and Vestas information indicate that these expenditures are associated with BMS, but the available information does not make it possible to determine how much of this expenditure is captured locally. For this reason, these costs are assigned a low local content share of 5 percent. A zero local share is not assumed, since some local subcontracting is still plausible. The local area also shows some relevant specialization in *civil engineering* (420000), with an enterprise SLQ of 1.4, and *manufacture of lifting and handling equipment* (282200), with an enterprise SLQ of 2.9. However, since BMS could not be consulted directly, the assumed local content remains deliberately conservative.

The local-content assumptions used in the cost model are summarized in Table 4.

Cost category	Local-content share
Users - CAPEX - Main-component replacements	
Catering and food	92%
Accommodation	83%
Site preparation	80%
Cranes	10%
Users - CAPEX - Turbine replacements	
Catering and food	92%
Accommodation	83%
Site preparation	80%
Cranes	10%
Users - CAPEX - Foundations & civil works	
Foundation	100%
Civil works for transformers	50%
Users - O&M - User operations & site support	
Catering and food	92%
Accommodation	83%
Electricity for operation of stands	80%
Equipment	80%
Site facilities	80%
Technical services	80%
DTU - CAPEX	
Accommodation and food service activities	100%
Construction	80%
Head-office activities and consultancy	15%
Electrical equipment	10%
Services to buildings and landscape	5%
DTU - O&M	
Sewerage and waste management	100%
Construction	90%
Accommodation and food service activities	60%
Electrical equipment	33%
Manufacture of fabricated metal products	30%
Electricity, gas and other utilities	15%
Head-office activities and consultancy	15%
Public administration and related activities	10%
Rental and leasing activities	10%
Land transport	5%
Retail sale	5%

Table 4: Local-content assumptions by model expenditure category and cost item.

The resulting dataset should be understood as a best estimate of local expenditure rather than as an audited accounting record. It combines the time series of turbine and main-component activity, DTU accounting data, the Siemens Gamesa cost structure, Vestas supplier-level input and local-content assumptions in order to construct the industry-level demand shock required for the input–output estimation.

8 Results

8.1 Test-center demand and local sourcing

The demand modeled for the Østerild Test Center totals approximately DKK 1,500 million over 2020–2024, equivalent to an annual average of DKK 300 million. CAPEX accounts for DKK 1,418 million over the period, or DKK 284 million annually, while O&M accounts for DKK 82 million, or DKK 16 million annually. The modeled activity is therefore predominantly capital-intensive, combining recurring component replacements with more irregular installation and construction events.

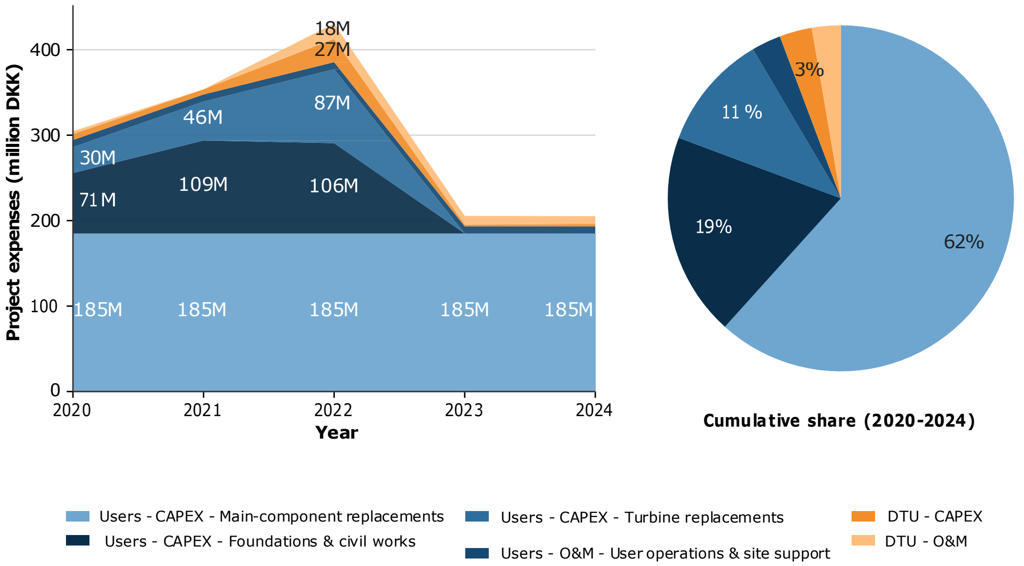


Figure 23: Evolution and cumulative distribution of modeled demand at the Østerild Test Center by cost category, 2020–2024.

Figure 23 shows the composition and annual evolution of demand. Main-component replacements account for DKK 925 million, or 62% of cumulative demand, providing recurring CAPEX throughout the period. Foundations and civil works account for 19%, turbine replacements for 11%, and the remainder for DTU investment and O&M by DTU and test-center users.

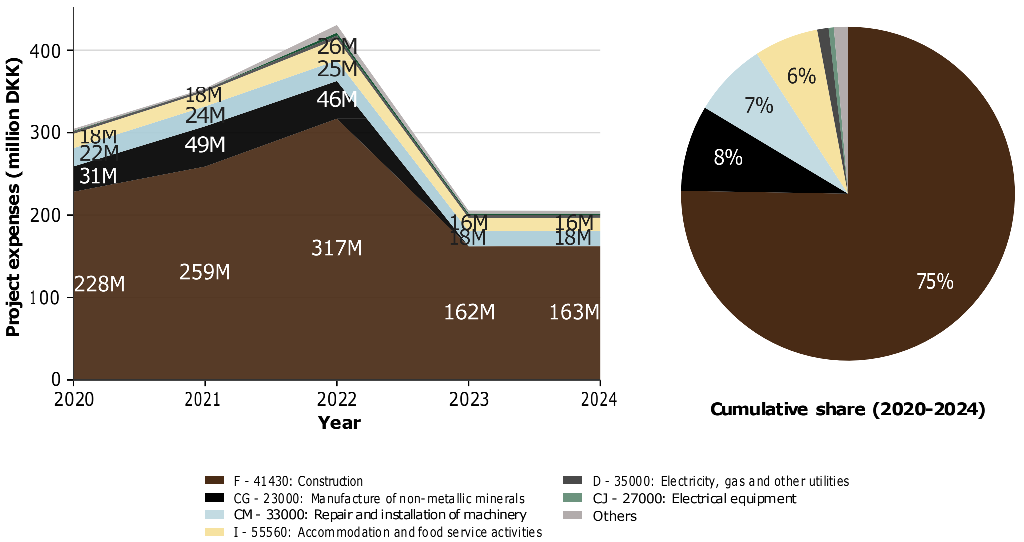


Figure 24: Evolution and cumulative distribution of modeled demand at the Østerild Test Center by supplying industry, 2020–2024.

This composition explains the temporal profile of demand. Main-component replacements maintain a recurring level of CAPEX activity, while foundations, turbine installations and turbine replacements generate the largest annual peaks. Routine O&M provides a smaller and more continuous demand flow.

Figure 24 shows that approximately 75% of modeled project demand is assigned to construction. This reflects the importance of foundations, civil works, installation, decommissioning and major replacement activities. Other receiving industries include manufacture of non-metallic mineral products, particularly concrete products used in foundations and related civil works, as well as accommodation and food services, repair and installation of machinery, utilities and electrical equipment. The demand shock is therefore concentrated in construction and related material inputs.

Figure 25 shows that modeled local demand totals approximately DKK 505 million over 2020–2024, equivalent to an annual average of DKK 101 million. Locally sourced CAPEX accounts for DKK 459 million over the period, or DKK 92 million annually, while locally sourced O&M accounts for DKK 46 million, or DKK 9 million annually. These amounts correspond to local-content shares of 32.3% for CAPEX, 56.5% for O&M and approximately 34% overall. The remaining demand is sourced outside the local area, either elsewhere in Denmark or abroad.

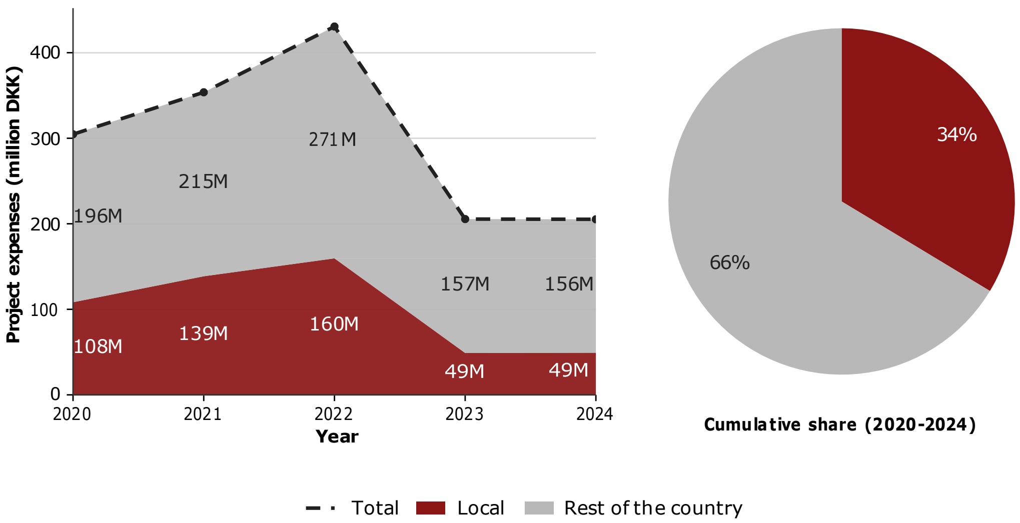


Figure 25: Evolution and cumulative distribution of modeled demand at the Østerild Test Center by geography, 2020–2024.

Although O&M has the higher local-content share, CAPEX accounts for most local demand because of its much larger scale. Applying the item-level assumptions in Table 4 to the demand composition of each model category produces the consolidated local-content shares reported in Table 5.

Cost category	Local-content share
Users – CAPEX – Main-component replacements	20%
Users – CAPEX – Turbine replacements	22%
Users – CAPEX – Foundations & civil works	72%
Users – O&M – User operations & site support	83%
DTU – CAPEX	62%
DTU – O&M	30%

Table 5: Consolidated local-content shares by model demand category, 2020–2024.

The category-level results show substantial variation in local retention. Foundations and civil works have a high local-content share because concrete products and related construction inputs can be supplied locally. User O&M also has a high local-content share because it includes accommodation, food services, site facilities and other locally available services. By contrast, main-component and tur-bine replacements have lower local-content shares because much of their demand is associated with specialized equipment, cranes and technical services sourced elsewhere in Denmark.

Annual local retention therefore varies with the composition of demand. Years dominated by foundations, civil works and locally supplied services have higher local-content shares, while years dominated by specialized technical campaigns, crane services and turbine-related inputs rely more heavily on suppliers elsewhere in Denmark or abroad. The test center generates local demand mainly through construction, concrete-related manufacturing and service capacities already present in the local economy, while remaining connected to specialized external supply chains.

The resulting dataset should be understood as a best estimate of local demand rather than as an audited record of transactions. It combines the time series of turbine and main-component activity, DTU accounting data, the Siemens Gamesa cost structure, Vestas supplier-level input and explicit local-content assumptions to construct the industry-level local demand shock required for the input–output estimation.

8.2 Local economic impacts

The DKK 505 million in modeled local demand identified above provides the basis for estimating the local economic impacts of the Østerild Test Center over 2020–2024. Equivalent to DKK 101 million annually, this demand comprises approximately DKK 92 million in CAPEX and DKK 9 million in O&M. The two channels are assessed separately because they differ in timing, industrial composition and local supply-chain linkages.

Including indirect effects through local supplier linkages and induced effects from household consumption, the annual local demand generates a total local effect of approximately DKK 140 million in output, DKK 58.3 million in GVA and 65.9 FTE jobs under the baseline assumptions. Table 6 shows the contribution of each effect type.

Effect	Direct	Indirect	Induced	Total
Output	101	15	23	140
GVA	38	6.5	13	58
Employment	49	6.5	10	66

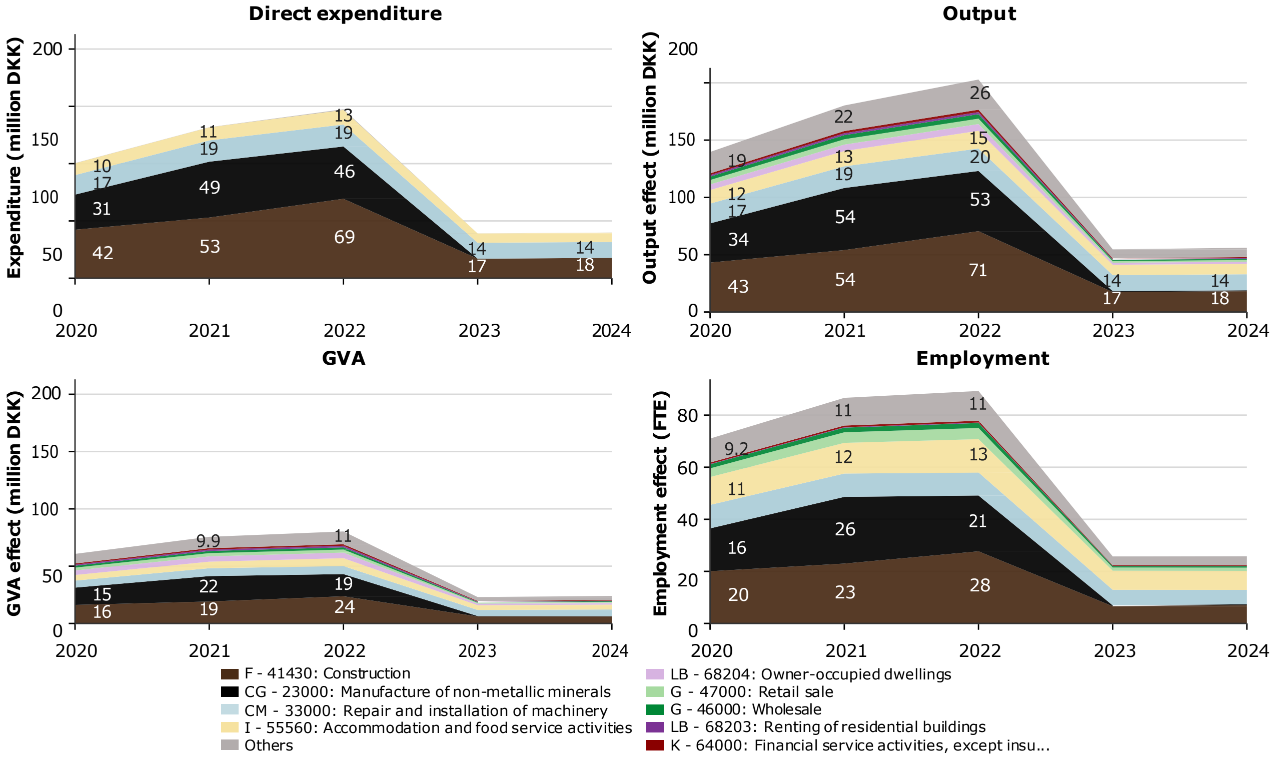
Table 6: Average annual local economic impacts generated by Østerild Test Center project demand under the baseline assumptions, 2020–2024.

