R&D-Report

Bodø2024: Simulating best-case and worst-case scenarios

Monitor 2024: Effects of Bodø as European Capital of Culture 2024

Evgueni Vinogradov

Nord University
R&D-Report no. 106
Bodø 2024

NORD University

www.nord.no

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R&D-Report no. 106
ISBN 978-82-7456-875-4
ISSN 2535-2733
Bodø 2024

NORD University

MONITOR 2024
EFFECTS OF BODØ AS EUROPEAN CAPITAL OF CULTURE

NORD University

Dean's approval

<table>
<tr><td rowspan="3">Title

Bodø2024:
Simulating best-case and worst-case scenarios</td><td>Publicly available
Yes</td><td>Publication no.
106</td></tr>
<tr><td>ISBN
978-82-7456-875-4</td><td>ISSN
2535-2733</td></tr>
<tr><td colspan="2">Number of pages and attachments
30</td></tr>
<tr><td>Keywords (in Norwegian, if applicable)</td><td colspan="2">Keywords
Culture
Evaluation
Agent-based modelling (ABM)

Bodø2024</td></tr>
<tr><td>Author(s)/project team members

Author: Evgueni Vinogradov
With contributions from: Veronika Vakulenko; Anastasiya Henk; Bjørn Willy Åmo; Anatoli Bourmistrov; Oliver Henk; Alena Nelaeva</td><td colspan="2">Project

Monitor 2024: Evaluation of Bodø as European Capital of Culture</td></tr>
<tr><td>Client(s)
European Commission; Bodø2024</td><td colspan="2">Client reference</td></tr>
</table>

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Internal quality assurer appointed by the Dean (name/sign.)

20 May 2024 **Dr Beatriz García**

Date **Dean (name /sign.)**

Gry Alsos

Updated 11/2021

Monitor 2024:
Effects of Bodø as European Capital of Culture 2024

BODØ2024: SIMULATING BEST-CASE AND WORST-CASE SCENARIOS

Nord University Business School

- May 2024 -

Evgueni Vinogradov

With contribution of Veronika Vakulenko, Anastasiya Henk, Bjørn Willy Åmo, Anatoli Bourmistrov, Oliver Henk, Alena Nelaeva

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List of abbreviations

ECoC –European Capital of Culture
EC – European Commission
IKS – Inter-municipal Company (Nor.: Interkommunal Selskap)
ABM – Agent-based model(ling)
SEM – Structural equation modelling
CSS – Computational social science
SD – Systems dynamics
LOS – Local simulations (model)
GIS – Geographic Information System
SSB – Statistics Norway
BSU – Basic statistical unit
NACE (industrial codes codes) – Nomenclature Statistique des Activités économiques dans la Communauté Européenne (Fr.)
B2024 – Bodø2024
NOK – Norwegian Kroner

Summary

The Bodø2024 project marks a significant cultural milestone as Bodø becomes the European Capital of Culture (ECoC), the first city above the Arctic Circle to receive this title. Throughout 2024, Bodø and the surrounding Nordland region will host a plethora of cultural events and initiatives, embracing the unique geographical and cultural characteristics of the Arctic.

The European Commission (EC) requires the organiser of the capital of culture (Bodø2024 IKS) to conduct an evaluation of the project. Bodø2024 has entered into an agreement with Nord University to assess the impacts of Bodø as EcoC. This evaluation was conducted by a group of researchers affiliated with the Nord University Business School as part of the Monitor2024 project.

Evaluating the effects of Bodø2024 on the population's urban and regional development is a challenging task, as the relationships between cultural investments and socioeconomic outputs are often indirect and difficult to quantify. Interactions between multiple aspects, from direct subsidies to local artists to increased life satisfaction, create a complex multidisciplinary picture that cannot be reduced to a simple chart connecting causes and consequences. To manage this complexity, the agent-based modelling (ABM) methodology was selected. This approach involves simulating the actions and interactions of autonomous agents (both individuals and collective entities such as organisations or groups) to understand the behaviour of a system and what governs its outcomes. ABM is broadly used in the natural sciences, but it is gradually being adopted in the socioeconomic field as well.

Based on statistical data for 2022, a "digital twin" of Bodø municipality was created, including 52,802 individuals; 25,560 households; 32,019 apartments, houses, industrial buildings and other real estate properties; and 1,250 organisations with 24,779 employees. Based on certain rules of behaviour, the individuals, firms and other entities in the model can "live" (i.e. interact with each other and their simulated environment over time). The model is calibrated against historical data. This paper provides information on the reliability and validity of the model. The resulting model, which can replicate the historical development of Bodø municipality, is also expected to provide reasonable forecasts when the model runs forward, simulating development from 2022 to 2036.

This paper describes in detail how cultural life and the Bodø2024 project are integrated into the overall socioeconomic model of Bodø municipality. Cultural life is incorporated into the simulation in several ways. First, all organisations present in a municipality, including culture-related organisations, are included in the basic model. Second, changes in cultural life are simulated through various cultural happenings

(anything that is related to culture and may have any measurable effect on the simulation, for example, concerts). Third, cultural life is assumed to influence Bodø's attractiveness as a tourist destination. Finally, cultural life is expected to influence the propensity to live or stay in Bodø, especially among young residents.

Using this socioeconomic model with a culture-related extension, two scenarios are simulated for Bodø in 2022–2036: The "success" scenario (the best-case scenario, in which all Bodø2024 activities proceed as planned at maximum capacity), and the "fiasco" scenario (the worst-case scenario, in which Bodø2024 fails to attract significant public attention). The results of the simulation suggest that in the success scenario, 2,046 more individuals will be living in Bodø than under the fiasco scenario. It is projected that the Bodø2024 project will lead to direct spending, increased turnover in tourism-related industries, indirect and induced increase in sales, a larger available workforce, and consumption effects related to a growing population. These factors are anticipated to increase the operating income of organisations/firms operating in Bodø. Compared to the fiasco scenario, the success scenario will generate NOK 1.236 billion over the simulated 15-year period, an average of NOK 82 million per year.

Among other consequences, migration, births, deaths, unemployment, and the number of children in kindergartens and pupils in schools are discussed.

This pioneering attempt to simulate a municipality with a focus on cultural life is based on the data available to the research team at the end of 2023. As the Bodø2024 project culminates in 2024, more precise assumptions for alternative scenarios will be developed, increasing the accuracy of the model.

Part 1. Agent-based simulations

What is agent-based modelling?

An agent-based model (ABM) is a computational model used to simulate the actions and interactions of autonomous agents (both individual and collective entities such as organisations or groups) in order to understand the behaviour of a system and what governs its outcomes. ABM is an alternative to equation-based models (regression analysis, structural equation modelling [SEM], etc.). ABM enables the creation of reasonably realistic digital copies of every citizen, organisation and building in a local setting. Simulations can then be run based on intuitively understandable interaction rules.

Equation-based (socioeconomic) models, such as regressions built by national statistics offices, deliver robust predictions based on large samples and are well-established and widely accepted. In contrast, ABM is broadly used in the natural sciences but has only recently infiltrated the socioeconomic field. This development is mainly due to improved access to open data and the growing computational power available to practitioners.

The main advantages of ABM compared to equation-based methods (e.g. regression analysis and SEM) are:

- The ability to predict tipping points and emergence (new effects that are not reducible to the sum of the parts of the original data)
- The relatively straightforward integration of network effects, individual learning and adaption
- The ability to accommodate individual decision-making processes and bounded rationality in a relatively straightforward manner
- Ease in managing heterogenic agents
- Its operation at individual and local levels, making it less dependent on large samples
- Its portrayal of people as individuals rather than aggregated populations or functions, which is important for empowerment and the communication of results to end-users

Agent-based modelling in socioeconomic research

ABM is "a form of computational modelling whereby a phenomenon is modelled in terms of agents and their interactions", where an agent is defined as "an autonomous computational individual or object with particular properties and actions" (Wilensky & Rand, 2015, p. 1). Over the last 20 years, the convergence of different factors – the increasing complexity of science, the "data deluge" and advances in information technologies – has triggered a paradigm shift in how we understand complex social systems and their evolution. While the integration of ABM into socioeconomic research is not yet widespread, there is increasing interest among academia (see, e.g. the field tourism research of Vinogradov et al., 2020).

