R&D-Report

Updated Simulation of Potential Effects of Bodø2024 European Capital of Culture for development of Bodø municipality by 2036

Evgueni Vinogradov
Anatoli Bourmistrov

Nord University
R&D-Report no. 139
Bodø 2026

NORD University

www.nord.no

Updated Simulation of Potential Effects of Bodø2024 European Capital of Culture for development of Bodø municipality by 2036

Evgueni Vinogradov
Anatoli Bourmistrov

Nord University
R&D-Report no. 139
ISBN 978-82-7456-911-9
ISSN 2535-2733
Bodø 2026

NORD University

MONITOR 2024
EFFECTS OF BODØ AS EUROPEAN CAPITAL OF CULTURE

NORD universitet

Dekangodkjenning

Tittel	Offentlig tilgjengelig	Publikasjonsnr.
Updated Simulation of Potential Effects of Bodø 2024 European Capital of Culture for development of Bodø municipality by 2036	Ja	139
	ISBN 978-82-7456-911-9	ISSN 2535-2733
	Antall sider og bilag 27	

Emneord	Keywords
Kultur Evaluering Bodø2024 Agentbasert modellering Scenario	Culture Evaluation Bodø2024 Agent-based modelling Scenario
Forfatter(e)/prosjektmedarbeider(e) Evgueni Vinogradov Anatoli Bourmistrov	Prosjekt Monitor2024: Effekter av Bodø som europeisk kulturhovedstad
Oppdragsgiver(e) EU, Bodø2024	Oppdragsgivers referanse

Alle FoU-rapporter/ arbeidsnotat skal utstyres med en Creative Commons (CC)-lisens, som definerer betingelsene for gjenbruk. Lisensene krever at opphavspersonen navngis og at endringer indikeres.

Kryss av for valgt lisens (obligatorisk):

☒ Navngivelse/CC BY
Den mest åpne/standard open access-lisensen som tillater ubegrenset gjenbruk

☐ Navngivelse-Del på samme vilkår/CC BY-SA
Nye arbeid må ha samme lisens som det opprinnelige arbeidet

☐ Navngivelse-Ingen bearbeidelse/CC BY-ND
Ved bearbeiding av materialet, kan det nye materialet ikke deles

Prosjektansvarlig (navn/sign.) Anatoli Bourmistrov

- Publikasjonen er vurdert etter gjeldende vitenskapelige standarder, nasjonale forskningsetiske retningslinjer, samt retningslinjer for forvaltning av forskningsdata ved Nord universitet.
- Det foreligger ikke egeninteresser/situasjoner som er egnet til å påvirke vurderingen av innholdet i denne publikasjonen, f. eks. økonomiske interesser i publikasjonens tema.

Intern kvalitetssikrer utpekt av dekan (navn/sign.)

Gry A Aas Dr. Martin Piber

Dato **Dekan (navn/sign.)**

Oppdatert 11/2021

Contents

List of abbreviations

ECOC –European Capital of Culture
EC – European Commission
IKS – Inter-municipal Company (Nor.: Interkommunalt 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

List of tables

List of figures

Summary

This report is an update of previously published scenario report (Vinogradov, 2024[1]). The report published in 2024 projected potential social-economic effects of Bodø2024 ECOC for Bodø municipality based on assumed data corresponding to two scenarios - "success" vs "failure". This report updates projections of potential social-economic effects by 2036 based on factual statistics and data collected available for 2024, illuminating new two scenarios – potential social-economic effects if legacy of Bodø2024 is maintained vs contrafactual scenario, where Bodø2024 ECOC has never taken place.

The Bodø2024 European Capital of Culture (ECOC) marked a significant cultural milestone being the first city above the Arctic Circle to receive this title. Throughout 2024, Bodø city and the surrounding Nordland region hosted a plethora of cultural events and initiatives, embracing the unique geographical and cultural characteristics of the Arctic.

The European Commission (EC) requires the organizer 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 research group[2].