Note: Indirect effects capture local supplier linkages, while induced effects capture household consumption supported by labor income. Output and GVA are reported in million DKK; employment is reported in FTE. Values are rounded.

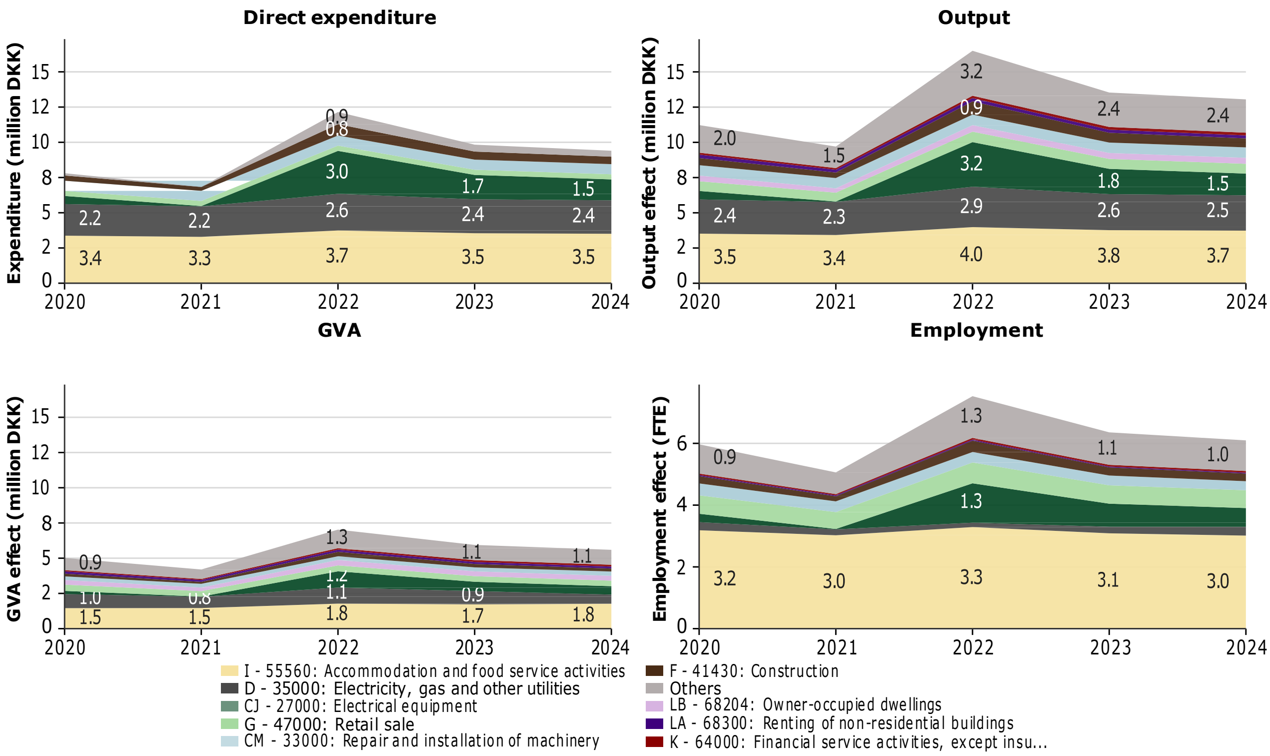
CAPEX accounts for approximately DKK 127 million in output, DKK 52.7 million in GVA and 59.7 FTE jobs, while O&M accounts for approximately DKK 13 million in output, DKK 5.6 million in GVA and 6.2 FTE jobs.

Figure 26 presents the annual industry distribution of the two project-demand channels. Panels a and b show CAPEX and O&M, respectively. In each panel, direct local demand is followed by the resulting total output, GVA and employment effects, including direct, indirect and induced components.

The annual average of DKK 92 million in local CAPEX demand generates approximately DKK 127 million in output and DKK 52.7 million in GVA, supporting 59.7 FTE jobs. Its annual effects follow an irregular investment cycle, with CAPEX-related employment at 26–89 FTE jobs across years. Peaks are associated with foundation construction, turbine installations and turbine replacements, while main-component replacements maintain activity between them. These effects represent temporary local activity supported by project demand rather than permanent employment at the test center and remain concentrated in construction and material-related industries, with additional activity in accommodation and food services.



(a) CAPEX



(b) O&M

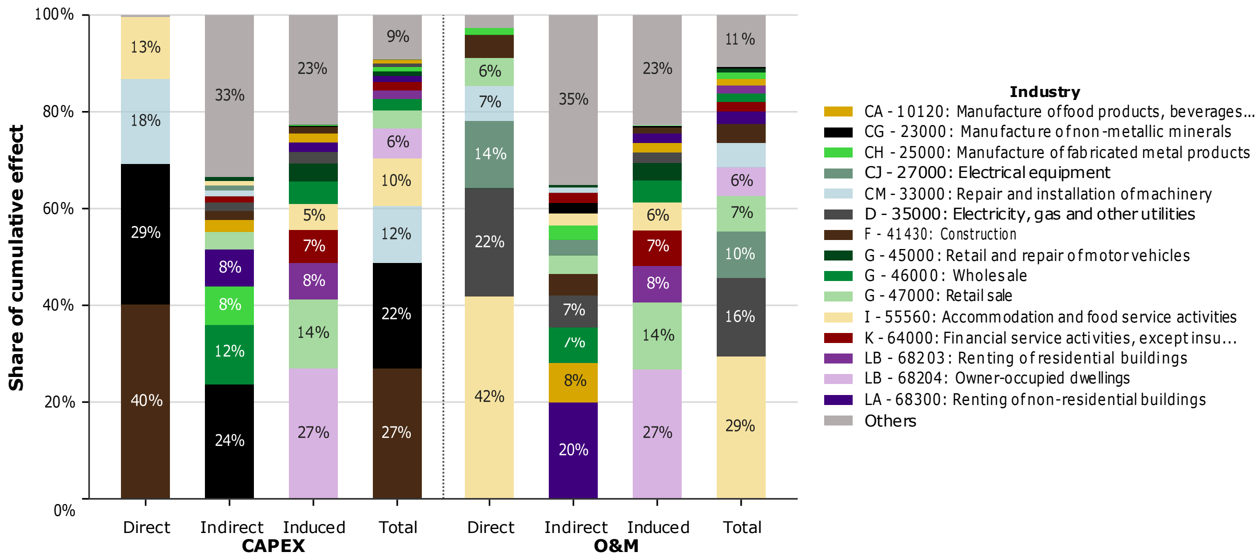
Figure 26: Annual industry distribution of direct local demand and estimated total effects on output, GVA and employment generated by project demand, 2020–2024.

The annual average of DKK 9 million in local O&M demand generates approximately DKK 13 million in output and DKK 5.6 million in GVA, supporting 6.2 FTE jobs. Its effects are smaller but more recurrent, reflecting continuing demand for operation, maintenance, technical support and local services. Its direct demand and resulting effects are also more diversified across machinery repair and

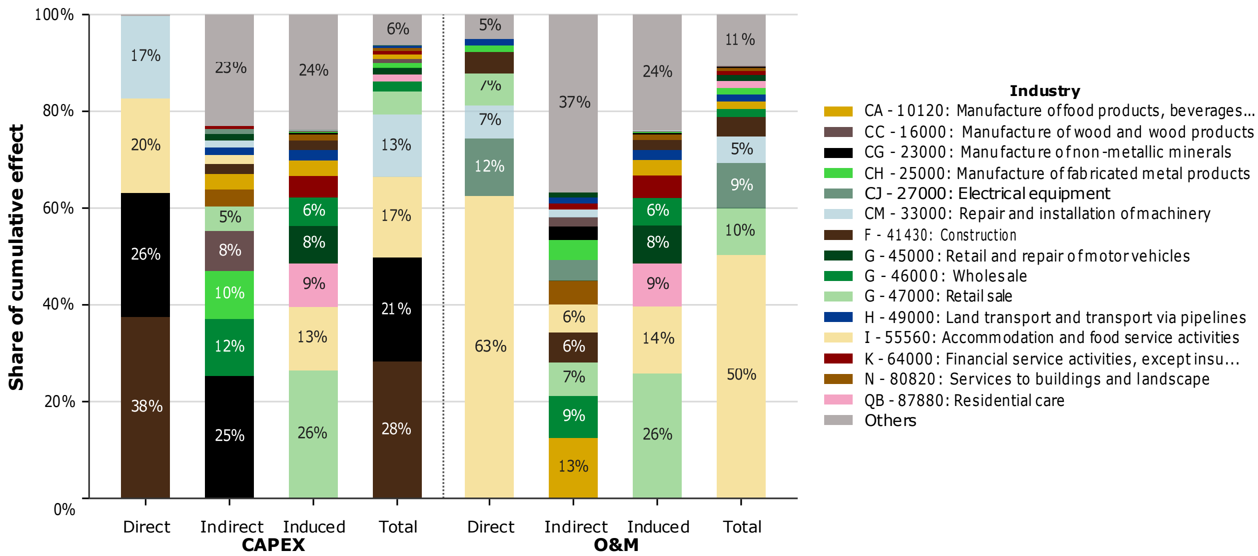
installation, construction, accommodation and food services and other operational suppliers.
The difference between direct demand and total output in Figures 26a–26b represents the additional ac-

tivity transmitted through local supply chains and household consumption. The GVA and employment panels also show that industries receiving the initial demand do not necessarily contribute proportionally to GVA and employment.

Figure 27 compares the cumulative GVA and employment effects by channel and effect type. Panels a and b report compositional shares rather than absolute magnitudes.



(a) GVA



(b) Employment

Figure 27: Industry distribution of estimated local GVA and employment effects from project demand by channel and effect type, 2020–2024.

For CAPEX, direct GVA is concentrated in construction (54%) and manufacture of non-metallic mineral products (45%), particularly concrete products used in foundations and related civil works. Direct O&M GVA is more diversified, with accommodation and food services (34%), machinery repair and installation (28%) and construction (17%) as the main receiving industries.

Indirect CAPEX GVA remains concentrated in manufacture of non-metallic mineral products (32%) and wholesale trade (13%), consistent with a construction-led channel based on materials and distribution. Indirect O&M GVA is more fragmented: non-residential property rental accounts for 17%, construction for 12%, wholesale trade for 9% and utilities for 6%, while the remaining 50% is distributed across other industries.

Induced GVA is similar across channels because it follows the same household-consumption mechanism. It is concentrated in owner-occupied dwellings (27%), retail sale (14–15%), residential property rental (8%), financial services (6–7%) and accommodation and food services (5–6%). Housing rents and financial flows therefore capture a substantial share of induced GVA.

Comparison of panels a and b shows that industries capturing GVA do not necessarily generate proportional employment, particularly in real-estate activities.

CAPEX employment closely follows its GVA composition. Direct employment is concentrated in construction (56%) and manufacture of non-metallic mineral products (44%), which also dominate total CAPEX employment at 41% and 35%, respectively. Indirect employment is led by manufacture of non-metallic mineral products (33%) and wholesale trade (12%).

O&M employment differs more clearly from its GVA composition. Indirect employment is led by wholesale trade (10%), food, beverage and tobacco manufacturing (9%), machinery repair and installation (7%), retail sale (6%) and construction (5%). Total O&M employment is concentrated in accommodation and food services (39%), machinery repair and installation (20%), construction (12%) and wholesale trade (6%).

Induced employment is concentrated in labor-intensive local services, particularly retail sale (26–27%), accommodation and food services (13–14%), residential care (9%), motor-vehicle trade and repair (8%) and wholesale trade (6%).

Overall, CAPEX transforms a larger and more irregular demand shock into concentrated construction and materials spillovers, whereas O&M generates smaller but more diversified operational linkages. O&M GVA is partly captured by property and service suppliers, while its employment effects flow primarily to wholesale, repair, hospitality and other labor-intensive local services.

8.2.1 Sensitivity analysis

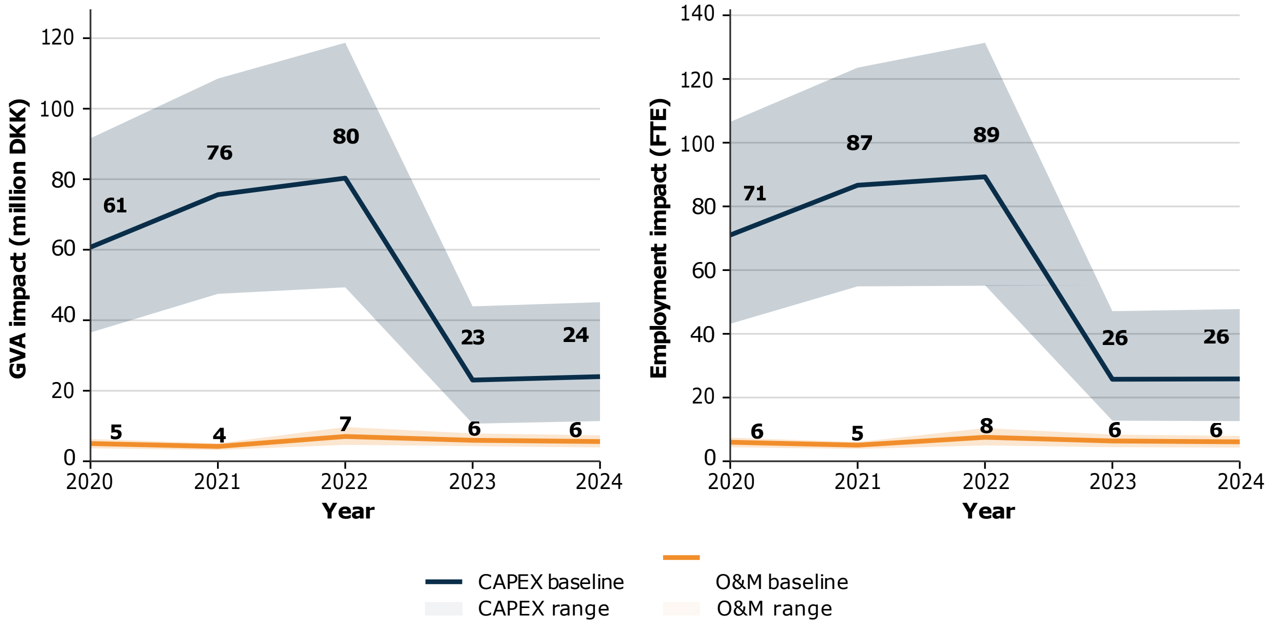
The estimated impacts depend mainly on two assumptions: the share of demand supplied locally and the frequency of main-component replacements. The timing and number of turbine replacements and associated foundation works are known, and the model assumes that both occur together. By contrast, the number of main-component replacements during 2020–2024 is not observed. Reasonable alternative frequencies are therefore used to assess how this uncertainty affects the results.