Beyond elucidating social dynamics, the emerging research area of computational social science (CSS) is providing a novel rationale for a more scientifically grounded and effective policy design (Dabbaghian & Mago, 2014; Jackson, 2014; Lettieri, 2016; Levitt, 2012). CSS encompasses the "integrated, interdisciplinary pursuit of social inquiry with emphasis on information processing and through the medium of advanced computation" (Cioffi-Revilla, 2010, p. 262). From an epistemological point of view (Benthall, 2016; Goebel, Siekmann, Wahlster, & Squazzoni, 2009), CSS is highly interdisciplinary as it is grounded in a scientific perspective that integrates various research traditions into a unified framework.

The two main simulation techniques used today in social and organisational research are systems dynamics (SD) (Forrester, 1961) and ABM (Hamill & Gilbert, 2015). SD models are based on the idea that the evolution of a social system can be represented as the result of complex cycles of action and feedback, which can be described in mathematical terms. Simulations are built upon this premise, with the phenomenon under investigation represented as a set of variables (stocks) and their associated rates of change (flows). Today, these models are widely applied in the industrial sector and social sciences. ABMs are founded on the theoretical premise that macro-level social phenomena are the result of interactions occurring at the micro- and meso-levels, involving individuals (people, organisations, institutions), and their interactions with the environment. ABMs typically include a set of heterogeneous artificial agents simulating real-world actors and their behaviours, a set of rules of interaction and an environment in which dynamic, organisational and spatial characteristics are defined. Social and organisational simulation enables policymakers to run "what-if" analyses that facilitate the observation of potential effects resulting from various choices through well-developed models of a given "target system" (Cioffi-Revilla & Rouleau, 2010).

General LOS model description

The local simulations (LOS) model is an ABM representing social and economic interactions within local societies. Figure 1 provides an overview of the model and clarifies its elements. Part 2 of this report provides a comprehensive contextualization and detailed description of the case of Bodø2024.

The model contains a core, i.e., baseline model, consisting of four elements that are essential for modelling a society:

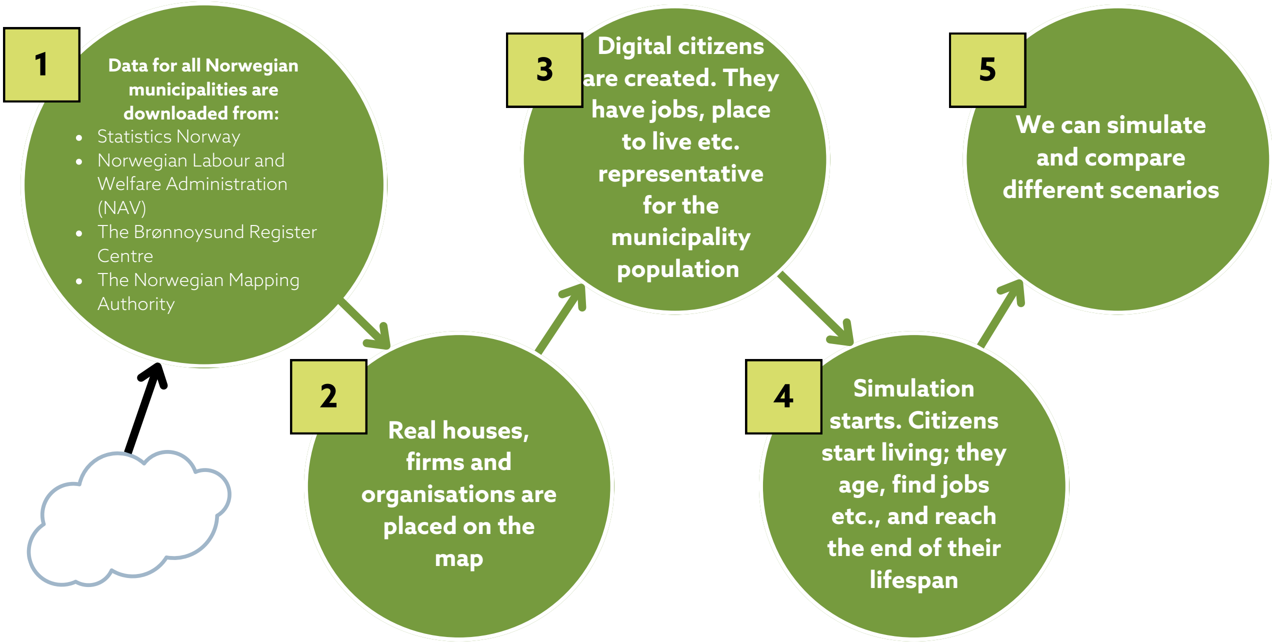

Figure 1. LOS model illustration exemplified in the Norwegian case

1. Population: A digital "copy" of every citizen in a municipality. While these digital agents may not replicate every individual exactly, their average age, employment status, family composition and other attributes precisely align with the statistics provided by state statistical services. Citizens are associated with households.

2. Organisations/Firms: Every real firm and organisation registered in each municipality is presented in a model. Information on the number of employees, financial indicators and other elements are obtained from registration information and other sources. Organisations supply goods/services to each other and import/export in/out of a municipality.

3. Labor Market: Connecting the synthetic population with organisations/firms.

4. Real Estate Market: Employs digital maps and other geospatial information to situate citizens and organisations on the map.

When the synthetic population is generated based on available statistical data, the model can run multiple times to simulate alternative scenarios. The output of the model typically includes:

- Historical (real) data to compare simulation results to.
- A baseline scenario used for calibration and validation, which replicates the historical data as closely as possible. No external changes are introduced in this scenario.
- Scenarios with external changes/shocks. For example, establishing a major factory in the municipality may be simulated, with the results compared to the baseline scenario to evaluate the expected consequences. The same

scenario may be tested multiple times to evaluate the significance of various assumptions, factors and stochastic elements. Multiple alternative scenarios may be compared.

All simulations are performed on the agent level. For example, nothing in the model says that the unemployment level must go up or down. Instead, each agent in the model obtains and loses jobs based on their personal situation and work availability. The unemployment level in the model is simply a count of individuals without jobs, divided by labour force.

All agents behave according to certain rules with respect to internal and external factors. For example, each individual transitions from kindergarten to school when they reach the age of 6 (an internal factor for the person). A person loses a job when the organisation employing them shuts down (an external factor for that individual).

Part 2. The digital twin of Bodø municipality

Synthetic population

For the purpose of simulating alternative scenarios for the Bodø2024 project, a "digital twin" of Bodø municipality was created. Based on statistical data for 2022, synthetic populations include:

- 52,802 individuals;
- 25,560 households;
- 32,019 apartments, houses, industrial buildings and other real estate properties;
- 1,250 organisations with 24,779 employees.

Reliability

As in the real world, many processes in the model are influenced by random deviations. This section describes how random processes affect the model results and how sensitive different output indicators are to random variations. In statistics, the overall consistency of a measure is called "reliability". A measure is said to have high reliability if it produces similar results under consistent conditions.