Evaluating long-term effects of Bodø2024 ECOC 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 grants to local artists to increased life satisfaction among citizens, 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 used in this report. This approach involves simulating the actions and interactions of autonomous agents (both individuals and collective entities such as organizations 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.

Initially, 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 organizations 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 was calibrated against historical data illuminating how Bodø municipality was actually developed over time. This report also illuminates procedures for assuring reliability and validity of the simulations. The resulting model replicated the historical development of Bodø municipality and provided reasonable forecasts for development from 2024 to 2036. In the first round, two scenarios were simulated for Bodø in the end of 2023: 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 (failure) scenario, in which Bodø2024 fails to attract significant public attention). The results of these simulations were reported in 2024.

[1] https://site.nord.no/monitor2024/wp-content/uploads/sites/58/2024/05/FoURapport1062024.pdf
[2] https://site.nord.no/monitor2024/

During 2024 and 2025, new data were collected. This time, the model was updated with actual numbers of tourists, cultural events, cultural event visitors, and recent demographic statistics. 223 separate cultural events with total publicum count of 280,000 were attributed to Bodø2024 ECOC. These numbers show that the actual results of Bodø2024 ECOC, in many respects, surpassed the "success" scenario. Based on these updated numbers, two new scenarios were simulated.

Therefore, this updated report describes two scenarios: how Bodø can develop the next decade "with Bodø2024" compared to a scenario for Bodø "without Bodø2024" (or as Bodø2024 never took place). 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 organizations present in a municipality, including culture-related organizations, 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.

The results of the simulations suggest that 2,836 more individuals may be living in Bodø municipality by 2036 as a result of Bodø2024 ECOC, under assumption that Bodø2024 legacy is maintained. It is projected that the Bodø2024 ECOC leads to direct spendings, increased turnover in tourism-related industries, indirect and induced increase in sales, a larger available workforce, and consumption effects related to the growing population. These factors are anticipated to increase the operating income of organizations/firms operating in Bodø. Spendings by Bodø2024 ECOC can generate additional NOK 1 billion over the simulated 13-year period, an average of NOK 80 million per year. The cultural sector can increase the turnover by NOK 360 million. Among other consequences, migration, births, deaths, unemployment, and the number of children in kindergartens and pupils in schools are also discussed.

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 organizations 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, organization 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 organizational 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 based on the theoretical premise that macro-level social phenomena are the result of interactions occurring at the micro- and meso-levels, involving individuals (people, organizations, 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, organizational and spatial characteristics are defined. Social and organizational 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.

Figure 1. LOS model illustration exemplified in the Norwegian case

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

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. **Organizations/Firms:** Every real firm and organization 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. Organizations supply goods/services to each other and import/export in/out of a municipality.
3. **Labor Market:** Connecting the synthetic population with organizations/firms.
4. **Real Estate Market:** Employs digital maps and other geospatial information to situate citizens and organizations 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 organization employing them shuts down (an external factor for that individual). Periodically, each household reevaluates the intention to move to another municipality and, with certain probability, takes a spontaneous decision to move. There is also a rule that tells the households to increase their probability to move if one of the adults in the household loses his/her employment.

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 organizations 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 by 2036 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*	*Std. deviation*	*Relative std. deviation (%)*
Population, total	54503	370	0.68
Population, men	27637	243	0.88
Population, women	26865	173	0.64
Excess of births (births minus deaths)	-176	39	-22.43
Number of births	435	30	7.01
Number of deaths	612	21	3.45
Migration, net migration	154	123	79.66
Migration, moved in	2588	56	2.19
Migration, moved out	2433	99	4.09
Employed, total	28769	185	0.64
Unemployed, total	799	37	4.68
Retired, total	12031	115	0.96
Commuting, commuting in	16564	163	0.98
Commuting, commuting out	1118	26	2.33
Work assessment, total	819	312	3.82
Labour market schemes, total	121	11	9.36
Disabled, total	3078	60	1.97
Jobs, total	44843	113	0.25
Number of employees, total	28278	177	0.62
Operating income, total, NOK mil	139723	214	0.3
Households, total	25286	97	0.38
Households, living alone	10759	98	0.91