Effect	Scenario	Direct	Indirect	Induced	Total
Output (million DKK)	Low	55	7.9	12	75
	Baseline	101	15	23	140
	High	180	29	42	250
GVA (million DKK)	Low	21	3.3	7.2	32
	Baseline	38	6.5	13	58
	High	67	12	24	103
Employment (FTE)	Low	27	3.3	5.6	36
	Baseline	49	6.5	10	66
	High	84	13	19	116

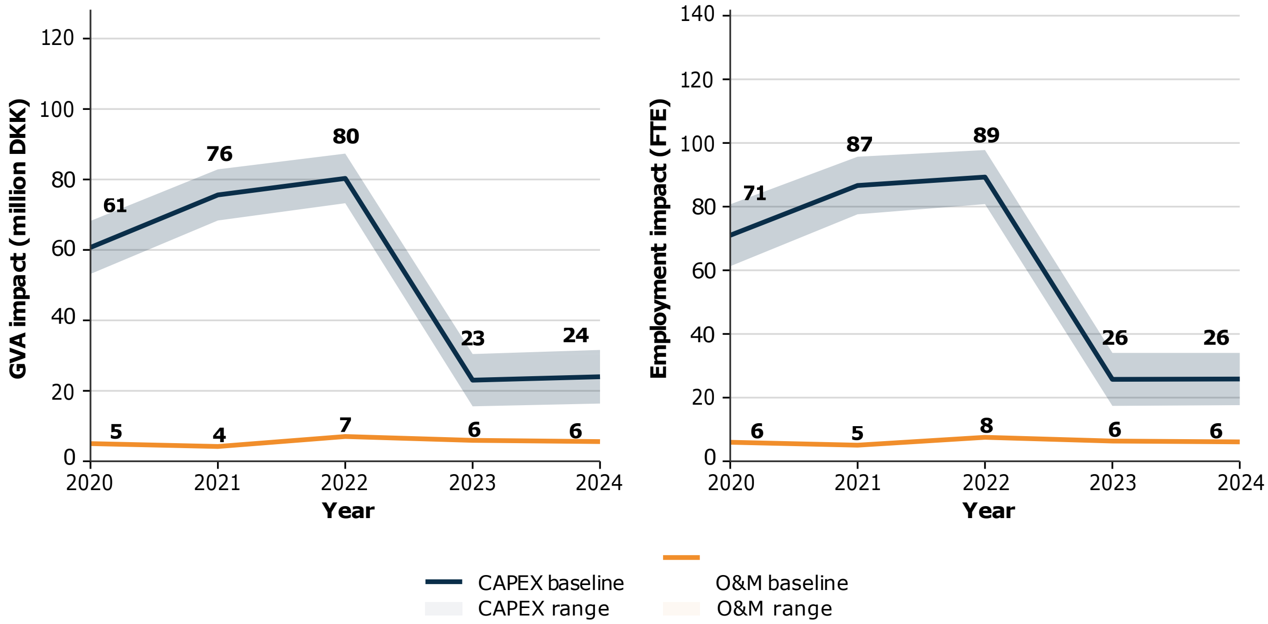
Table 7: Average annual local economic impacts generated by Østerild Test Center project demand under alternative local-content and main-component replacement assumptions, 2020–2024.

The Low scenario reduces the baseline local-content shares by 20 percentage points and assumes one main-component replacement per stand per year. The Baseline uses the estimated local-content shares and assumes 1.5 replacements, while the High scenario increases the local-content shares by 20 percentage points and assumes two replacements. These cases represent alternative modeling assumptions rather than statistical confidence intervals.

Across the combined scenarios, average annual impacts are DKK 74.9–250.1 million in output, DKK 31.6–103.1 million in GVA and 35.8–115.5 FTE jobs. The Baseline corresponds to the estimates presented above: DKK 139.5 million in output, DKK 58.3 million in GVA and 65.9 FTE jobs.



(a) Local-content sensitivity



(b) Main-component replacement sensitivity

Figure 28: Sensitivity of estimated local impacts to local-content and main-component replacement assumptions, 2020–2024.

Figure 28 subsequently isolates the contribution of each assumption by varying it separately while holding the remaining model inputs constant. The local-content sensitivity varies the baseline shares by 20 percentage points in each direction, changing the proportion of CAPEX and O&M expenditure introduced as a local demand shock. The main-component sensitivity varies the assumed annual number of replacements per stand between 1 and 2, with 1.5 used as the middle case. Common axis limits are used across both exercises to facilitate comparison.

8.3 Benchmarking against conventional wind farms

The results for the Østerild Test Center should not be interpreted as the impacts of a conventional wind farm. Conventional projects are generally evaluated in relation to installed capacity, construction expenditure, operational expenditure and decommissioning. The test center is instead a testing and innovation infrastructure whose local effects arise from recurrent O&M, turbine replacements, site works and technical services. The benchmark is therefore used as an interpretative reference rather than as a direct counterfactual.

The main reference is the QBIS socio-economic impact study of offshore wind, which reports local employment generated for suppliers, contractors, developers and operators in Danish offshore-wind projects (Sylvest, 2020). Installation and grid connection provide the closest comparison to CAPEX-related activity at Østerild, while operation and maintenance provide the closest comparison to recurrent O&M activity.

Table 8 compares employment intensity, measured as total FTE per million EUR of total local output, for Østerild and the QBIS benchmarks. The Østerild values are calculated from the baseline average annual impacts reported in Table 7. Tourism is excluded because it represents visitor-related service demand and comparable effects are not available for the benchmark projects.

Benchmark	**Phase**	**Local expenditure/output** (million EUR)	**Total FTE**	**FTE per million EUR**
Østerild Test Center	CAPEX	8.8–31.3	31.5–107.5	3.4–3.6
QBIS Esbjerg	Installation	304–495	869–1,415	2.9
QBIS Other ports	Installation	10.6–28.0	30–96	2.8–3.4
Østerild Test Center	O&M	1.2–2.3	4.4–8.0	3.6
QBIS Esbjerg	O&M	34–48	91–130	2.7
QBIS Other ports	O&M	3.2–9.1	59–81	8.9–18.4

Table 8: Employment intensity benchmark for Østerild Test Center and selected Danish offshore-wind local benchmarks.

Note: All output/turnover and employment impacts reported in this table are total impacts, including direct, indirect and induced effects, for both Østerild and all QBIS benchmarks. The Østerild range reports average annual impacts under the low and high combined sensitivity scenarios, converted at DKK 7.45 per EUR. O&M values are annual.

Employment intensity provides a different perspective from absolute employment levels. CAPEX-related activity at Østerild generates 3.4–3.6 FTE per million EUR of total local output, compared with 2.9 FTE for Esbjerg and 2.8–3.4 FTE for other ports. The estimates are therefore of the same order of magnitude as the comparable installation benchmarks.

O&M generates 3.6 FTE per million EUR of total local output, compared with 2.7 FTE for Esbjerg and 8.9–18.4 FTE for other ports. The Østerild estimate is therefore close to the Esbjerg benchmark but below the range reported for the other ports.

The absolute employment values remain useful for describing scale, although not for comparing employment intensity. The Østerild baseline supports 59.7 annual FTE through CAPEX-related activity and 6.2 through O&M.

Studies of Energy Island Bornholm reinforce the interpretation of the sectoral results. COWI and CRT find that local opportunities from large wind-energy projects are often concentrated in port services, logistics, accommodation, catering, local transport, minor construction, maintenance and other service activities rather than turbine manufacturing itself (COWI, 2022; Hedetoft et al., 2023). This is consistent with the construction-related and recurrent service effects estimated for Østerild.

Overall, the benchmark indicates that Østerild's CAPEX employment intensity is comparable to the local impacts estimated by QBIS for offshore-wind ports. Its O&M employment intensity is similar to that reported for Esbjerg, although its absolute O&M impact is smaller. Tourism is interpreted separately because it supports visitor-facing local services rather than conventional wind-sector supply-chain activity.

8.3.1 Relative size within the local economy

The baseline average annual employment impact of 65.9 FTE is compared with average annual FTE employment in individual local industries over 2020–2024. Both are expressed as shares of total local-area FTE employment. The project estimate combines CAPEX and O&M effects and excludes tourism.

At 0.203% of local-area FTE employment, the project supports more employment than forestry (0.151%) and market-based education (0.169%). It is comparable in scale to postal and courier activities, renting of residential buildings, insurance and pension funding, manufacture of basic metals, and mining and quarrying.

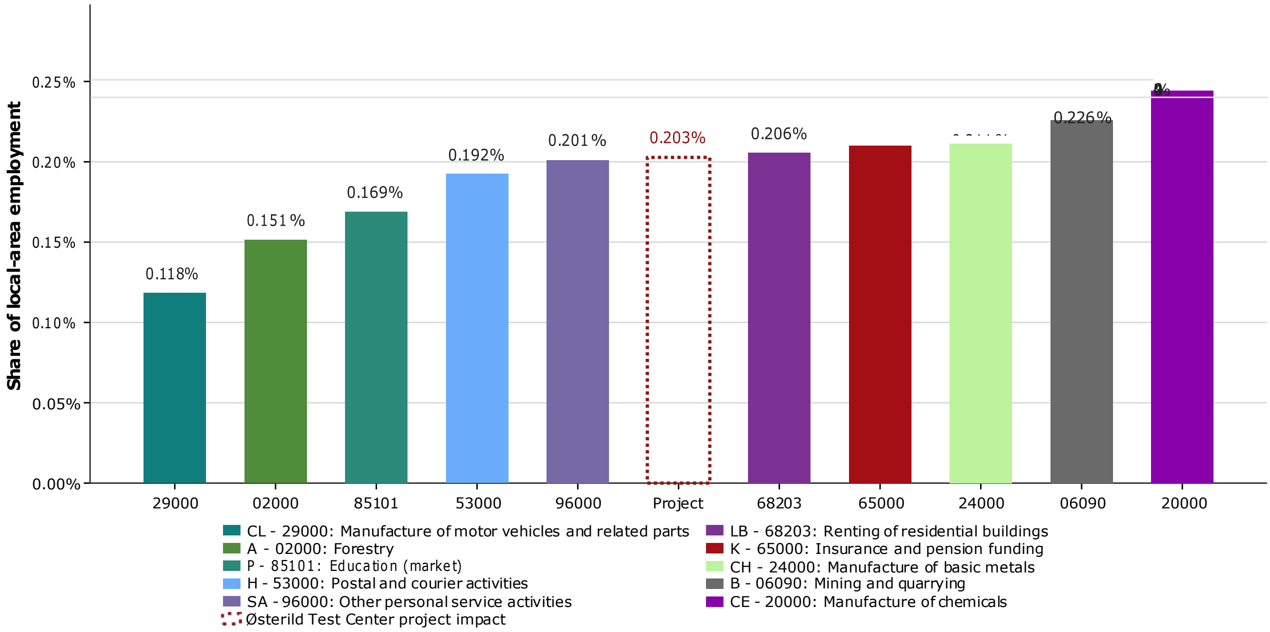


Figure 29: Baseline project employment impact as a share of local-area FTE employment, compared with local industries of a similar scale, 2020–2024.

Local industry employment is derived from compensation of employees in the regional input–output accounts using the same wage-per-FTE basis as the impact model. The comparison therefore places the project and local industries on a consistent basis.

8.4 Tourism

Visitor expenditure represents an additional source of local economic activity associated with the Østerild Test Center. It differs from the project demand analyzed above: CAPEX and O&M primarily affect construction, technical services and supply-chain industries, whereas visitor demand is concentrated in accommodation, restaurants, retail, transport and cultural activities.

The tourism analysis uses VisitDenmark's economic significance reports for 2018–2023 (Fonnesbech-Sandberg, 2025; Fonnesbech-Sandberg & Rich, 2020). These reports provide information on tourism consumption, accommodation and day-trip types, visitor origin, overnight stays, length of stay, daily expenditure and the composition of tourism demand.

8.4.1 Available information

At the municipal level, the available tourism variable is annual tourism consumption, measured in million DKK. The observations distinguish three forms of tourism: tourism with paid accommodation, tourism without paid accommodation and day trips. Corresponding municipal observations of arrivals and overnights are not available.

At the national level, VisitDenmark reports overnight stays by detailed accommodation and day-trip type, domestic or foreign origin and year. It also reports average daily expenditure and length of stay by accommodation or day-trip type and origin.

The available information further includes tourism consumption by accommodation type for *coastal and nature tourism* and the distribution of tourism expenditure across products such as accommodation, restaurants, local transport, travel services, culture and entertainment, marinas and retail purchases.

Each detailed national observation combines an accommodation or day-trip type, origin—domestic or foreign—and year. The *accommodation and day-trip types* retained in the analysis are:

- **Paid accommodation:** hotel holiday, hotel business, holiday centers, camping, hostels, rented holiday homes, pleasure boats and rented year-round homes.
- **Non-paid accommodation:** own holiday homes, borrowed holiday homes and stays with family or friends.
- **Day trips:** holiday day trips and business day trips.

8.4.2 Methodological framework

The analysis constructs comparable consumption, overnight-stay and arrival indicators for the local tourism sector and the Østerild Visitor Centre. Figure 30 summarizes the two procedures. The left-hand side derives the local tourism structure from municipal consumption and national tourism data, while the right-hand side applies this structure to the assumed Visitor Centre arrivals and estimates their associated local economic effects.

The local tourism indicators are estimated as follows:

1.1 Municipal tourism consumption is aggregated across the three municipalities while preserving the distinction between paid accommodation, non-paid accommodation and day trips. The resulting series is reported in Figure 31.

1.2 Within each form of tourism, national overnight stays are converted into joint shares across accommodation type–origin combinations. Assuming that the local area follows the national composition, these shares are applied to the corresponding local tourism consumption. The shares sum to one within each form of tourism.

1.3 Local consumption by accommodation type and origin is divided by national average daily expenditure to estimate overnight stays. The 2022 expenditure values are used in Steps 1.3 and 2.7 because they provide the most comprehensive coverage of the detailed tourism types. Holding them constant also prevents changes in expenditure assumptions from being interpreted as changes in tourism activity.

1.4 Estimated overnight stays are divided by average length of stay to obtain arrivals. Length-of-stay values are matched by year where available, with the latest observation used otherwise. The same estimation is performed for the North Denmark Region (Nordjylland) and the national benchmark. The resulting comparison is reported in Figure 32.

1.5 Domestic and foreign consumption and arrivals are combined within each accommodation type to calculate local consumption per arrival. The resulting measure varies by accommodation type but not by origin and provides the conversion used in Step 2.2.

1.6 Domestic and foreign arrival shares are calculated within each accommodation type. These shares sum to one and are used in Step 2.4.