To assess its reliability, the model was run 30 times with the same parameters and standard deviations between the outputs were calculated. Table 1 shows the absolute and relative standard deviations. Standard deviation is a quantity expressing how much the individual observations differ from the mean value for all observations. For example, a relative standard deviation of 1% shows that the respective variable is relatively stable. In practical projects, this measure is important for the interpretation of simulation results. If, for example, the simulation shows that establishing a new factory leads to a 0.1% increase in total population after 10 years, this small effect will be insignificant when the random population variation is, for example, 1%. In these cases, it is possible to calculate accumulated changes over all 10 years, making the result more significant.

Some relative standard deviations, like number of births, are very large. This is because in the real world, the number of children born in a municipality is truly a relatively random process. In this respect, the ABM is more realistic than traditional equation-based models producing smooth trends.

Table 1. Relative standard deviation as a result of 30 model runs

Variable	***Mean***	***Standard deviation***	***Relative standard deviation (%)***
Population, total	48,697.0	299.0	0.61
Population, man	24,660.0	219.0	0.89
Population, women	24,037.0	80.0	0.33
Excess of births, excess	-14.0	34.0	242.86
Excess of births, births	420.0	31.0	7.38
Excess of births, deaths	434.0	3.0	0.69
Migration, net migration	58.0	39.0	67.24
Migration, moved in	2,126.5	45.5	2.14
Migration, moved out	2,068.5	84.5	4.09
Employed, total	27,007.5	228.5	0.85
Unemployed, total	728.0	36.0	4.95
Retired, total	9,136.5	138.5	1.52
Commuting, commuting in	4,275.5	2.5	0.06
Commuting, commuting out	204.0	9.0	4.41
Work assessment, total	1.194	29.0	2.43
Labour market schemes, total	142.5	5.5	3.86
Disabled, total	2,019.0	0.0	0.0
Jobs, total	42,185.0	39.0	0.09
Number of employees, total	37,901.5	37.5	0.1
Job openings, total	8.0	4.0	50.0
Operating income, total	131,687,201.5	214,394.5	0.16
Households, total	23,275.0	69.0	0.3
Households, living alone	4,731.5	34.5	0.73

Variable	***Mean***	***Standard deviation***	***Relative standard deviation (%)***
Households, couples without resident children	4,987.0	10.0	0.2
Culture sector: total employees, total	638.5	18.5	2.9
Culture sector: in commuters, total	124.0	2.0	1.61
Culture sector: turnover, total	1,399,739.5	44,276.5	3.16
Kindergarten, total	1.979.0	7.0	0.35
Primary and low secondary school, total	4,813.0	1.0	0.02
Upper secondary school, total	2,043.0	15.0	0.73
Students, total	6,052	93.0	1.54

Validity

This section examines to what degree the model corresponds to the real world. First, we verify whether the digital individuals in the model accurately represent the real population as depicted in official statistics. Second, we compare the simulation results to historical data and Statistics Norway (SSB) population forecasts.

Initial values deviating from statistics

To distinguish it from the real population, the digital twins in the model are referred to as a synthetic population. This synthetic population is constructed to be representative in terms of age, gender, employment status and other factors. However, initial synthetic populations in the model may deviate (slightly) from the real statistical numbers. This happens because:

To distinguish it from the real population, the digital twins in the model are referred to as a synthetic population. This synthetic population is constructed to be representative in terms of age, gender, employment status and other factors. However, initial synthetic populations in the model may deviate (slightly) from the real statistical numbers. This happens because:

- some statistics may reflect situations measured on different days of the year, while the synthetic population is generated as of 1 January, and
- stochastic (probabilistic) elements are also used when generating the synthetic populations.

Table 2 lists the measures with the most substantial deviations (only deviations greater than 0.1% are shown). Therefore, all measures that do not appear in the table correspond closely to the real data, with a less than 0.1% deviation.

Table 1. Relative standard deviation as a result of 30 model runs

Variable	***Deviation***	***Deviation, %***
Population, total	253	0.5
Employed, total	379	1.3
Commuting, commuting in	-206	-6.0
Commuting, commuting out	-2,528	-99.8
Disabled, total	6	0.2
Students, total	-91	-1.4

Comparing historical data to the model results and SSB forecasts

To ensure the model functions as it should, it is run starting from 10 years prior. The output is compared to 1) actual historical data for the given municipality and 2) SSB population forecasts from 10 years ago.

SSB delivers a range of population forecasts depending on various assumed national growth, ageing and immigration rates. Figure 1 illustrates that the 10-year population forecasts from SSB are provided in a very broad range. Using these forecasts as a guide, we expect the LOS model forecasts to be somewhere in this range.

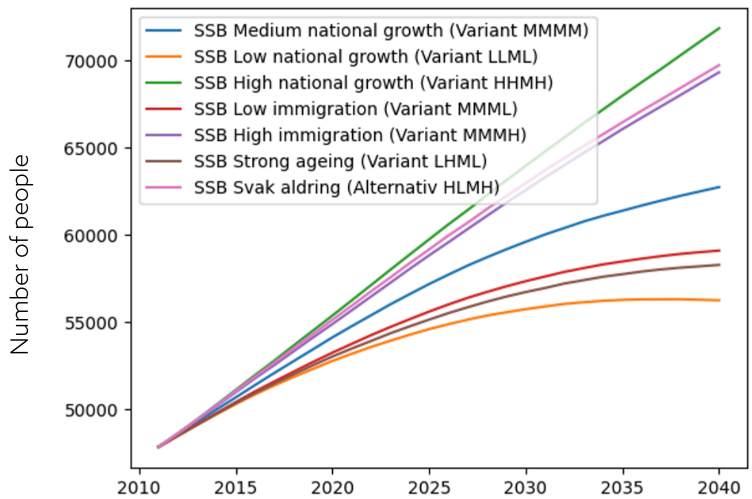

Figure 2. SSB population projections

Figure 3 shows that the actual population development for Bodø municipality has been somewhat below the broad range of forecasts provided by SSB 10 years ago.

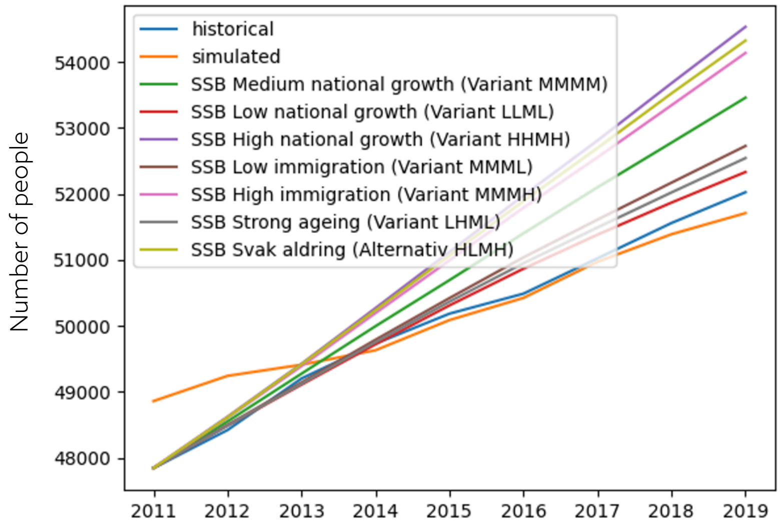

Figure 3. SSB population projections made in 2011 plotted against historical and modelled data

In Figure 4, the medium SSB predictions are plotted alongside the LOS simulation data and historical data. The LOS prediction concludes within a reasonable distance from both historical numbers and SSB predictions. While it is impossible to definitively determine whether the LOS model is superior to the SSB or more valuable in predicting the future, both models operate within a realistic range that aligns with actual data.