Households, couples without resident children	6157	92	1.5
Culture sector: total employees, total	1024	19	1.89
Culture sector: in commuters, total	432	20	4.64
Culture sector: turnover, total NOK mil	2682	51	1.9
Kindergarten, total	2269	81	3.54
Primary and low secondary school, total	5389	164	3.04
Upper secondary school, total	1672	51	3.07
Students, total	5550	83	1.51

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:

- 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 2. Differences between simulated and historical initial values

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 12 years prior to 2024. The output is compared to 1) actual historical data for the given municipality and 2) SSB population forecasts made in 2011.

SSB delivers a range of population forecasts depending on various assumed national growth, ageing and immigration rates. Figure 2 illustrates that the population forecasts for Bodø municipality 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.

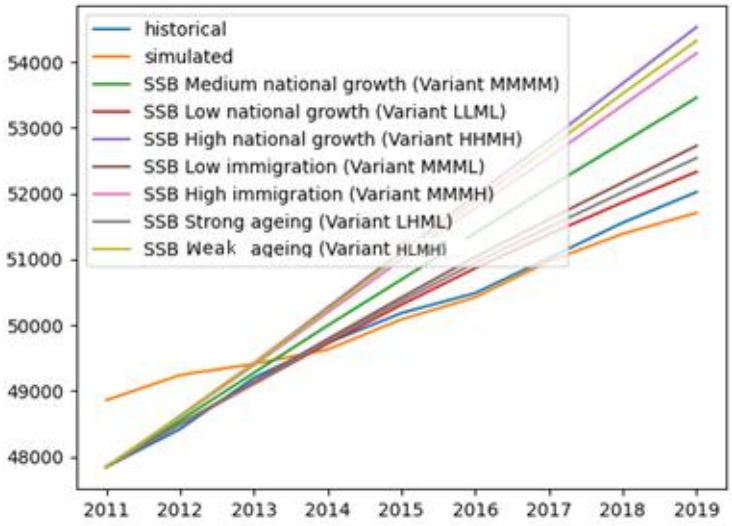

Figure 2. SSB population projections for Bodø municipality

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

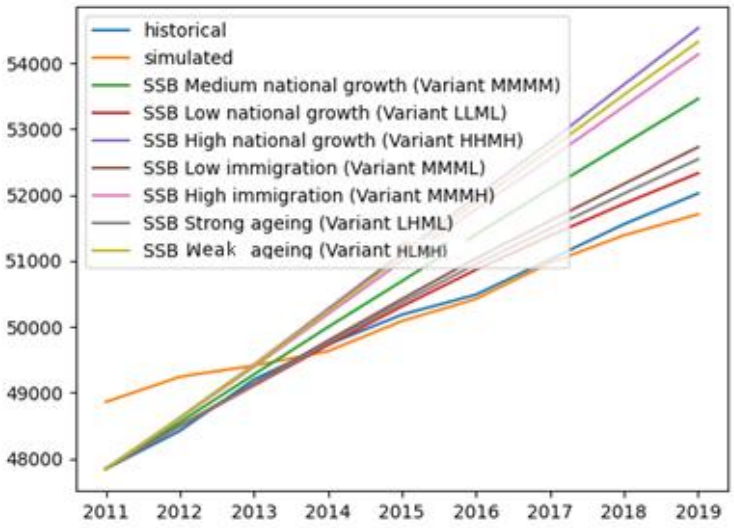

Figure 3. SSB population projections made in 2011 plotted against historical and modelled data

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.