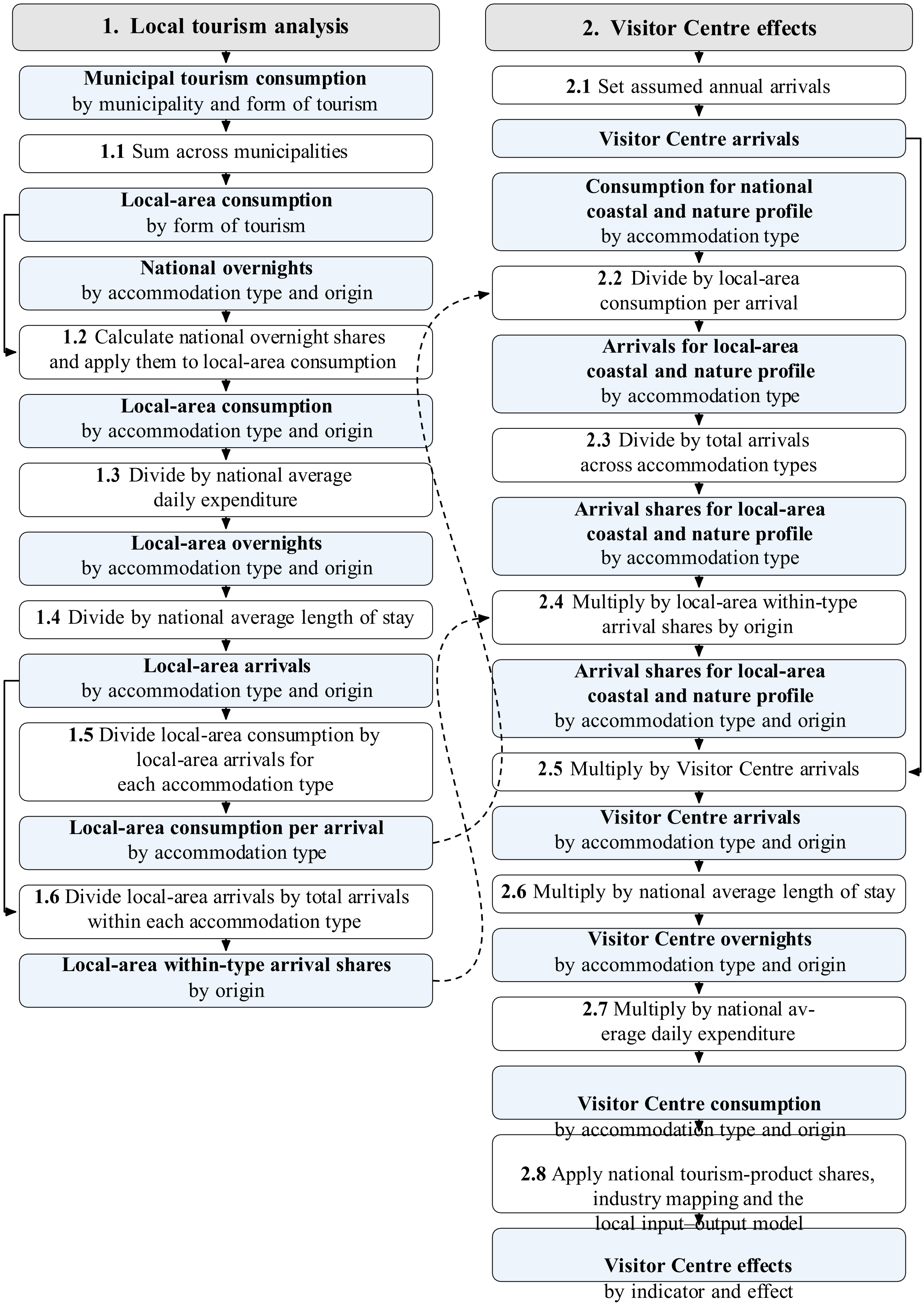


Figure 30: Method used to estimate local tourism activity and the visitor-related effects associated with the Østerild Visitor Centre.

The results of Steps 1.1–1.6 provide the local consumption-per-arrival estimates and within-type origin shares required for the Visitor Centre analysis. The visitor-related effects are estimated as follows:

2.1 The procedure begins with an assumed annual number of Visitor Centre arrivals, which provides the scale of the visitor-related demand estimate.

2.2 The accommodation mix of Visitor Centre arrivals is derived from the national *coastal and nature tourism* consumption profile. Because this profile is reported as consumption rather than arrivals, consumption for each accommodation type is divided by the corresponding local consumption per arrival. This accounts for differences in spending intensity across accommodation types.

2.3 The resulting arrivals are normalized across accommodation types, preserving the relative composition of the profile without carrying its national scale into the local analysis.

2.4 Assuming that the local-area origin composition also applies to Visitor Centre visitors, the accommodation-type shares are combined with the corresponding domestic and foreign shares to obtain arrival shares by accommodation type–origin.

2.5 These shares are applied to the assumed annual Visitor Centre arrivals, preserving the total while distributing it across accommodation types and origins.

2.6 Visitor Centre arrivals are converted into overnight stays using average length of stay.

2.7 Visitor Centre overnight stays are converted into consumption using average daily expenditure.

2.8 Consumption is distributed across tourism products using national expenditure shares differentiated by accommodation type and origin. Appendix Table A8 presents 2023 as an example, showing the variation in expenditure composition and the importance of retaining both dimensions when constructing the demand shock. Products are then mapped to the industries listed in Appendix Table A7. The resulting demand vector is introduced into the local input–output model to estimate direct, indirect, induced and total effects on output, GVA, labor income and employment.

8.4.3 Numerical implementation and results

The implementation begins with the observed municipal consumption data. Figure 31 presents annual tourism consumption after aggregating the municipal observations for the local area. It covers paid accommodation, non-paid accommodation and day trips and therefore represents the entire local tourism sector rather than consumption attributed to the Visitor Centre.

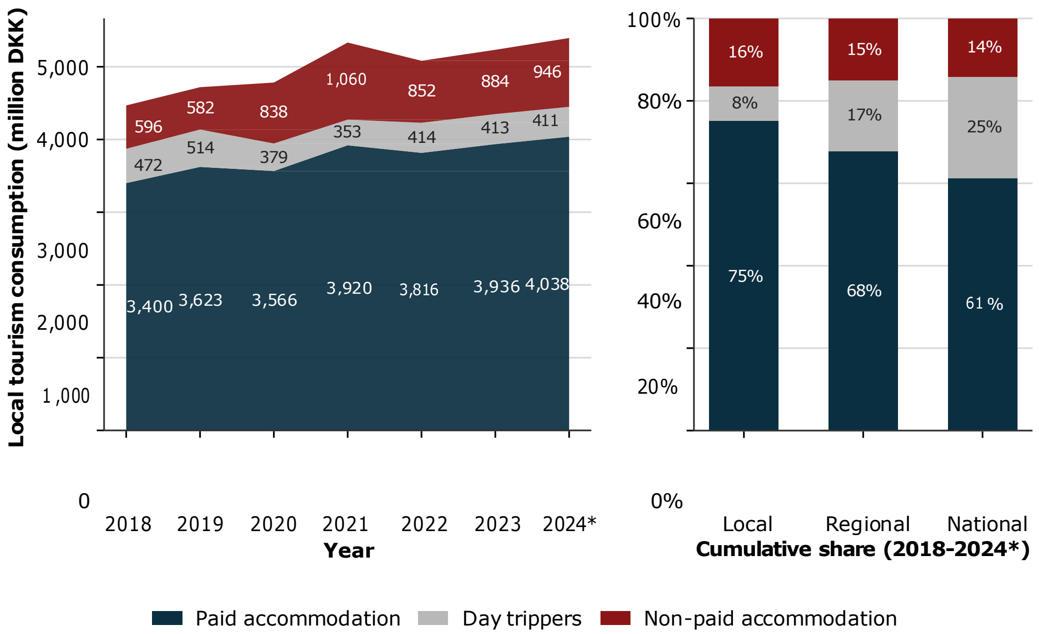


Figure 31: Annual tourism consumption in the local area from paid accommodation, non-paid

accommodation and day trips, 2018–2024.

National overnight shares are used to allocate this consumption across accommodation type–origin pairs. Applying the selected daily-expenditure values and average lengths of stay produces the estimated arrivals presented in Figure 32. Together, the observed consumption and estimated overnights and arrivals provide a consistent quantitative description of local tourism activity.

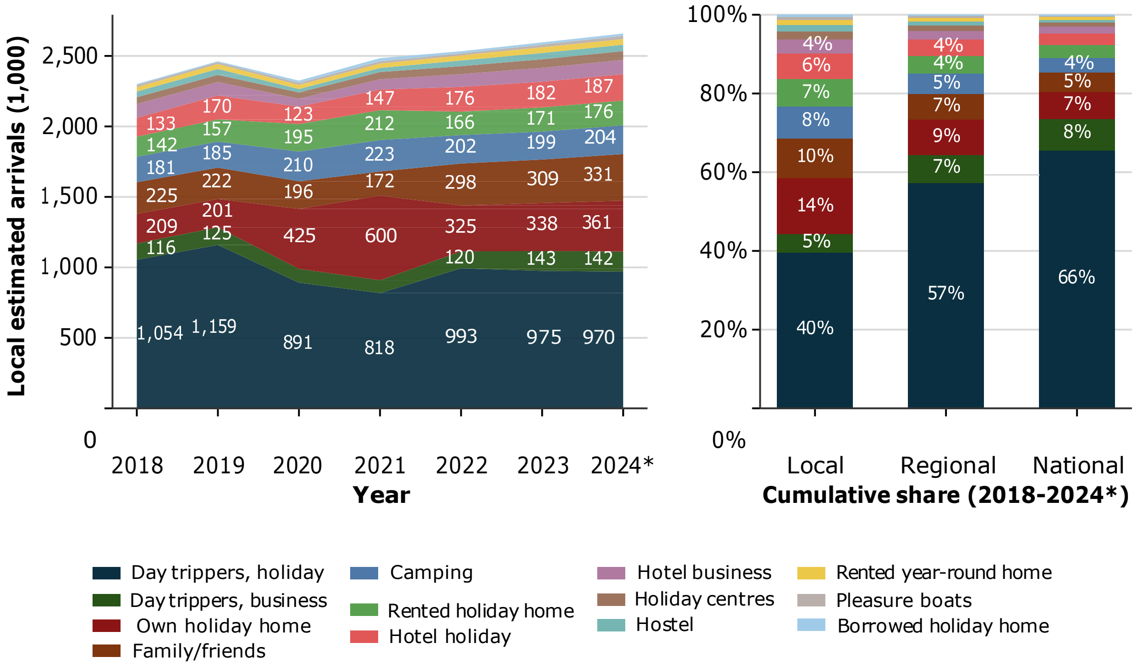


Figure 32: Estimated arrivals in the local tourism sector by accommodation type, 2018–2024.

The resulting local estimates are used to distribute Visitor Centre arrivals across accommodation type–origin pairs. Estimated consumption is then distributed across accommodation, restaurants, local transport, travel services, culture and entertainment, marinas, retail products and other tourism purchases using the corresponding expenditure profiles. These products are mapped to the input–output industries listed in Appendix Table A7, producing the industry-level demand vector introduced into the local input–output model.

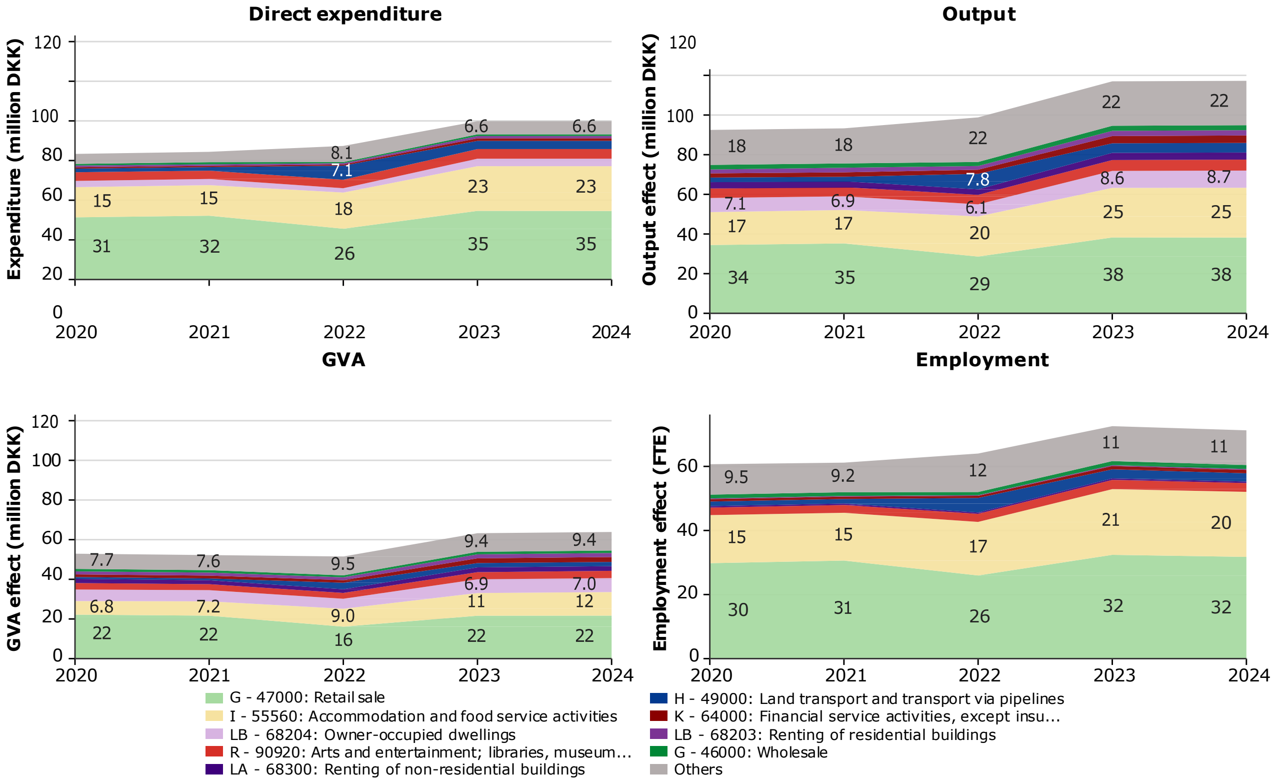
Effect	Scenario	Direct	Indirect	Induced	Total
Output (million DKK)	Low	36	5.1	11	52
	Middle	71	10	23	104
	High	106	15	34	156
GVA (million DKK)	Low	20	2.4	6.5	28
	Middle	39	4.8	13	57
	High	58	7.2	20	85
Employment (FTE)	Low	26	1.8	5.1	33
	Middle	52	3.6	10	66
	High	78	5.4	15	99

Table 9: Average annual local economic impacts associated with visitors to the Østerild Visitor Centre under Low, Middle and High scenarios of 25,000, 50,000 and 75,000 annual arrivals, respectively, 2020–2024.