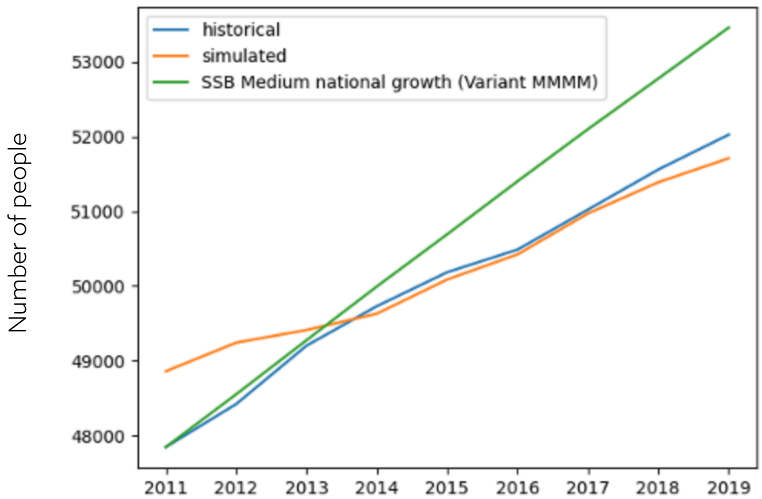

Figure 4. SSB population projections (medium national growth alternative) made in 2011 plotted against historical and modelled data

Endogenous parameters and calibration procedures

The model output is influenced by 1) various parameters within the model (endogenous parameters/variables), 2) assumptions behind the given project/scenario (exogenous variables) and 3) random variations. This section accounts for endogenous parameters. The uncalibrated model is based on data at the municipality and BSU (basic statistical unit, Norw. 'grunnkrets') levels, yielding reasonably accurate simulation results. However, the endogenous parameters are calibrated for each municipality to achieve a closer match with historical data for the last 10 years.

The calibration procedure includes the following steps:

- Parameters that regulate the probability of birth and death were adjusted. In real life, the number of births and deaths is mostly independent of short-term socioeconomic influences, and yearly variations are mostly random. Birth and death rates depend to a large degree on the age composition of the population. Since official statistics provide precise data on age and fertility/mortality, we can calibrate the model in a way that enables extremely precise predictions. This part of the calibration is executed automatically through "machine learning" mechanisms, closely replicating the last 10 years of historical records.
- Parameters regulating the number of individuals/households moving in and out of the municipality for reasons unknown to us are calibrated against historical data.
- The number of individuals who are retired and become disabled is calibrated against historical data. These parameters are relatively stable given the known age structure of the population.
- The parameters related to the labour market (such as the individual probability of obtaining a job when a vacant position is locally available or initiating out-commuting) are calibrated.
- The final balance is achieved through fine adjustments to the exogenous growth (the number of new job openings created in the municipality). This parameter is the most inherently unpredictable and volatile and was therefore calibrated last.

Part 3. Simulating culture and the case of Bodø

Culture

Cultural life is incorporated into the simulation in several ways:

1. All organisations present in a municipality, including culture-related organisations, are included in the basic model.
2. Changes in cultural life are simulated through various cultural happenings (anything that is related to culture and may have any measurable effect on the simulation, for example, concerts).
3. Cultural life is assumed to increase the attractiveness of Bodø as a tourist destination.
4. Cultural life is expected to influence the propensity to live or stay in Bodø, especially among young residents.

Cultural organisations

First, data for all organisations present in a municipality, including culture-related organisations, are included in the basic model. The organisations with the following NACE (SSB,2009) codes are considered part of cultural life:

1. Creative industries:
   a. creative arts and entertainment, including performing artists and the operation of art facilities (code 90)
   b. design, photography and translation (partly code 74)
   c. architecture and advertising (partly code 73)
   d. information service activities (partly code 63)
   e. programming and broadcasting (partly code 60)
   f. video, TV and sound production (partly code 59)
   g. publishing (partly code 58)
   h. manufacture of jewellery and musical instruments (partly code 32)
2. County, region and city attractors:
   a. libraries, archives, museums, zoological and botanical gardens and other relevant activities (code 91)
3. Visitor infrastructure: Described separately in other sections.
4. Retail:
   a. renting of videotapes and discs (code 77.22)
   b. retail sale of books and music in specialty shops (partly code 47.6)
   c. printing (partly code 18)
5. Cultural education capacity and religion:
   a. cultural education (code 85.52)

The full list of cultural NACE codes: 85521, 90040, 91022, 58130, 47610, 91012, 77220, 18140, 18200, 32200, 91013, 91023, 91040, 58210, 91029, 18110, 91011, 85529, 47630, 60200, 91021, 59140, 63910, 90039, 71113, 60100, 90033, 90035, 32120, 59120, 91030, 18130, 58140, 90019, 90032, 58110, 18120, 85522, 59200, 74300, 74103, 90012, 74101, 71112, 90031, 90020, 74102, 90034, 74200, 59110, 90011.

Cultural life

Second, changes in cultural life are simulated through various cultural happenings (anything that is related to culture and may have any measurable effect on the simulation).

For simulation purposes, cultural life happenings are divided into several types:

1. Cultural single events: happenings that occur at a specific time and place and are open to the public (concerts, exhibitions). If a festival takes place over several days, it is divided into separate concerts.
2. Ongoing cultural contributions that are open to the public and related to a

specific venue (museums, cinema).

3. Cultural contributions lacking distinct ties to a specific venue, occurring over an extended period, and not necessarily involving the public (such as cultural infrastructure programmes, educational initiatives for local officials and networking activities).

Information about single events is sourced from a table where each row corresponds to a single event. The cultural events are divided into the following genres (SSB classification from table 13503 cited below):

- Cinema
- Public library
- Book
- Museum
- Exhibition of visual art or handicrafts
- Concert
- Festival
- Theatre/musical
- Opera
- Ballet or dance performance
- Sports event
- Religious or ethical meeting

Participants in cultural events

Third, individuals in the simulations choose to attend some events. The probability that an individual will attend an event depends on their age and cultural preferences and whether they are engaged in other activities (for example, working at the time of the event or attending another event at the same time). Individual preferences are calculated based on:

1. SSB table 13503: "Use of different cultural activities, by sex and age" (SSB, 2023a)
2. SSB table 13507: "Percentage of the population who wants to use cultural activities more frequently, by sex and age" (SSB, 2023b)
3. SSB table 13508: "Barriers against wanted usage, of different cultural activities, by sex and age (per cent)" (SSB, 2023c)

Part 4. Simulating Bodø2024

A diagram for the outcomes of Bodø2024 for Bodø municipality is shown in Figure 5.

Organising Bodø2024 results in the following main outcomes in the model:

1. An organisation, Bodø2024 IKS, is formed with up to 20 employees. This creates ripple effects as salaries are paid to these employees and the organisation buys products/services from local suppliers. The organisation also provides funding for some cultural events.
2. ECoC events attract additional tourists to the municipality. The economic effects are most visible in the accommodations, catering and cultural/entertainment sectors.
3. The additional vibrancy in cultural life makes some people less likely to migrate out of the municipality. The effect of different cultural events depends