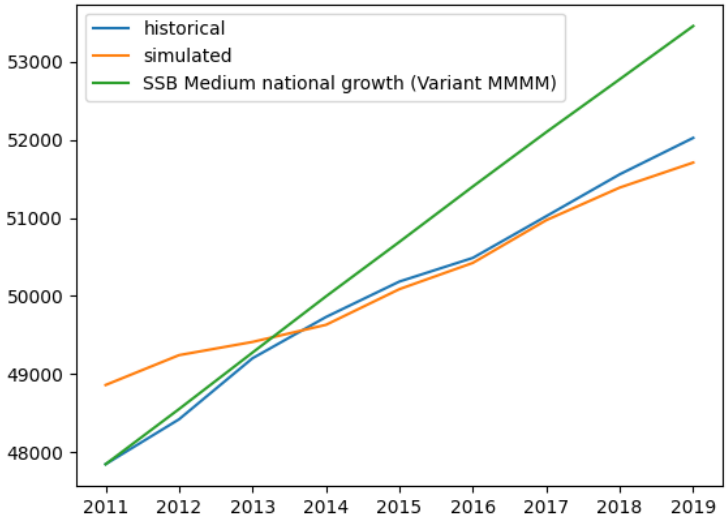

Figure 4. SSB population projections (medium national growth alternative) made in 2011 plotted against historical and modelled data

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, grunnkrets) levels, yielding reasonably accurate simulation results. However, the endogenous parameters are further calibrated for Bodø municipality to achieve a closer match with historical data for the last 12 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 Bodø2024

Culture

Cultural life is incorporated into the simulation in several ways:

1) All organizations present in a municipality, including culture-related organizations, 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 organizations

First, data for all organizations present in a municipality, including culture-related organizations, are included in the basic model. The organizations with the following NACE[3] 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 (selected manually from different code groups).
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:

[3] Detailed information on NACE ('Nomenclature statistique des activités économiques dans la Communauté européenne') codes: https://www.ssb.no/en/klass/klassifikasjoner/6

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”[4]
2) SSB table 13507: “Percentage of the population who wants to use cultural activities more frequently, by sex and age”[5]

[4] https://www.ssb.no/en/statbank/table/13503/
[5] https://www.ssb.no/en/statbank/table/13507/

3) SSB table 13508: "Barriers against wanted usage, of different cultural activities, by sex and age (per cent)"[6]

Part 4. Simulating Bodø2024ECOC

A diagram for the outcomes of Bodø2024ECOC for Bodø municipality is shown in Figure 5.