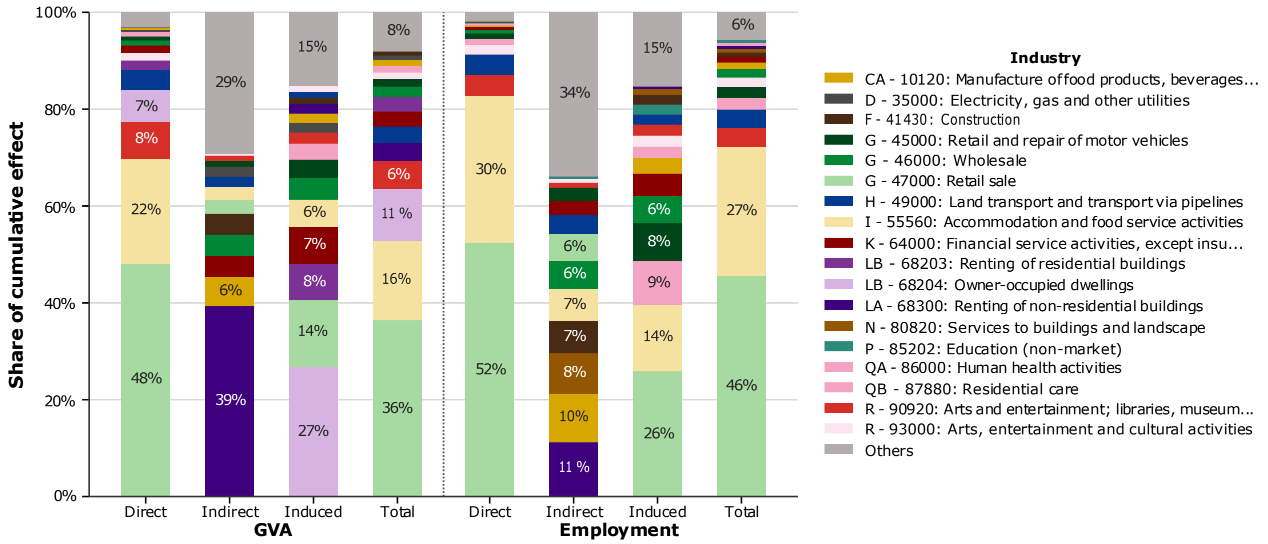
Table 9 reports the average annual effects under the Low, Middle and High Visitor Centre arrival assumptions. These represent alternative assumptions about the scale of visitor activity rather than minimum, average and maximum estimates of an observed outcome. The corresponding annual arrival assumptions are reported in the table note.

Under the Middle assumption of 50,000 annual arrivals, visitor expenditure is associated with DKK 103.8 million in output, DKK 56.8 million in GVA, DKK 35.8 million in labor earnings and 65.9 FTE jobs per year. The effects increase proportionally with assumed arrivals because accommodation shares, origin shares, length of stay, daily expenditure and input–output relationships are held constant across cases.

The Middle case is equivalent to approximately 2.0% of estimated arrivals, 1.6% of estimated overnights and 1.4% of estimated tourism consumption in the entire local tourism sector over 2020–2024. These comparisons place the assumed Visitor Centre activity within the scale of existing local tourism.



(a) Annual sectoral distribution of visitor-related effects



(b) GVA and employment composition by effect type

Figure 33: Industry distribution of estimated local economic effects associated with Visitor Centre

visitors, 2020–2024.

Figure 33 presents the sectoral composition of visitor-related effects. Panel a shows their annual distribution, while Panel b decomposes cumulative GVA and employment effects into direct, indirect and induced components.

Panel b shows that direct GVA is led by retail sale (48%), accommodation and food services (22%) and arts and entertainment (8%). Indirect GVA is dominated by non-residential property rental (39%), reflecting the role of local property owners as suppliers to retail and hospitality activities.

Induced GVA is concentrated in owner-occupied dwellings (27%), retail sale (14–15%), residential property rental (8%) and financial services (6–7%). Housing rents and financial flows therefore capture a substantial share of induced GVA.

The employment composition differs from that of GVA. Indirect employment is led by food, beverage and tobacco manufacturing (10%) and services to buildings and landscape (8%), while construction, accommodation and food services, motor-vehicle trade and repair, wholesale trade, retail sale and land transport each account for approximately 6–7%.

Total employment is concentrated in retail sale (46%), accommodation and food services (27%) and arts, entertainment and cultural activities (7%). Induced employment is also concentrated in labor-intensive services, particularly retail sale (26–27%), accommodation and food services (13–14%), residential care (9%), motor-vehicle trade and repair (8%) and wholesale trade (6%).

Overall, visitor-related activity mainly supports retail, hospitality and other visitor-facing services, while indirect GVA also reflects the role of local property owners.

These results should be interpreted as local economic activity associated with expenditure by visitors who also visit the Østerild Visitor Centre, rather than as a causal estimate of tourism generated by the test center. A counterfactual assessment relative to a no-test-center scenario is beyond the scope of the analysis.

9 Conclusions

The modeled demand associated with the Østerild Test Center totals approximately DKK 1,500 million over 2020–2024, equivalent to an annual average of DKK 300 million. CAPEX accounts for around DKK 1,418 million, or DKK 284 million annually, while O&M accounts for DKK 82 million, or DKK 16 million annually. Under the baseline reconstruction, main-component replacements account for DKK 925 million, or 62% of cumulative demand, providing recurring CAPEX activity between periods of foundation construction, turbine installation and turbine replacement. Foundations and civil works account for a further 19%, while turbine replacements account for 11%.

Approximately DKK 505 million of this demand is sourced locally over the study period, equivalent to DKK 101 million annually. This comprises approximately DKK 459 million in locally sourced CAPEX and DKK 46 million in locally sourced O&M, or annual averages of DKK 92 million and DKK 9 million, respectively. The overall local-content share is approximately 34%, with 32% for CAPEX and 57% for O&M. The remaining demand is sourced outside the local area, either elsewhere in Denmark or abroad. Despite its lower local-content share, CAPEX generates most local demand because of its much larger scale.

Around 75% of modeled project demand is assigned to construction, reflecting foundations, civil works, installation, decommissioning and replacement activities. Manufacture of non-metallic mineral products also receives demand, particularly through concrete products used in foundations and related civil works. Specialized turbine inputs, crane services and technical services are more frequently sourced outside the local area.

Under the baseline assumptions, the annual local demand generates approximately DKK 139.5 million in output, DKK 58.3 million in GVA and 65.9 FTE jobs. These estimates include direct, indirect and induced effects and therefore represent local economic activity supported by project demand rather than employment within the test center alone.

CAPEX accounts for approximately DKK 127 million in annual output, DKK 52.7 million in GVA and 59.7 FTE jobs, compared with approximately DKK 13 million in output, DKK 5.6 million in GVA and 6.2 FTE jobs for O&M. CAPEX-related employment varies across years within a range of 26–89 FTE jobs, following the timing of foundation construction, turbine installations and turbine replacements. Main-component replacements maintain activity between these periods, while O&M provides a smaller but more stable contribution.

The sectoral distribution of these effects reflects existing local capabilities. CAPEX effects are concentrated in construction and concrete-related manufacturing, with additional activity in accommodation and food services associated with personnel involved in project works. O&M supports accommodation and food services, machinery repair and installation, construction and other local services. The test center therefore generates local value mainly through activities already present in the local economy.

The sensitivity analysis addresses uncertainty in both local sourcing and main-component replacement activity. The number of foundation replacements and associated turbine replacements during the study period is known, and the two are assumed to occur together. By contrast, the number of main-component replacements is not observed. The Low, Baseline and High cases therefore assume one, 1.5 and two main-component replacements per stand per year, respectively, while adjusting the baseline local-content shares by −20, 0 and +20 percentage points. Across these combined scenarios, annual impacts range across DKK 74.9–250.1 million in output, DKK 31.6–103.1 million in GVA and 35.8–115.5 FTE jobs. The results are more sensitive to local-content assumptions than to main-component replacement frequency. These ranges represent alternative modeling assumptions rather than statistical confidence intervals.

The benchmark results support the plausibility of the estimates. Per million EUR of total local output, CAPEX supports 3.4–3.6 FTE jobs, comparable to the local impacts estimated by QBIS for Danish offshore-wind ports (Sylvest, 2020). O&M supports 3.6 FTE jobs per million EUR, similar to the employment intensity reported for Esbjerg, although its absolute impact is smaller.

The baseline project impact is equivalent to approximately 0.203% of total local-area FTE employment. It exceeds the employment scale of forestry and market-based education and is comparable to postal and courier activities, renting of residential buildings, insurance and pension funding, manufacture of basic metals, and mining and quarrying. This comparison places the project within the scale of recognizable local industries without implying that the supported employment consists of permanent positions at the test center.

Visitor expenditure represents a separate and more uncertain channel. Under the Middle assumption of 50,000 annual arrivals, expenditure by visitors who also visit the Østerild Visitor Centre is associated with DKK 103.8 million in output, DKK 56.8 million in GVA, DKK 35.8 million in labor earnings and 65.9 FTE jobs per year. Across assumptions of 25,000–75,000 annual arrivals, estimated employment ranges across 33–99 FTE jobs. These results describe local economic activity associated with visitor expenditure but do not establish how much tourism or spending is caused specifically by the Visitor Centre.

The employment estimates represent the labor required to satisfy additional demand, not net new jobs for local residents. The input–output model assumes that sufficient labor and productive capacity are available and does not account for local unemployment, skills mismatches, commuting, wage and price responses, production constraints or displacement from other sectors. The local-content results indicate that greater local retention would depend on stronger links between project actors and local firms and on local participation in procurement categories where suitable capabilities exist or can be developed.

Taken together, the study reaches two main conclusions. First, the Østerild Test Center supports a measurable level of local economic activity, primarily through construction, component replacement and other activities linked to its testing function. The scale of this contribution varies with the timing and local sourcing of project demand, while its sectoral distribution reflects the capabilities already present in the local economy.

Second, the study develops a transparent and reproducible methodology for estimating local impacts where publicly available data on interregional trade flows are limited. The approach combines national accounts, FLQ^+ regionalization, local employment data, project-specific demand and explicit local-content assumptions. It is grounded in the regionalization literature, avoids the mechanical application of national multipliers and can be replicated for other Danish municipalities with comparable data. Its consistency with relevant Danish wind-sector benchmarks further supports the plausibility of the estimates and the methodology's applicability to other case studies.

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A Appendix

A.1 NACE Rev. 2.1 statistical classification

Code	Description	Code	Description
A	Agriculture, forestry and fishing	H	Transportation
B	Mining and quarrying	I	Accommodation and food service activities
CA	Manufacture of food products, beverages and tobacco	JA	Publishing, television and radio broadcasting
CB	Textiles and leather products	JB	Telecommunications
CC	Wood and paper products and printing	JC	IT and information service activities
CD	Oil refinery etc.	K	Financial and insurance
CE	Manufacture of chemicals	LA	Real estate activities and renting of non-residential buildings
CF	Pharmaceuticals	LB	Dwellings
CG	Manufacture of plastic, glass and concrete	MA	Consultancy etc.
CH	Basic metals and fabricated metal products	MB	Scientific research and development
CI	Manufacture of electronic components	MC	Advertising and other business services
CJ	Electrical equipment	N	Travel agents, cleaning, and other operational services
CK	Manufacture of machinery	O	Public administration, defence and compulsory social security
CL	Transport equipment	P	Education
CM	Manufacture of furniture and other manufacturing etc.	QA	Human health activities
D	Electricity, gas, steam and air conditioning supply	QB	Residential care
E	Water supply, sewerage and waste management	R	Arts, entertainment and recreation activities
F	Construction	SA	Other service activities
G	Wholesale and retail trade	SB	Activities of households as employers of domestic personnel

Table A1: 36a2 Industry Classification

Code	Description	Code	Description
01000	Agriculture and horticulture	53000	Postal and courier activities
02000	Forestry	55560	Accommodation and food service activities
03000	Fishing	58000	Publishing activities
06090	Mining and quarrying	59600	Motion picture and television programme prod
10120	Manufacture of food products, beverages and tobacco	61000	Telecommunications
13150	Textiles and leather products	62630	IT and information service activities
16000	Manufacture of wood and wood products	64000	Financial service activities
17000	Manufacture of paper and paper products	65000	Insurance and pension funding
18000	Printing etc.	66000	Other financial activities
19000	Oil refinery etc.	68100	Buying and selling of real estate
20000	Manufacture of chemicals	68300	Renting of non-residential buildings
21000	Pharmaceuticals	68203	Renting of residential buildings
22000	Manufacture of rubber and plastic products	68204	Owner-occupied dwellings
23000	Manufacture of other non-metallic mineral products	69700	Legal and accounting activities
24000	Manufacture of basic metals	71000	Architectural and engineering activities
25000	Manufacture of fabricated metal products	72001	Scientific research and development (market)
26000	Manufacture of electronic components	72002	Scientific research and development (non-market)
27000	Electrical equipment	73000	Advertising and market research
28000	Manufacture of machinery	74750	Other professional, scientific and technical activities
29000	Manufacture of motor vehicles and related parts	77000	Rental and leasing activities
30000	Manufacture of ships and other transport equipment	78000	Employment activities
31320	Manufacture of furniture and other manufacturing	79000	Travel agent activities
33000	Repair and installation of machinery and equipment	80820	Security and investigation; services to buildings
35000	Electricity, gas, steam and air conditioning supply	84202	Public administration etc.
36000	Water collection, purification and supply	84101	Rescue service etc. (market)
37390	Sewerage; waste collection, treatment and disposal act.	85202	Education (non-market)
41430	Construction	85101	Education (market)
45000	Wholesale and retail trade and repair of motor vehicles	86000	Human health activities
46000	Wholesale	87880	Residential care
47000	Retail sale	90920	Arts and entertainment; libraries, museums and other
49000	Land transport and transport via pipelines	93000	Sports activities and amusement and recreation
50000	Water transport	94000	Activities of membership organisations
51000	Air transport	95000	Repair of personal goods
52000	Support activities for transportation	96000	Other personal service activities
		97000	Activities of households as domestic personnel