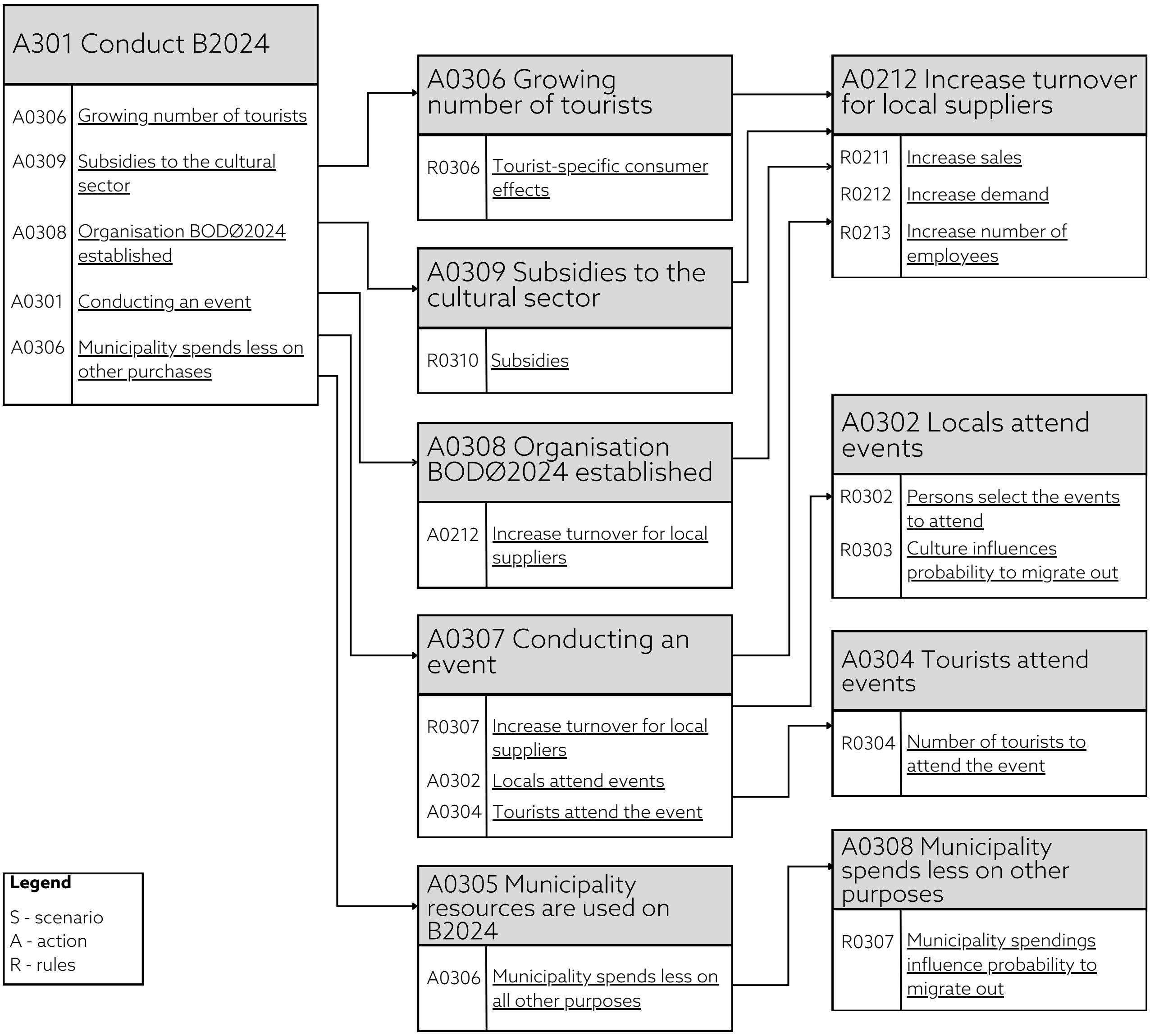

Figure 5. Consequences of Bodø2024

individuals' age, gender and engagement level as well as on the quality and scale of the event.

4. NOK 56 million is allocated as direct subsidies to various actors in the cultural sector.
5. NOK 50 million, which could be otherwise used to improve municipal services for citizens, is taken from the municipality budget and reallocated to Bodø2024. The negative effect of this reallocation is considered.

Creating Bodø2024 as an organisation

Bodø2024 IKS was registered as an organisation on 3 March 2020. In 2024, Bodø2024 has 20 employees (Table 3) and a total budget of NOK 310 million (Table 4).

Table 3. Bodø2024 employees

	2020	2021	2022	2023	2024	2025	2026
Employee number	4	8	16	20	20	18	0
Employed man-years	0.83	5.2	12.7	17.5	18	8.1	0

Table 4. Bodø2024 budget

In NOK 1,000	2020	2021	2022	2023	2024	2025	Sum
Income							
*Public funding**	9,000	30,000	47,500	60,500	60,500		207,500
Other sources		2,300	7,265	28,585	64,350		102,500
Sum	9,000	32,300	54,765	89,085	124,850		310,000
Expenditures							
Salaries	2,275	7,989	11,783	14,125	15,800	6,000	57,972
Purchases of goods and services	5,407	7,749	22,383	43,400	104,240	2,685	185,864
Transfers to others		2,895	9,959	16,000	27,500		56,354
Other			1,235	1,775	1,800	5,000	9,810
Sum	7,682	18,633	45,360	75,300	149,340	13,685	310,000

** Including NOK 50,000 from Bodø municipality and NOK 50,000 from Nordland county*

For simplification, we establish the Bodø2024 organisation in January 2022. We choose to ignore the year 2020 as the model normally runs from 2021 and the number of man-years was insignificant in 2020. We use the average number of man-years (11.39) instead of simulating yearly variations. NOK 58 million is the total salary for these employees.

Bodø2024 will spend NOK 185 million to purchase products/services. Of this budget, NOR 130 million will go towards expenditures in the cultural sector (30% of these products/services are supplied by actors in Bodø municipality), NOR 40 million to communication/advertising/marketing (70% Bodø) and NOR 16 million to administration/rents, etc. (95% Bodø). The precise distribution between industries and local/non-local suppliers is expected to be clarified by the Bodø2024 administration at a later date.

The simulated organisation is closed in December 2025.

Establishing any new organisation in the model leads to ripple effects, as illustrated in Figure 6.