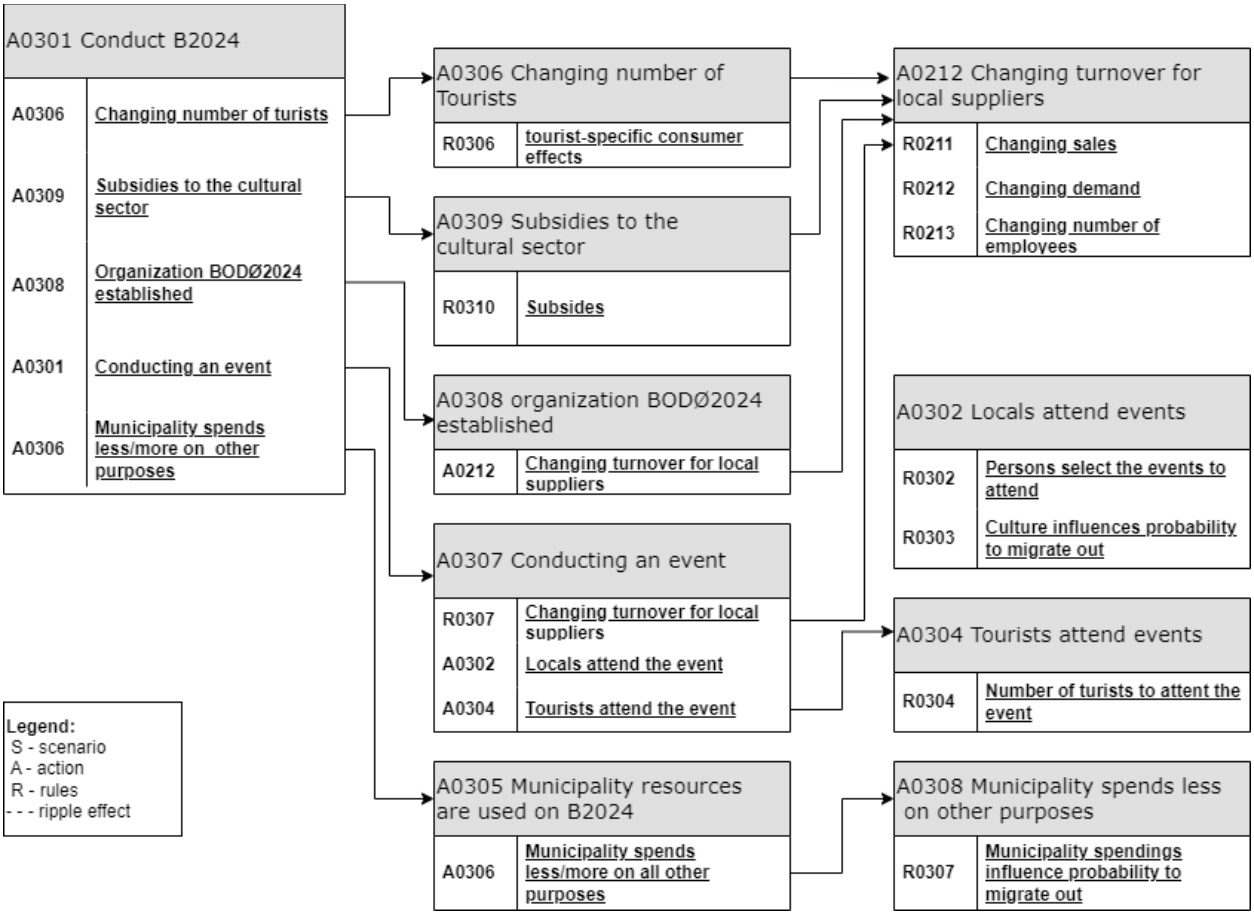

Figure 5. Consequences of Bodø2024.

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

1) An organization, Bodø2024 IKS - the organization that administered Bodø2024 ECOC, is formed with up to 20 employees. This creates ripple effects as salaries are paid to these employees and the organization buys products/services from local suppliers. The organization 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.

[6] https://www.ssb.no/en/statbank/table/13508/

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 on individuals' age, gender and engagement level as well as on the quality and scale of the event.
4) NOK 56 million are 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, are taken from the municipality budget and reallocated to Bodø2024. The negative effect of this reallocation is considered.

Creating Bodø2024 as an organization

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

Table 3. Bodø2024 IKS 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 IKS 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 (in our model) the Bodø2024 IKS as an organization 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 IKS has planned to spend NOK 185 million to purchase products/services. Of this budget, NOR 130 million went 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 simulated organization is closed in December 2025.