Table A2: 69 Industry Classification

A.2 Location quotients

Category	Absolute			Share (%)			LQ	
	National	Region	Local	National	Region	Local	Region	Local
TOTAL	**3,114,886**	**293,508**	**46,210**	**100.0**	**100.0**	**100.0**		
Primary	**70,200**	**12,602**	**3,499**	**2.3**	**4.3**	**7.6**	**1.9**	**3.4**
A Agriculture, forestry and fishing	66,594	12,177	3,410	2.1	4.1	7.4	1.9	3.5
B Mining and quarrying	3,606	425	89	0.1	0.1	0.2	1.3	1.7
Secondary	**552,919**	**62,278**	**11,330**	**17.8**	**21.2**	**24.5**	**1.2**	**1.4**
C Manufacturing	331,892	39,898	7,894	10.7	13.6	17.1	1.3	1.6
CA Manufacture of food, beverages and...	58,252	7,662	1,832	1.9	2.6	4.0	1.4	2.1
CB Textiles and leather products	5,459	831	58	0.2	0.3	0.1	1.6	0.7
CC Wood and paper products and printing	16,601	3,187	1,300	0.5	1.1	2.8	2.0	5.3
CE Manufacture of chemicals	12,844	583	93	0.4	0.2	0.2	0.5	0.5
CF Pharmaceuticals	40,868	697	1	1.3	0.2	0.0	0.2	0.0
CG Manufacture of plastic, glass and...	24,397	3,697	639	0.8	1.3	1.4	1.6	1.8
CH Basic metals and fabricated metal...	38,430	6,771	813	1.2	2.3	1.8	1.9	1.4
CI Manufacture of electronic components	16,611	1,051	180	0.5	0.4	0.4	0.7	0.7
CJ Electrical equipment	11,264	1,678	325	0.4	0.6	0.7	1.6	1.9
CK Manufacture of machinery	60,879	8,415	1,747	2.0	2.9	3.8	1.5	1.9
CL Transport equipment	7,076	1,270	81	0.2	0.4	0.2	1.9	0.8
CM Manufacture of furniture and other.	38,387	4,056	825	1.2	1.4	1.8	1.1	1.4
D_E Utility services	31,078	3,360	373	1.0	1.1	0.8	1.1	0.8
D Electricity, gas, steam and air...	16,544	1,742	198	0.5	0.6	0.4	1.1	0.8
E Water supply, sewerage and waste...	14,534	1,618	175	0.5	0.6	0.4	1.2	0.8
F Construction	189,949	19,020	3,063	6.1	6.5	6.6	1.1	1.1
Terciary	**2,491,767**	**218,628**	**31,381**	**80.0**	**74.5**	**67.9**	**0.9**	**0.8**
G_I Trade and transport etc.	746,330	66,251	10,148	24.0	22.6	22.0	0.9	0.9
G Wholesale and retail trade	468,168	43,874	6,746	15.0	14.9	14.6	1.0	1.0
H Transportation	141,412	9,665	1,364	4.5	3.3	3.0	0.7	0.7
I Accommodation and food service...	136,750	12,712	2,038	4.4	4.3	4.4	1.0	1.0
J Information and communication	128,723	8,582	565	4.1	2.9	1.2	0.7	0.3
JA Publishing, television and radio...	37,647	2,570	325	1.2	0.9	0.7	0.7	0.6
JB Telecommunications	12,028	968	24	0.4	0.3	0.1	0.9	0.1
JC IT and information service activities	79,048	5,044	216	2.5	1.7	0.5	0.7	0.2
K Financial and insurance	90,529	5,428	826	2.9	1.8	1.8	0.6	0.6
L Real estate activities	51,065	4,761	880	1.6	1.6	1.9	1.0	1.2
M_N Other business services	372,095	26,050	3,383	11.9	8.9	7.3	0.7	0.6
M Knowledge-based services	207,195	12,176	1,396	6.7	4.1	3.0	0.6	0.5
MA Consultancy etc.	145,615	9,273	958	4.7	3.2	2.1	0.7	0.4
MB Scientific research and development	21,703	468	44	0.7	0.2	0.1	0.2	0.1
MC Advertising and other business services	39,877	2,435	394	1.3	0.8	0.9	0.6	0.7
N Travel agents, cleaning, and other...	164,900	13,874	1,987	5.3	4.7	4.3	0.9	0.8
O_Q Public administration, education...	958,157	95,739	13,449	30.8	32.6	29.1	1.1	0.9
O Public administration, defence and...	163,214	15,844	1,469	5.2	5.4	3.2	1.0	0.6
P Education	230,921	22,249	3,141	7.4	7.6	6.8	1.0	0.9
Q Human health and social work	564,022	57,646	8,839	18.1	19.6	19.1	1.1	1.1
QA Human health activities	207,985	19,886	1,824	6.7	6.8	3.9	1.0	0.6
QB Residential care	356,037	37,760	7,015	11.4	12.9	15.2	1.1	1.3
R_S Arts, entertainment and other services	144,868	11,817	2,130	4.7	4.0	4.6	0.9	1.0
R Arts, entertainment and recreation...	67,422	5,654	1,134	2.2	1.9	2.5	0.9	1.1
S Other service activities etc.	77,446	6,163	996	2.5	2.1	2.2	0.8	0.9

Table A3: Employment and location quotients at the 36a2 sectoral resolution for Denmark, North Denmark Region, and Thisted, Morsø, and Jammerbugt, 2024.

Source: Statistics Denmark (2025d).

Category	Absolute			Share (%)			LQ	
	National	Region	Local	National	Region	Local	Region	Local
TOTAL	**416,316**	**40,443**	**7,866**	**100.0**	**100.0**	**100.0**		
Primary	**26,172**	**4,732**	**1,389**	**6.3**	**11.7**	**17.7**	**1.9**	**2.8**
A Agriculture, forestry and fishing	25,732	4,668	1,361	6.2	11.5	17.3	1.9	2.8
01000 Agriculture and horticulture	23,113	4,171	1,225	5.6	10.3	15.6	1.9	2.8
010000 Agriculture and horticulture	23,113	4,171	1,225	5.6	10.3	15.6	1.9	2.8
02000 Forestry	1,874	238	42	0.5	0.6	0.5	1.3	1.2
020000 Forestry	1,874	238	42	0.5	0.6	0.5	1.3	1.2
03000 Fishing	745	259	94	0.2	0.6	1.2	3.6	6.7
030000 Fishing	745	259	94	0.2	0.6	1.2	3.6	6.7
B Mining and quarrying	440	64	28	0.1	0.2	0.4	1.5	3.4
06090 Mining and quarrying	440	64	28	0.1	0.2	0.4	1.5	3.4
060000 Extraction of oil and gas	10	0	0	0.0	0.0	0.0	0.0	0.0
080090 Extraction of gravel and stone	131	28	13	0.0	0.1	0.2	2.2	5.3
090000 Mining support service activities	79	4	1	0.0	0.0	0.0	0.5	0.7
Secondary	**53,980**	**6,052**	**1,282**	**13.0**	**15.0**	**16.3**	**1.2**	**1.3**
C Manufacturing	15,553	1,863	440	3.7	4.6	5.6	1.2	1.5
CA Manufacture of food, beverages and tobacco	1,688	212	61	0.4	0.5	0.8	1.3	1.9
10120 Manufacture of food, beverages and tobacco	1,688	212	61	0.4	0.5	0.8	1.3	1.9
100010 Production of meat and meat products	125	18	4	0.0	0.0	0.1	1.5	1.7
100020 Processing and preserving of fish	83	43	17	0.0	0.1	0.2	5.3	10.8
100030 Manufacture of dairy products	82	9	2	0.0	0.0	0.0	1.1	1.3
100040 Manufacture of grain mill and bakery...	15	3	2	0.0	0.0	0.0	2.1	7.1
100050 Other manufacture of food products	1,101	113	28	0.3	0.3	0.4	1.1	1.3
110000 Manufacture of beverages	282	26	8	0.1	0.1	0.1	0.9	1.5
120000 Manufacture of tobacco products	0	0	0	0.0	0.0	0.0		
CB Textiles and leather products	764	64	6	0.2	0.2	0.1	0.9	0.4
13150 Textiles and leather products	764	64	6	0.2	0.2	0.1	0.9	0.4
130000 Manufacture of textiles	295	42	4	0.1	0.1	0.1	1.5	0.7
140000 Manufacture of wearing apparel	408	17	2	0.1	0.0	0.0	0.4	0.3
150000 Manufacture of leather and footwear	61	5	0	0.0	0.0	0.0	0.8	0.0
CC Wood and paper products and printing	1,074	120	31	0.3	0.3	0.4	1.2	1.5
16000 Manufacture of wood and wood products	485	63	18	0.1	0.2	0.2	1.3	2.0
160000 Manufacture of wood and wood products	485	63	18	0.1	0.2	0.2	1.3	2.0
17000 Manufacture of paper and paper products	115	11	3	0.0	0.0	0.0	1.0	1.4
170000 Manufacture of paper and paper products	115	11	3	0.0	0.0	0.0	1.0	1.4
18000 Printing etc.	474	46	10	0.1	0.1	0.1	1.0	1.1
180000 Printing etc.	474	46	10	0.1	0.1	0.1	1.0	1.1
CD Oil refinery etc.	15	2	0	0.0	0.0	0.0	1.4	0.0
19000 Oil refinery etc.	15	2	0	0.0	0.0	0.0	1.4	0.0
190000 Oil refinery etc.	15	2	0	0.0	0.0	0.0	1.4	0.0
CE Manufacture of chemicals	267	24	4	0.1	0.1	0.1	0.9	0.8
20000 Manufacture of chemicals	267	24	4	0.1	0.1	0.1	0.9	0.8
200010 Manufacture of basic chemicals	62	10	3	0.0	0.0	0.0	1.7	2.6
200020 Manufacture of paints and soap etc.	205	14	1	0.0	0.0	0.0	0.7	0.3
CF Pharmaceuticals	149	8	2	0.0	0.0	0.0	0.6	0.7
21000 Pharmaceuticals	149	8	2	0.0	0.0	0.0	0.6	0.7
210000 Pharmaceuticals	149	8	2	0.0	0.0	0.0	0.6	0.7
CG Manufacture of plastic, glass and concrete	926	109	24	0.2	0.3	0.3	1.2	1.4

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Category	Absolute			Share (%)			LQ	
	National	Region	Local	National	Region	Local	Region	Local
22000 Manufacture of rubber and plastic products	448	49	7	0.1	0.1	0.1	1.1	0.8
220000 Manufacture of rubber and plastic products	448	49	7	0.1	0.1	0.1	1.1	0.8
23000 Manufacture of other non-metallic...	478	60	17	0.1	0.1	0.2	1.3	1.9
230010 Manufacture of glass and ceramic products	85	10	2	0.0	0.0	0.0	1.2	1.2
230020 Manufacture of concrete and bricks	393	50	15	0.1	0.1	0.2	1.3	2.0
CH Basic metals and fabricated metal products	2,975	404	84	0.7	1.0	1.1	1.4	1.5
24000 Manufacture of basic metals	150	23	4	0.0	0.1	0.1	1.6	1.4
240000 Manufacture of basic metals	150	23	4	0.0	0.1	0.1	1.6	1.4
25000 Manufacture of fabricated metal products	2,825	381	80	0.7	0.9	1.0	1.4	1.5
250000 Manufacture of fabricated metal products	2,825	381	80	0.7	0.9	1.0	1.4	1.5
CI Manufacture of electronic components	578	43	11	0.1	0.1	0.1	0.8	1.0
26000 Manufacture of electronic components	578	43	11	0.1	0.1	0.1	0.8	1.0
260010 Manufacture of computers and...	264	23	5	0.1	0.1	0.1	0.9	1.0
260020 Manufacture of other electronic products	314	20	6	0.1	0.0	0.1	0.7	1.0
CJ Electrical equipment	482	60	11	0.1	0.1	0.1	1.3	1.2
27000 Electrical equipment	482	60	11	0.1	0.1	0.1	1.3	1.2
270010 Manufacture of electric motors, etc.	135	26	2	0.0	0.1	0.0	2.0	0.8
270020 Manufacture of wires and cables	31	2	1	0.0	0.0	0.0	0.7	1.7
270030 Manufacture of household appliances,...	316	32	8	0.1	0.1	0.1	1.0	1.3
CK Manufacture of machinery	1,819	232	63	0.4	0.6	0.8	1.3	1.8
28000 Manufacture of machinery	1,819	232	63	0.4	0.6	0.8	1.3	1.8
280010 Manufacture of engines, windmills and pumps	254	32	9	0.1	0.1	0.1	1.3	1.9
280020 Manufacture of other machinery	1,565	200	54	0.4	0.5	0.7	1.3	1.8
CL Transport equipment	286	34	8	0.1	0.1	0.1	1.2	1.5
29000 Manufacture of motor vehicles and...	139	14	4	0.0	0.0	0.1	1.0	1.5
290000 Manufacture of motor vehicles and...	139	14	4	0.0	0.0	0.1	1.0	1.5
30000 Manufacture of ships and other...	147	20	4	0.0	0.0	0.1	1.4	1.4
300000 Manufacture of ships and other...	147	20	4	0.0	0.0	0.1	1.4	1.4
CM Manufacture of furniture and other.	4,530	551	135	1.1	1.4	1.7	1.3	1.6
31320 Manufacture of furniture and other...	1,867	155	41	0.4	0.4	0.5	0.9	1.2
310000 Manufacture of furniture	668	59	21	0.2	0.1	0.3	0.9	1.7
320010 Manufacture of medical instruments, etc.	451	42	8	0.1	0.1	0.1	1.0	0.9
320020 Manufacture of toys and other manufacturing	748	54	12	0.2	0.1	0.2	0.7	0.8
33000 Repair and installation of machinery...	2,663	396	94	0.6	1.0	1.2	1.5	1.9
330000 Repair and installation of machinery...	2,663	396	94	0.6	1.0	1.2	1.5	1.9
D_E Utility services	2,582	564	131	0.6	1.4	1.7	2.2	2.7
D Electricity, gas, steam and air...	2,256	526	119	0.5	1.3	1.5	2.4	2.8
35000 Electricity, gas, steam and air...	2,256	526	119	0.5	1.3	1.5	2.4	2.8
350010 Production and distribution of electricity	1,703	428	93	0.4	1.1	1.2	2.6	2.9
350020 Manufacture and distribution of gas	137	16	2	0.0	0.0	0.0	1.2	0.8
350030 Steam and hot water supply	416	82	24	0.1	0.2	0.3	2.0	3.1
E Water supply, sewerage and waste management	326	38	12	0.1	0.1	0.2	1.2	1.9
36000 Water collection, purification and supply	0	0	0	0.0	0.0	0.0		
360000 Water collection, purification and supply	0	0	0	0.0	0.0	0.0		
37390 Sewerage; waste collection, treatment...	326	38	12	0.1	0.1	0.2	1.2	1.9
370000 Sewerage	0	0	0	0.0	0.0	0.0		
383900 Waste management and materials recovery	326	38	12	0.1	0.1	0.2	1.2	1.9