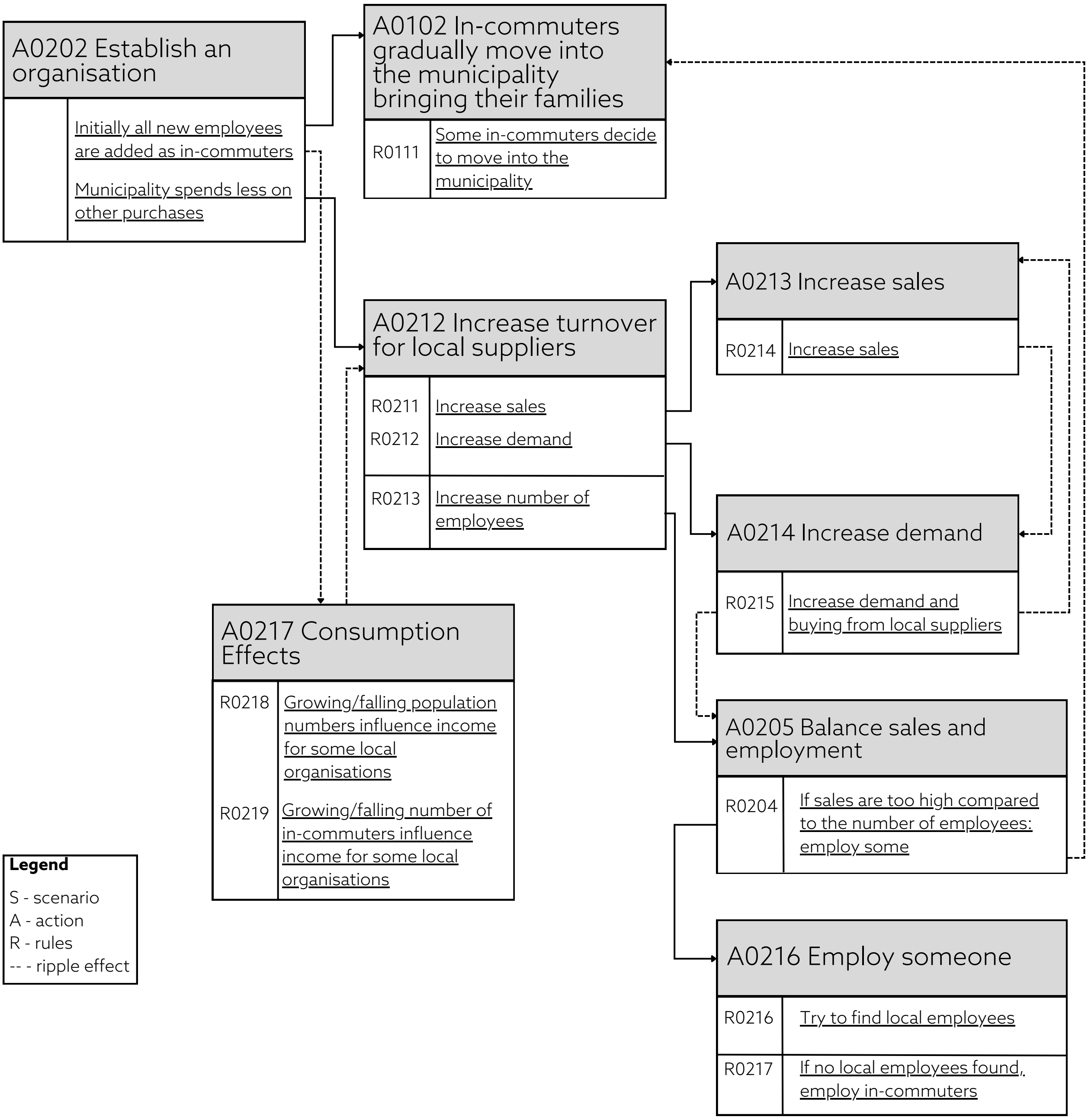

Figure 6. Ripple effects of establishing a new organisation in the model

Growing number of tourists

The Norway Guide reports that, on average, each international tourist spends NOK 1,680 (163 USD) per day, which includes all expenditures except airfare to and from Norway. However, tourists who visit Northern Norway during the winter spend more, with an average of NOK 2,560 (250 USD) per day (Iversen, 2023) spent on everything from accommodations and food to excursions and souvenirs.

Bodø attracts approximately 250,000 tourists annually, with an average stay duration of 1.7 days. This results in about 350,000 nights spent, with 50% related to work (increasing to 76% in July). On average, guests spend NOK 1,156 per visit and NOK 727 per night.

Visit Norway describes how Norwegian and foreign tourists spend money at the destination (Visit Norway, n/d). Based on these numbers, we make the following assumptions regarding the daily expenditures of an average tourist (see Table 5).

Table 5. Assumed daily expenditures of an average tourist

	NACE codes	**%**	**NOK**
Accomodations	55	35	735
Restaurants	56	30	630
Local land transportation	49.31	10	210
Activities/entertainment	90,91	25	525
Sum		100	2,100

The relevant NACE codes were selected based on EU classifications within the tourism sector (Eurostat, 2024). The sea and air transportation categories were excluded to prevent the misallocation of additional tourism effects due to the substantial turnover of sea and air transportation companies headquartered in the relevant municipality.

- In Valetta, a 14.3% increase in tourist visits was registered in ECoC year 2018 (Valetta, 2018).
- In Plzen, a 14.1% increase in tourist visits was registered in ECoC year 2015 (Plzen, 2015).
- In Marseilles, 1.9 million additional visitors registered in 2013, representing a 25.2% increase over 2012 based on the increase in hotel taxes. Nine out of 10 tourists indicated their desire to return to Marseilles, suggesting that the impact of ECoC designation may endure for years to come (Marseille-Provence, 2013).
- In Matera, which was EcoC in 2019, a 31% increase in tourism was registered (Matera, 2019).
- In Mons (2015), there was a 211% increase in the number of visits to the tourist office Visit Mons (Mons, 2015).
- The Liverpool ECoC attracted 9.7 million additional visits in 2008. The Liverpool ECoC in 2008 attracted 2.6 million European and global visits, 97% of which were first-time visits to the city, and generated an additional 1.14 million visitor nights in Liverpool hotels. In 2008 there were an estimated 27.7 million visits to Liverpool, a 34% rise over the previous year (Liverpool, 2008).
- Plovdiv ECoC 2019 generated increases of 20% in national and 30% in international visitors, with a 27% increase in visitors staying overnight in accommodation facilities with 10+ beds (Plovdiv, 2019).

- In the Czech Republic, visitor expenditures resulted in an increase of production of CZK 711 million for both direct and indirect suppliers of goods and services for visitors, CZK 90 million of which was the result of foreign visitor spending, representing a net benefit for the Czech Republic (Plzen, 2015).

Based on these numbers, the average increase in number of visits across five ECoCs was about 30%. The effects of increased tourism in the event of the full success of Bodø2024 are modelled as follows:

- The effects take place in January–December 2024.
- The half-life of the effects after 2024 is set to one year (the effects are reduced by 50% every year starting from 2025).
- The daily increase in number of tourists is 287 individuals (30% x 350,000 visitors/365 days).
- Daily local consumption by tourists is set at NOK 2,100.

Conducting an event

Events are scheduled to take place on specific day(s) (the start time).

Events attract a certain audience, which is specified by:

- Visitor numbers
- Share of local visitors (versus tourists)
- Age distribution (min, max, skewness)
- Gender distribution

Cultural events are divided into types (concert, festival etc.).

Cultural events have repercussions for participants. Local participants exhibit a reduced inclination to move out of the municipality. The impact on tourists is not taken into account here.

The extent of the impact (impression) that different events have on an individual may vary. For example, a small local exhibition is expected to have a lower impact on a particular visitor than a concert featuring world-famous artists. Therefore, the impression force is rated on a 0–1 scale for each event.

The event's budget is allocated partially to local cultural suppliers (denoted by the variables "budget" and "share of local suppliers").

A typical example of a cultural event is shown in Table 6.

Currently, 45 cultural events localised in Bodø are simulated.

Table 6. Cultural event example

Type	***Cultural event / happening***
title	"UKM-festivalen"
sub_type	"festival"
start time	2024/06/21
number of visitors	600
share of local visitors	0.5
age_min	16
age_max	70
age_skewness	0.8
share_women	0.5
impression	0.5
budget_local_suppliers, NOK 1000	10
budget_local_cultural_suppliers, NOK 1000	10
longitude	14.375319530301832°
latitude	67.28318292939502°

Subsidies to the cultural sector

NOK 56.354 million will be provided as subsidies to actors in the cultural sector. About 50 million goes to the cultural sector. Currently, we propose that 40% be allocated to the cultural sector in Bodø municipality. The precise distribution between industries and organisations is expected to be determined later by the Bodø 2024 administration. The subsidies are to be paid to the actors in advance; therefore, payments are not contingent on the success of the subsidised cultural event.

Use of municipal resources

When municipal resources are removed from the ordinary budget, the overall quality and quantity of municipal services are reduced. When the exact allocation of this effect is unknown, the overall likelihood of citizens moving to another municipality is simulated to increase. The magnitude of this effect for individual citizens is estimated to lie between two extremes:

- When municipal expenditures are reduced, the likelihood of moving to another municipality should not decrease (effect > 0).
- The effect of reduced municipal expenditures on decisions made by individuals and households is not expected to exceed the effect of an individual losing their job. The increased probability of relocating if one or more individuals in the household become unemployed is quantified based on the following publications: Andreev (2017), Stambøl (1998), Stambøl (2000).

Bodø municipality has allocated NOK 50 million to Bodø2024. With about 52,000 inhabitants in Bodø, the average per capita decrease in municipality expenditures due to the reallocation of resources to Bodø2024 is approximately NOK 961 spanning the life of the project. The total expenditure in the 2024 budget is NOK 4.664 million, with about 1.07% of the municipality's budget allocated to Bodø2024. In the model, we assume a 1% reduction in municipal expenditure will result in a 1% increase in the likelihood of leaving the municipality across all households.

Part 5. Scenarios

Assumptions behind alternative scenarios

Two scenarios are simulated for Bodø in 2022–2036:

1. Success (all Bodø2024 activities go as planned at maximum capacity), and
2. Fiasco (Bodø2024 fails to attract significant public attention).