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Category	Absolute			Share (%)			LQ	
	National	Region	Local	National	Region	Local	Region	Local
F Construction	35,845	3,625	711	8.6	9.0	9.0	1.0	1.0
41430 Construction	35,845	3,625	711	8.6	9.0	9.0	1.0	1.0
410009 Construction of new buildings	4,214	463	57	1.0	1.1	0.7	1.1	0.7
420000 Civil engeneering	571	71	15	0.1	0.2	0.2	1.3	1.4
430003 Professionel repair and maintenance of...	23,450	2,304	475	5.6	5.7	6.0	1.0	1.1
430004 Own-account repair and maintenance of...	7,610	787	164	1.8	1.9	2.1	1.1	1.1
Terciary	**336,164**	**29,659**	**5,195**	**80.7**	**73.3**	**66.0**	**0.9**	**0.8**
G_I Trade and transport etc.	67,222	6,687	1,279	16.1	16.5	16.3	1.0	1.0
G Wholesale and retail trade	40,788	4,182	789	9.8	10.3	10.0	1.1	1.0
45000 Wholesale and retail trade and repair...	7,777	881	164	1.9	2.2	2.1	1.2	1.1
450010 Sale of motor vehicles	2,319	243	43	0.6	0.6	0.5	1.1	1.0
450020 Repair and maintenance of motor...	5,458	638	121	1.3	1.6	1.5	1.2	1.2
46000 Wholesale	15,271	1,359	215	3.7	3.4	2.7	0.9	0.7
460000 Wholesale	15,271	1,359	215	3.7	3.4	2.7	0.9	0.7
47000 Retail sale	17,740	1,942	410	4.3	4.8	5.2	1.1	1.2
470000 Retail sale	17,740	1,942	410	4.3	4.8	5.2	1.1	1.2
H Transportation	12,091	1,151	228	2.9	2.8	2.9	1.0	1.0
49000 Land transport and transport via pipelines	8,929	797	174	2.1	2.0	2.2	0.9	1.0
490010 Passenger rail transport, interurban	9	1	0	0.0	0.0	0.0	1.1	0.0
490020 Transport by suburban trains, buses...	4	0	0	0.0	0.0	0.0	0.0	0.0
490030 Freight transport by road and via pipeline	8,916	796	174	2.1	2.0	2.2	0.9	1.0
50000 Water transport	325	44	6	0.1	0.1	0.1	1.4	1.0
500000 Water transport	325	44	6	0.1	0.1	0.1	1.4	1.0
51000 Air transport	94	6	0	0.0	0.0	0.0	0.7	0.0
510000 Air transport	94	6	0	0.0	0.0	0.0	0.7	0.0
52000 Support activities for transportation	1,613	150	25	0.4	0.4	0.3	1.0	0.8
520000 Support activities for transportation	1,613	150	25	0.4	0.4	0.3	1.0	0.8
53000 Postal and courier activities	1,130	154	23	0.3	0.4	0.3	1.4	1.1
530000 Postal and courier activities	1,130	154	23	0.3	0.4	0.3	1.4	1.1
I Accommodation and food service activities	14,343	1,354	262	3.4	3.3	3.3	1.0	1.0
55560 Accommodation and food service activities	14,343	1,354	262	3.4	3.3	3.3	1.0	1.0
550000 Hotels and similar accommodation	1,728	239	69	0.4	0.6	0.9	1.4	2.1
560000 Restaurants	12,615	1,115	193	3.0	2.8	2.5	0.9	0.8
J Information and communication	20,660	1,073	127	5.0	2.7	1.6	0.5	0.3
JA Publishing, television and radio broadcasting	5,551	238	33	1.3	0.6	0.4	0.4	0.3
58000 Publishing activities	1,887	107	10	0.5	0.3	0.1	0.6	0.3
580010 Publishing	895	53	7	0.2	0.1	0.1	0.6	0.4
580020 Publishing of computer games and other...	992	54	3	0.2	0.1	0.0	0.6	0.2
59600 Motion picture and television programme...	3,664	131	23	0.9	0.3	0.3	0.4	0.3
590000 Motion picture and television...	3,544	124	20	0.9	0.3	0.3	0.4	0.3
600000 Radio and television broadcasting	120	7	3	0.0	0.0	0.0	0.6	1.3
JB Telecommunications	311	18	3	0.1	0.0	0.0	0.6	0.5
61000 Telecommunications	311	18	3	0.1	0.0	0.0	0.6	0.5
610000 Telecommunications	311	18	3	0.1	0.0	0.0	0.6	0.5
JC IT and information service activities	14,798	817	91	3.6	2.0	1.2	0.6	0.3
62630 IT and information service activities	14,798	817	91	3.6	2.0	1.2	0.6	0.3
620000 Computer programming, consultancy and...	13,545	739	83	3.3	1.8	1.1	0.6	0.3

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Category	Absolute			Share (%)			LQ	
	National	Region	Local	National	Region	Local	Region	Local
630000 Information service activities	1,253	78	8	0.3	0.2	0.1	0.6	0.3
K Financial and insurance	88,867	8,123	1,429	21.3	20.1	18.2	0.9	0.9
64000 Financial service activities, except...	87,202	8,018	1,419	20.9	19.8	18.0	0.9	0.9
640010 Monetary intermediation	88	6	4	0.0	0.0	0.1	0.7	2.4
640020 Mortgage credit institutes, etc.	87,114	8,012	1,415	20.9	19.8	18.0	0.9	0.9
65000 Insurance and pension funding	161	8	2	0.0	0.0	0.0	0.5	0.7
650000 Insurance and pension funding	161	8	2	0.0	0.0	0.0	0.5	0.7
66000 Other financial activities	1,504	97	8	0.4	0.2	0.1	0.7	0.3
660000 Other financial activities	1,504	97	8	0.4	0.2	0.1	0.7	0.3
LA Real estate activities and renting of...	8,551	849	94	2.1	2.1	1.2	1.0	0.6
68100 Buying and selling of real estate	4,661	533	52	1.1	1.3	0.7	1.2	0.6
680010 Buying and selling of real estate	4,661	533	52	1.1	1.3	0.7	1.2	0.6
68300 Renting of non-residential buildings	3,890	316	42	0.9	0.8	0.5	0.8	0.6
680030 Renting of non-residential buildings	3,890	316	42	0.9	0.8	0.5	0.8	0.6
LB Dwellings	30,593	3,451	646	7.3	8.5	8.2	1.2	1.1
68203 Renting of residential buildings	7,753	801	96	1.9	2.0	1.2	1.1	0.7
680023 Renting of residential buildings	7,753	801	96	1.9	2.0	1.2	1.1	0.7
68204 Owner-occupied dwellings	22,840	2,650	550	5.5	6.6	7.0	1.2	1.3
680024 Owner-occupied dwellings	22,840	2,650	550	5.5	6.6	7.0	1.2	1.3
M_N Other business services	62,641	4,476	744	15.0	11.1	9.5	0.7	0.6
M Knowledge-based services	41,567	2,591	365	10.0	6.4	4.6	0.6	0.5
MA Consultancy etc.	28,896	1,900	270	6.9	4.7	3.4	0.7	0.5
69700 Legal and accounting activities;...	21,001	1,316	169	5.0	3.3	2.1	0.6	0.4
690010 Legal activities	1,897	106	9	0.5	0.3	0.1	0.6	0.3
690020 Accounting and bookkeeping activities	4,882	364	67	1.2	0.9	0.9	0.8	0.7
700000 Business consultancy activities	14,222	846	93	3.4	2.1	1.2	0.6	0.3
71000 Architectural and engineering activities	7,895	584	101	1.9	1.4	1.3	0.8	0.7
710000 Architectural and engineering activities	7,895	584	101	1.9	1.4	1.3	0.8	0.7
MB Scientific research and development	866	48	7	0.2	0.1	0.1	0.6	0.4
72001 Scientific research and development (market)	801	48	7	0.2	0.1	0.1	0.6	0.5
720001 Scientific research and development...	801	48	7	0.2	0.1	0.1	0.6	0.5
72002 Scientific research and development...	65	0	0	0.0	0.0	0.0	0.0	0.0
720002 Scientific research and development...	65	0	0	0.0	0.0	0.0	0.0	0.0
MC Advertising and other business services	11,805	643	88	2.8	1.6	1.1	0.6	0.4
73000 Advertising and market research	3,720	225	24	0.9	0.6	0.3	0.6	0.3
730000 Advertising and market research	3,720	225	24	0.9	0.6	0.3	0.6	0.3
74750 Other professional, scientific and...	8,085	418	64	1.9	1.0	0.8	0.5	0.4
740000 Other technical business services	8,085	418	64	1.9	1.0	0.8	0.5	0.4
750000 Veterinary activities	0	0	0	0.0	0.0	0.0		
N Travel agents, cleaning, and other...	21,074	1,885	379	5.1	4.7	4.8	0.9	1.0
77000 Rental and leasing activities	3,567	443	98	0.9	1.1	1.2	1.3	1.5
770000 Rental and leasing activities	3,567	443	98	0.9	1.1	1.2	1.3	1.5
78000 Employment activities	1,295	132	22	0.3	0.3	0.3	1.0	0.9
780000 Employment activities	1,295	132	22	0.3	0.3	0.3	1.0	0.9
79000 Travel agent activities	692	44	9	0.2	0.1	0.1	0.7	0.7

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Category	Absolute			Share (%)			LQ	
	National	Region	Local	National	Region	Local	Region	Local
790000 Travel agent activities	692	44	9	0.2	0.1	0.1	0.7	0.7
80820 Security and investigation; services to...	15,520	1,266	250	3.7	3.1	3.2	0.8	0.9
800000 Security and investigation activities	537	33	5	0.1	0.1	0.1	0.6	0.5
810000 Services to buildings, cleaning and...	11,219	973	202	2.7	2.4	2.6	0.9	1.0
820000 Other business service activities	3,764	260	43	0.9	0.6	0.5	0.7	0.6
O_Q Public administration, education and health	30,238	2,466	405	7.3	6.1	5.1	0.8	0.7
O Public administration, defence and social...	316	23	7	0.1	0.1	0.1	0.7	1.2
84202 Public administration etc.	271	21	7	0.1	0.1	0.1	0.8	1.4
840010 Public administration	259	19	7	0.1	0.0	0.1	0.8	1.4
840022 Defence, public order, security and...	12	2	0	0.0	0.0	0.0	1.7	0.0
84101 Rescue service etc. (market)	45	2	0	0.0	0.0	0.0	0.5	0.0
840021 Rescue service etc. (market)	45	2	0	0.0	0.0	0.0	0.5	0.0
P Education	7,106	532	98	1.7	1.3	1.2	0.8	0.7
85202 Education (non-market)	1,288	137	37	0.3	0.3	0.5	1.1	1.5
850010 Primary education	0	0	0	0.0	0.0	0.0		
850020 Secondary education	623	65	22	0.1	0.2	0.3	1.1	1.9
850030 Higher education	575	67	14	0.1	0.2	0.2	1.2	1.3
850042 Education (non-market)	90	5	1	0.0	0.0	0.0	0.6	0.6
85101 Education (market)	5,818	395	61	1.4	1.0	0.8	0.7	0.6
850041 Education (market)	5,818	395	61	1.4	1.0	0.8	0.7	0.6
Q Human health and social work	22,816	1,911	300	5.5	4.7	3.8	0.9	0.7
QA Human health activities	19,439	1,584	229	4.7	3.9	2.9	0.8	0.6
86000 Human health activities	19,439	1,584	229	4.7	3.9	2.9	0.8	0.6
860010 Hospital activities	98	4	0	0.0	0.0	0.0	0.4	0.0
860020 Medical and dental practice activities	19,341	1,580	229	4.6	3.9	2.9	0.8	0.6
QB Residential care	3,377	327	71	0.8	0.8	0.9	1.0	1.1
87880 Residential care	3,377	327	71	0.8	0.8	0.9	1.0	1.1
870000 Residential care activities	904	110	27	0.2	0.3	0.3	1.3	1.6
880000 Social work activities without...	2,473	217	44	0.6	0.5	0.6	0.9	0.9
R_S Arts, entertainment and other services	27,392	2,534	471	6.6	6.3	6.0	1.0	0.9
R Arts, entertainment and recreation activities	8,248	726	131	2.0	1.8	1.7	0.9	0.8
90920 Arts and entertainment; libraries,...	4,105	231	38	1.0	0.6	0.5	0.6	0.5
900000 Theatres, concerts, and arts activities	3,834	184	27	0.9	0.5	0.3	0.5	0.4
910001 Libraries, museums and other cultural...	271	47	11	0.1	0.1	0.1	1.8	2.1
910002 Libraries, museums and other cultural...	0	0	0	0.0	0.0	0.0		
920000 Gambling and betting activities	0	0	0	0.0	0.0	0.0		
93000 Sports activities and amusement and...	4,143	495	93	1.0	1.2	1.2	1.2	1.2
930011 Sports activities (market)	3,545	429	77	0.9	1.1	1.0	1.2	1.1
930012 Sports activities (non-market)	0	0	0	0.0	0.0	0.0		
930020 Amusement and recreation activities	598	66	16	0.1	0.2	0.2	1.1	1.4
SA Other service activities	19,114	1,807	340	4.6	4.5	4.3	1.0	0.9
94000 Activities of membership organisations	5,893	615	143	1.4	1.5	1.8	1.1	1.3
940000 Activities of membership organisations	5,893	615	143	1.4	1.5	1.8	1.1	1.3
95000 Repair of personal goods	1,285	129	22	0.3	0.3	0.3	1.0	0.9
950000 Repair of personal goods	1,285	129	22	0.3	0.3	0.3	1.0	0.9
96000 Other personal service activities	11,936	1,063	175	2.9	2.6	2.2	0.9	0.8
960000 Other personal service activities	11,936	1,063	175	2.9	2.6	2.2	0.9	0.8
SB Activities of households as employers of...	30	1	0	0.0	0.0	0.0	0.3	0.0

Continued on next page

Category	Absolute			Share (%)			LQ	
	National	Region	Local	National	Region	Local	Region	Local
97000 Activities of households as employers...	10	1	0	0.0	0.0	0.0	1.0	0.0
970000 Activities of households as employers...	10	1	0	0.0	0.0	0.0	1.0	0.0

Table A4: Enterprise counts and location quotients at 117, 69, and 36a2 sectoral resolutions for Denmark, North Denmark Region, and Thisted, Morsø, and Jammerbugt, 2023.

Source: Statistics Denmark (2025c).

A.3 Synthetic employment procedure

The synthetic employment procedure uses three inputs defined at different levels of industrial aggregation: observed regional employment controls for 38 industries, denoted by $E^r_{h,t}$ and indexed by h; regional and national enterprise counts for 742 detailed industries, denoted by $B^r_{d,t}$ and $B^n_{d,t}$ and indexed by d; and national detailed employment for the same 742 industries, denoted by $E^n_{d,t}$. The final estimates are required in the 69–industry classification, indexed by k. Here, r is the region and t is the year.

National employment-per-enterprise ratios are computed at the detailed level:

$$\rho^E_{d,t} = \frac{E^n_{d,t}}{B^n_{d,t}}. \tag{54}$$

For a composite region r consisting of municipalities $M(r)$, municipal enterprise counts are summed as:

$$B^r_{d,t} = \sum_{m \in M(r)} B^m_{d,t}, \qquad M(r) = \{\text{Jammerbugt, Morsø, Thisted}\}. \tag{55}$$

The national ratios are applied to regional enterprise counts to obtain expected detailed regional employment:

$$\tilde{E}^r_{d,t} = B^r_{d,t}\rho^E_{d,t}. \tag{56}$$

The expected detailed employment estimates are then converted into shares within each 38-industry control sector. Let $I(h)$ be the set of detailed industries belonging to sector h. Then

$$s^{r,E}_{d|h,t} = \frac{\tilde{E}^r_{d,t}}{\sum_{j \in I(h)} \tilde{E}^r_{j,t}}. \tag{57}$$

These shares are used to distribute the observed employment totals across detailed industries:

$$\hat{E}^r_{d,t} = E^r_{h,t}\, s^{r,E}_{d|h,t}, \qquad d \in I(h). \tag{58}$$

By construction, the distributed estimates add up to the observed totals within each 38-industry control sector.

Finally, the detailed employment estimates are aggregated to the target 69–industry classification. Let $I(k)$ denote the set of detailed industries belonging to sector k in this classification. Then

$$E^r_{k,t} = \sum_{d \in I(k)} \hat{E}^r_{d,t}. \tag{59}$$

The resulting total-employment vector $E^r_{k,t}$ is used to compute the SLQ/CILQ location quotients. The same procedure is also applied to employee-only employment, using $E^{r,e}_{h,t}$ and $E^{n,e}_{d,t}$, to obtain $E^{r,e}_{k,t}$ for employee-based checks and full-time-equivalent employment indicators.

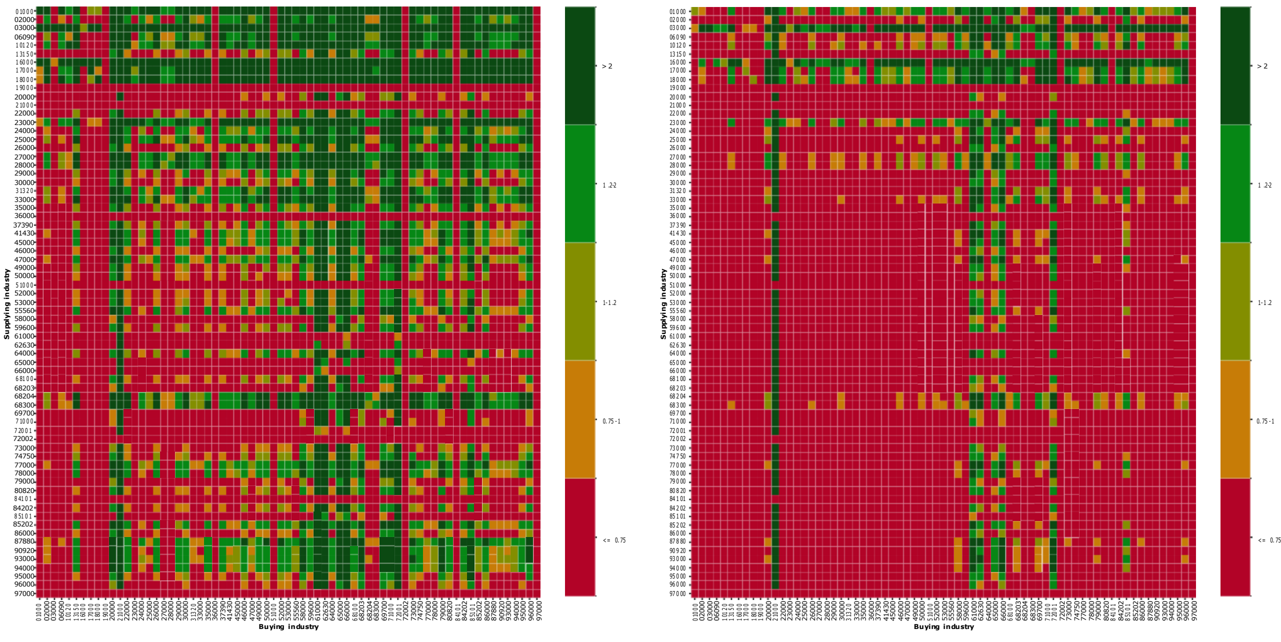
A.4 Model calibration

Year	Mean Y	log(β)	δ	SE	t	p-value	CI low	CI high	N	MSE
2008	-1.1289	-3.6690	0.3077	0.0075	40.9826	1.90×10^{-257}	0.2930	0.3224	1738	1.3180
2009	-1.1436	-3.6878	0.3101	0.0077	40.4461	9.94×10^{-252}	0.2951	0.3251	1716	1.3710
2010	-1.1260	-3.6903	0.3051	0.0078	39.3529	5.68×10^{-241}	0.2899	0.3203	1691	1.3835
2011	-1.1279	-3.6927	0.3055	0.0078	39.1884	1.41×10^{-239}	0.2902	0.3207	1693	1.4017
2012	-1.1264	-3.7062	0.3039	0.0078	38.8240	1.96×10^{-236}	0.2886	0.3193	1696	1.4267
2013	-0.9781	-3.7113	0.2635	0.0056	46.7066	6.27×10^{-304}	0.2525	0.2746	1647	0.7218
2014	-0.9987	-3.7179	0.2686	0.0056	48.0508	1.84×10^{-312}	0.2576	0.2796	1598	0.6898
2015	-0.9877	-3.7391	0.2642	0.0055	47.9540	5.73×10^{-318}	0.2534	0.2750	1698	0.7199
2016	-0.9957	-3.7494	0.2656	0.0055	48.0607	9.09×10^{-320}	0.2547	0.2764	1712	0.7344
2017	-0.9942	-3.7589	0.2645	0.0056	47.1648	2.59×10^{-307}	0.2535	0.2755	1637	0.7270
2018	-1.0021	-3.7668	0.2660	0.0059	45.4538	3.37×10^{-293}	0.2546	0.2775	1651	0.8020
2019	-0.9365	-3.7784	0.2479	0.0053	46.8292	9.29×10^{-305}	0.2375	0.2583	1643	0.6567
2020	-0.9255	-3.7850	0.2445	0.0053	46.1524	3.80×10^{-299}	0.2341	0.2549	1648	0.6623
2021	-0.9148	-3.7979	0.2409	0.0052	46.4124	3.04×10^{-301}	0.2307	0.2510	1645	0.6387
2022	-0.9062	-3.8128	0.2377	0.0051	46.3570	1.93×10^{-298}	0.2276	0.2477	1606	0.6134
2023	-0.8982	-3.8333	0.2343	0.0051	45.8327	2.16×10^{-294}	0.2243	0.2443	1614	0.6195
2024	-1.0755	-3.8498	0.2794	0.0079	35.1956	1.38×10^{-203}	0.2638	0.2949	1675	1.5632

Table A5: Annual regression estimates of the FLQ+ delta parameter for Thisted, Morsø, and Jammerbugt, 2008–2024.

A.5 Additional model outputs

Figure A1 compares the traditional CILQ adjustment with the calibrated FLQ adjustment for the combined local area. The figure illustrates the intensity of the adjustment applied to the national technical coefficients. Without the regional size adjustment introduced by the FLQ, and relying solely on the CILQ method, the adjustment would be less nuanced. Red and orange dots indicate downward adjustments to the national technical coefficients, while the remaining values remain unchanged.



(a) CILQ

(b) FLQ with optimal δ

Figure A1: FLQ vs. CILQ for Thisted, Morsø, and Jammerbugt, 2024.

The CILQ measures the intensity of transactions between supplying and purchasing industries. A high CILQ indicates that regional supply is relatively larger compared to the demand of the purchasing sector, whereas a low CILQ suggests that regional supply is insufficient relative to expected demand. Each cell in the matrix is therefore used as a reference for adjusting the regional technical coefficients: when regional supply is lacking for a specific transaction, the corresponding input is assumed to be sourced from outside the region.

In the heatmap of Figure A1a, horizontal red bands indicate that local industries are too small to act as suppliers for others, while greener horizontal patterns indicate stronger local capacity to meet regional demand. Vertical lines carry a different interpretation: red vertical patterns do not necessarily indicate the absence of a sector, but rather its inability to meet input requirements locally. Green vertical patterns often correspond to smaller regional sectors whose relatively modest demand can be satisfied within the region.

Taking into account that industrial categories are not neutral in the way they are ordered—primary sectors (A–B), secondary sectors (C–F), and tertiary sectors (G–U), also reflecting increasing levels of complexity—some patterns emerge from the heatmap. Despite the absence of certain manufacturing sectors in the region, such as oil refining (CD), chemicals (CE), electronic components (CI), and pharmaceuticals (CF), there are still significant clusters of activity in the extractive industries (A–B), primary manufacturing (CA and CC), and secondary industries (CG–CK). By contrast, the area corresponding to service activities (JA–QA) reflects the weaker local specialization in services, unlike larger urban centres such as Aarhus or Copenhagen. Nevertheless, there is evidence of an industrial base in activities related to construction, metals, and electrical equipment, which may be relevant for projects requiring material-intensive inputs.

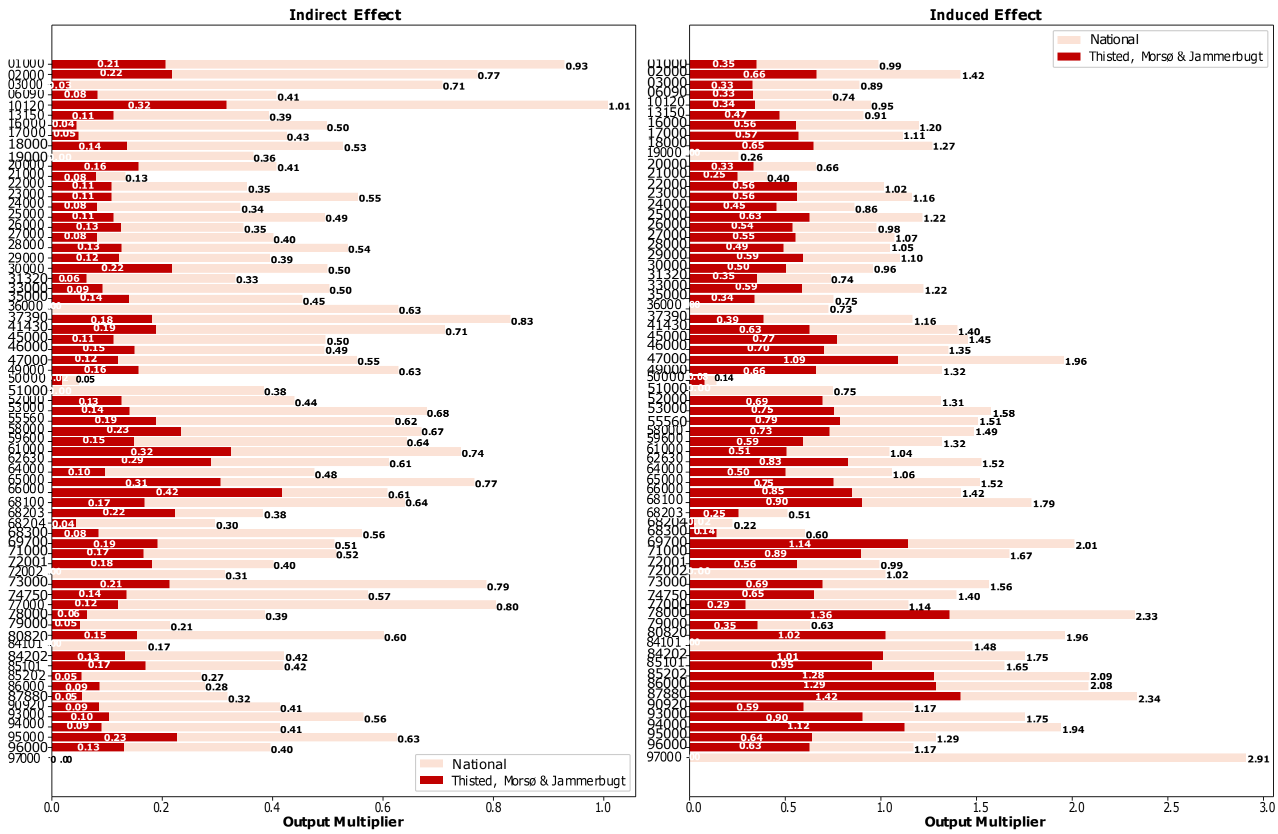


Figure A2: Indirect and induced effects for the local area, 2024 (69 industries).

A.6 Project expenditure and tourism inputs

Stand	Company	Size	Foundations					Turbines				
			2020	2021	2022	2023	2024	2020	2021	2022	2023	2024
1	Siemens	10–20 MW			1					1		
2	Vestas	10–20 MW										
3	Vestas	10–20 MW			1					1		
4	Vestas	10–20 MW	1					1				
5	Vestas	10–20 MW		1					1			
6	Siemens	>20 MW			1					1		
7	Siemens	10–20 MW		1					1			
8	Siemens	10–20 MW	1					1				
9	GE	10–20 MW		1					1			

Table A6: Number of installed foundations, turbine replacements and main-component replacements used to construct the Østerild Test Center project expenditure model, by stand, 2020–2024.

Tourism product item	Industry code	Description
Accommodation	55560	Accommodation and food services
Restaurant	55560	Accommodation and food services
Local transport	49000	Land transport
Travel service	79000	Travel agency activities
Culture and entertainment	90920	Arts and cultural activities
Marina	93000	Sports and recreation activities
Food, beverages and tobacco	47000	Retail sale
Gasoline and other fuel	47000	Retail sale
Other retail	47000	Retail sale
Other products	–	All sectors by final consumption share

Table A7: Mapping from tourism product items to input–output industries.

Tourism product item	Borrowed holiday home	Camping		Cruise		Day trippers—business		Day trippers—holiday		Family/friends		Festival		Holiday centre		Hostel		Hotel business		Hotel holiday		Own holiday home	Pleasure boats		Rented holiday home		Rented year-round home	
	D	D	F	D	F	D	F	D	F	D	F	D	F	D	F	D	F	D	F	D	F	D	D	F	D	F	D	F
Accommodation	0	28	39	0	0	0	0	0	0	0	0	18	19	3	2	9	7	36	26	35	24	0	0	0	13	12	0	0
Culture and entertainment	4	3	3	17	24	0	7	21	8	8	3	26	11	6	5	6	6	1	1	4	4	4	3	3	3	2	4	4
Food, beverages and tobacco	35	22	13	9	5	0	23	8	22	21	13	8	34	27	21	12	9	7	6	7	7	27	27	25	19	20	8	7
Gasoline and other fuel	12	11	18	0	0	0	8	19	10	24	2	11	16	11	19	8	10	11	8	7	6	5	12	13	8	10	7	7
Local transport	4	3	4	7	5	93	6	0	3	5	7	1	0	6	10	16	28	13	21	8	16	3	1	1	3	2	11	19
Marina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	20	0	0	0	0
Other products	10	9	4	10	13	0	14	20	10	17	42	24	14	9	8	9	6	6	7	4	3	29	10	6	33	33	37	32
Other retail	15	10	7	20	26	0	23	3	23	13	28	3	6	14	12	16	8	11	13	9	11	26	12	7	11	11	11	10
Restaurant	20	14	10	38	27	4	18	28	24	12	4	9	0	24	22	24	25	14	19	22	24	7	21	23	12	10	22	21
Travel service	0	1	1	0	0	3	0	0	0	0	0	0	0	0	1	1	1	1	0	4	4	0	0	0	0	0	0	0
Total	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Notes: Values are percentages. D denotes domestic tourism and F foreign tourism. Foreign-origin columns without observations for borrowed holiday homes and own holiday homes are omitted. Column totals may differ slightly from 100 due to rounding.

Table A8: Distribution of tourism consumption across product items by accommodation or day-trip type and origin, 2023.