Table 7 illustrates the differences between the assumed success and fiasco scenarios.

Table 7. Differences between the assumptions for success and fiasco scenarios

Aspect	***Success***	***Fiasko***
Bodø2024 IKS and subsidies to the cultural sector		
Existing period	2022-2025	same
Average number of man-years	11.39	same
Paid to the culture sector in Bodø (NOK)	59 million	same
Paid to other suppliers in Bodø (NOK)	49 million	same
Tourism		
Tourism increase (daily number of additional tourists)	287 (30%)	57 (6%)
Cultural events (programme posts)		
Audience count for cultural events (number of participants)	98,020 (100%)	19,604 (20%)
Use of municipal resources		
Increase in propensity to move (percentage of population)	1%	same

Results of simulations for two alternative scenarios

The figures and tables in this section compare two scenarios: Scenario 1 (success) and Scenario 2 (fiasco). As illustrated by Figure 7 and Table 8, it is expected that in the best-case scenario, 2,036 more individuals will be living in Bodø than under the fiasco scenario.

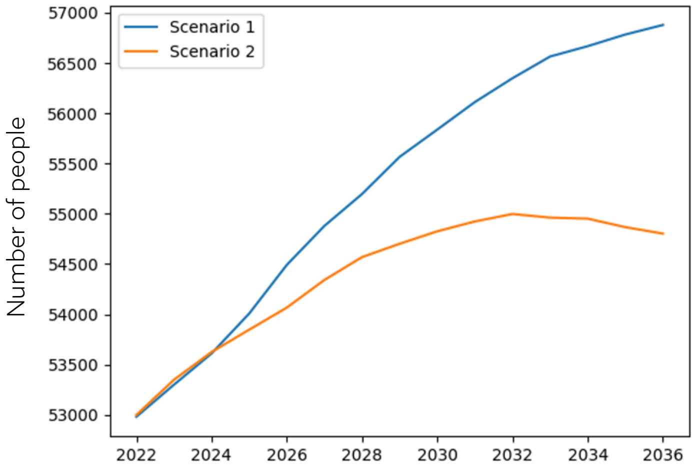

Figure 7. Simulated population growth

Table 8. Simulated population growth (number of people)

	S1 Success	S2 Fiasko	Difference
2022	52,981	52,999	18
2023	53,300	53,349	49
2024	53,611	53,625	14
2025	54,008	53,847	-161
2026	54,492	54,067	-425
2027	54,880	54,342	-538
2028	55,197	54,569	-628
2029	55,567	54,702	-865
2030	55,838	54,826	-1,012
2031	56,112	54,924	-1,188
2032	56,349	54,998	-1,351
2033	56,565	54,962	-1,603
2034	56,668	54,952	-1,716
2035	56,784	54,867	-1,917
2036	56,879	54,803	-2,076

Figure 8. Migration out of Bodø

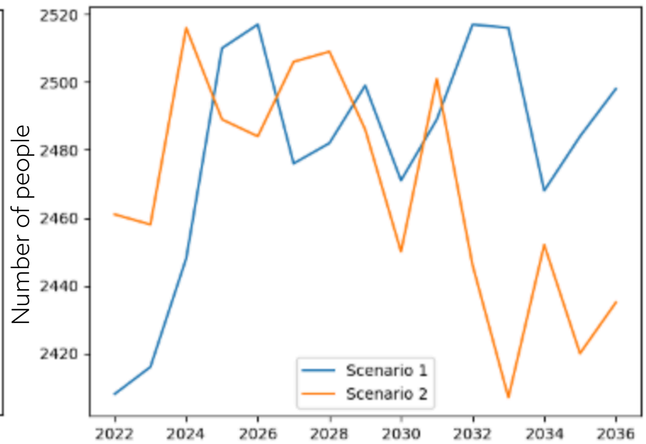

Figure 9. Migration from other regions to Bodø

This growth is mostly due to reduced migration out of Bodø. Figure 8 shows that in the best-case scenario, out-migration will be reduced by more than 100 individuals per year due to increased overall satisfaction with living in Bodø and more employment opportunities in culture- and tourism-related industries.

It is difficult to make definitive statements about the outcomes of simulating migration from other regions to Bodø. As shown in Figure 9, in-migration numbers exhibit considerable volatility, and the potential effects of Bodø2024 are masked by yearly changes.

The net effect of Bodø migration (in-migration minus out-migration) is illustrated in Figure 10.

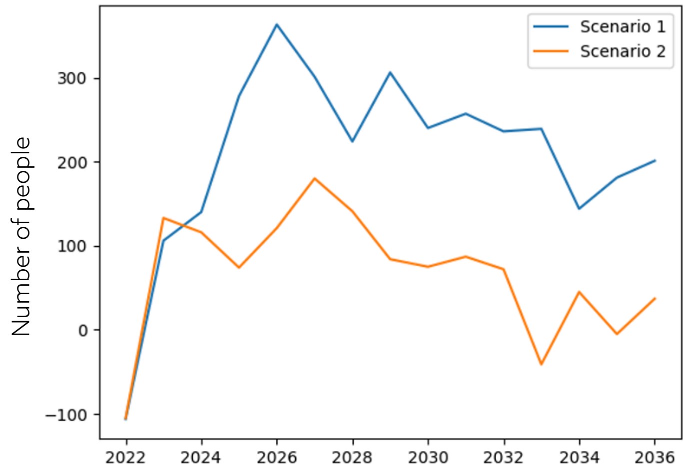

Figure 10. Net migration

Another factor influencing the total population in a municipality is natural population growth determined by birth and death rates (see Figures 11, 12, 13). The impact of Bodø2024 on the surplus of births over deaths is insignificant.

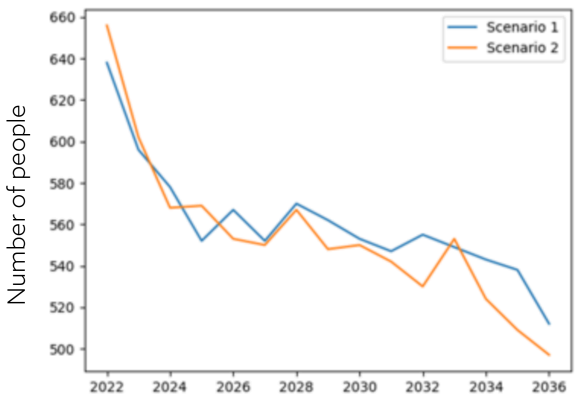

Figure 11. Yearly number of births

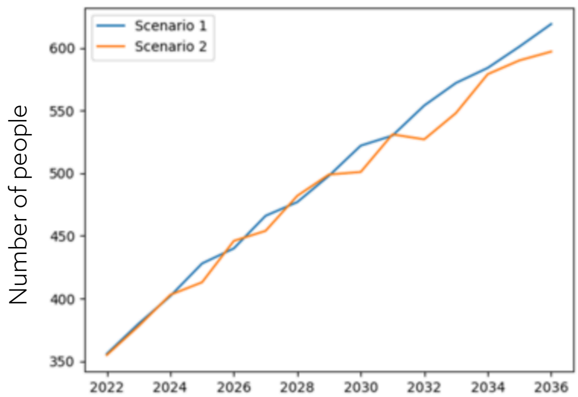

Figure 12. Yearly number of deaths

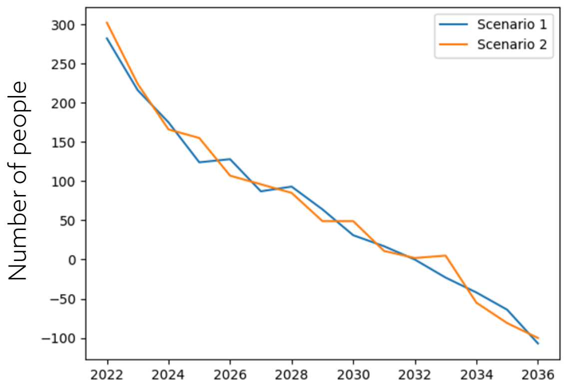

Figure 13. Excess of births over deaths

The alternative scenarios have differing impacts on the size of several social groups. While young people may exhibit greater mobility, the success of Bodø2024 will also lead to an increase in the number of retired individuals, with the success scenario resulting in approximately 400 more retirees (see Figure 14).

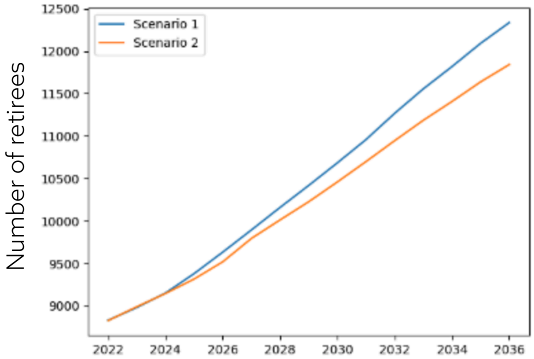

Figure 14. Number of retirees in Bodø

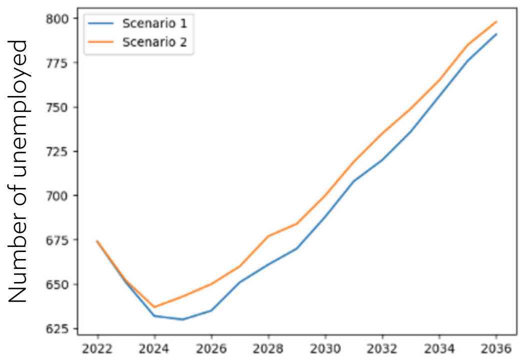

Figure 15. Number of unemployed

As the success scenario results in the creation of a greater number of job openings in Bodø than the fiasco scenario, it is expected that the success scenario will result in a lower level of unemployment (Figure 15). This takes into account both the job opportunities created directly in the Bodø2024 organisation and the increasing demand for labour in the cultural and tourism-related sectors. This effect is largest during the Bodø2024 period but is still apparent in 2026.

Under the success scenario, as more young people, couples and families opt to remain in or move to Bodø, we expect to see an increase in demand for places in kindergartens and schools (Figure 16). As couples who opt to prolong their residency in Bodø have children and these children mature, the relevant effects, which are almost imperceptible in the first year, become increasingly pronounced with each subsequent year (Figures 17 and 18).

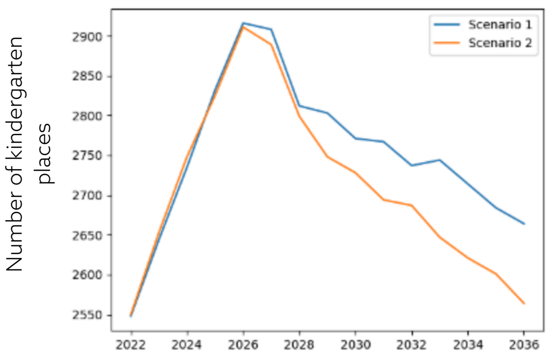

Figure 16. Demand for kindergarten places

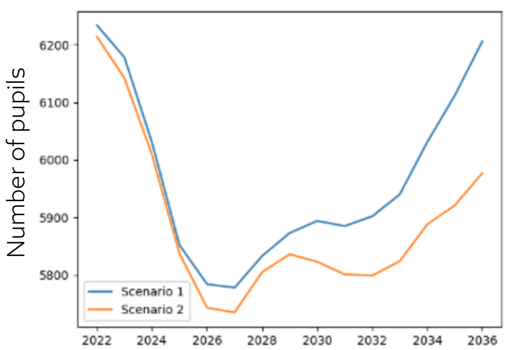

Figure 17. Pupils in primary and low secondary schools

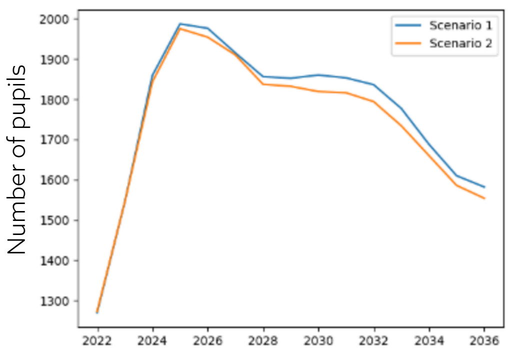

Figure 18. Pupils in upper secondary schools

Finally, it is expected that direct expenditures related to the Bodø2024 project, increased turnover in tourism-related industries, indirect and induced increases in sales, a larger available workforce, and consumption effects stemming from a growing population will collectively lead to an increase in operating income among organisations operating in Bodø (Table 8). Compared to the fiasco scenario, the best-case scenario will generate a total of NOK 1.236 billion over the 15 years simulated (82 million per year on average).

Table 9. Sum of operating income for all organisations in Bodø municipality, NOK million

	S1 Success	**S2 Fiasko**	**Difference**
2022	96,743	96,719	-24
2023	99,702	99,621	-81
2024	102,791	102,639	-152
2025	105,905	105,769	-136
2026	109,107	109,043	-64
2027	112,433	112,320	-113
2028	115,876	115,778	-98
2029	119,468	119,388	-80
2030	123,184	123,124	-60
2031	127,055	126,952	-103
2032	131,087	130,934	-153
2033	135,238	135,135	-103
2034	139,498	139,425	-73
2035	143,956	143,899	-57
2036	148,616	148,617	1

Conclusion

Using the statistical data for 2011–2022, the digital twin of Bodø municipality was created, including 52,802 individuals; 25,560 households; 32,019 apartments, houses, industrial buildings and other real estate properties; and 1,250 organisations with 24,779 employees. Based on certain rules of behaviour, the individuals, firms and other entities in the model can "live" (i.e. interact with each other and their simulated environment over time). The model is calibrated against historical data. This report explains how the reliability and validity of the model is assured. The resulting model can replicate the historical development of Bodø municipality as well as provide reasonable forecasts when the model runs forward, simulating development from 2022 to 2036.

This report details how the cultural life and Bodø2024 project are integrated into the overall socioeconomic model of Bodø municipality. Cultural life is incorporated into the simulation in several ways. First, all organisations present in a municipality, including culture-related organisations, are included in the basic model.

Second, changes in cultural life are simulated through various cultural happenings (anything that is related to culture and may have any measurable effect on the simulation, such as concerts). Third, cultural life is assumed to influence the attractiveness of Bodø as a tourist destination. Finally, cultural life is expected to influence the likelihood of living or staying in Bodø, especially among young residents.

Using this socioeconomic model with a culture-related extension, two scenarios were simulated for Bodø in 2022–2036: the "success" scenario (all Bodø2024 activities go as planned at maximum capacity), and the "fiasco" scenario (Bodø2024 fails to attract significant public attention). The simulation results suggest that in the best-case scenario, about 2,000 more individuals will be living in Bodø than under the fiasco scenario. It is estimated that direct expenditures related to the Bodø2024 project, increased turnover in tourism-related industries, direct and induced increases in sales, a larger available workforce, and consumption effects stemming from the growing population will lead to increased operating income among organisations/firms operating in Bodø. Compared to the fiasco scenario, the best-case scenario would generate a total of NOK 1.236 billion over the 15 years simulated (an average of 82 million per year). Among other consequences of Bodø2024, migration, births, deaths, unemployment, number of children in kindergartens and pupils in schools were discussed.

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