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

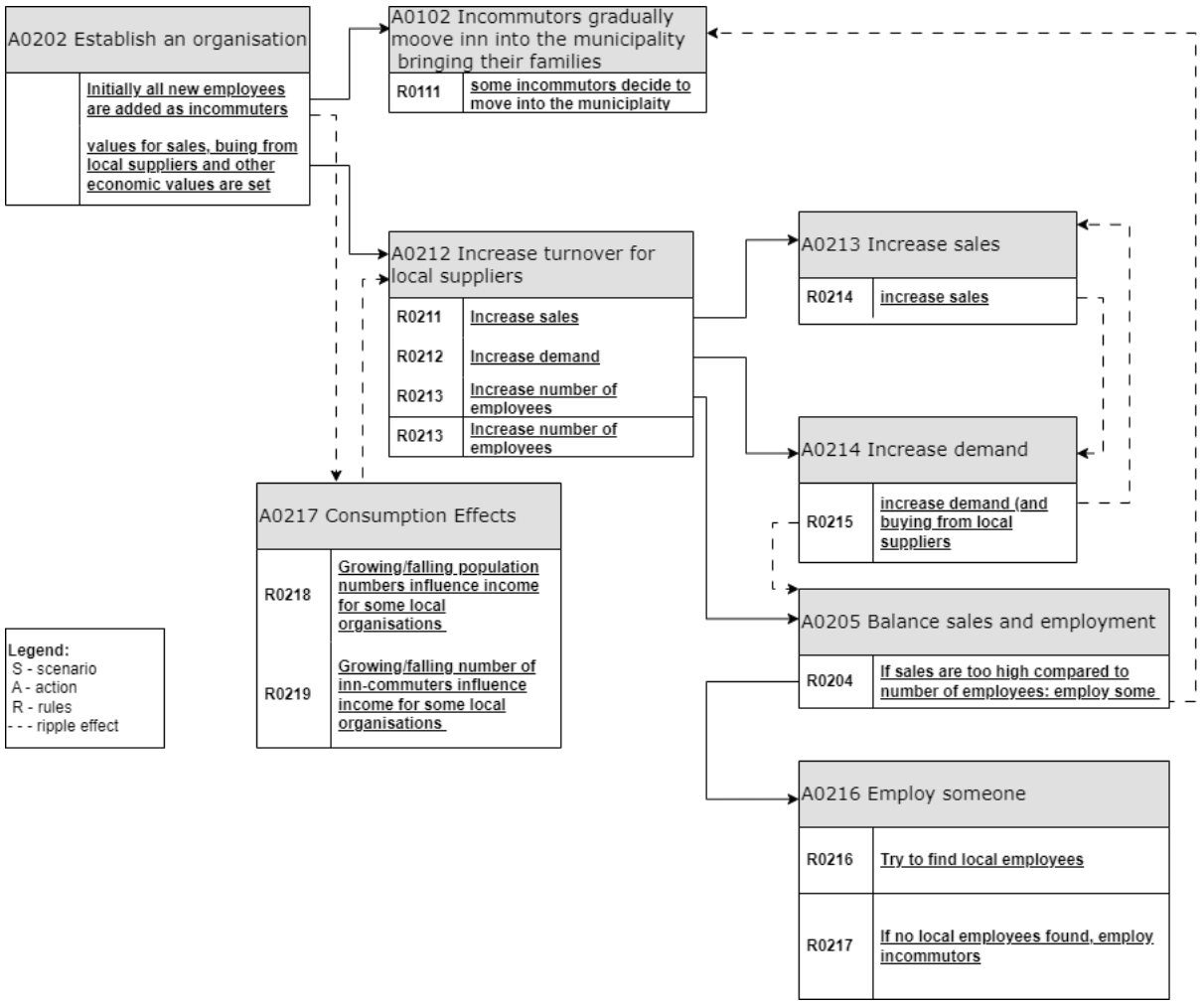

Figure 6. Ripple effects of establishing a new organization in the model

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[7] 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[8].

[7] https://thenorwayguide.com/stats-for-tourism-in-norway/#how-much-tourists-spend-when-visiting-norway
[8] https://www.ssb.no/statbank/table/14174/

Visit Norway describes how Norwegian and foreign tourists spend money at the destination[9]. 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
Accommodations	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[10]. 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. Statistics Norway reports that the number of tourists visiting Bodø increased by 34.3% in 2024. This is almost exactly the figure representing the "success" scenario from our previous simulations (30%), plus the general increase in Norway as a whole (3.3%). Thus, in this report the scenarios with and without Bodø2024 suggest tourism increases of approximately 34% and 4%, respectively.

The effects of Bodø2024 for increased tourism are modelled as follows (assumptions):

- The effects have taken 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 325 individuals (34%).
- Daily local consumption by tourists is set at NOK 2,100.

Conducting a Bodø2024 ECOC program 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[11])
- Gender distribution

Cultural events are divided into types (concert, festival etc., see list on page 15).

[9] https://business.visitnorway.com/no/markedsdata/nokkeltall/nokkeltall-2018/turismens-betydning-for-norge/
[10] Tourism industries - economic analysis - Statistics Explained (europa.eu)
[11] Skewness in statistics describes how asymmetric a data distribution is, indicating whether it is stretched more to the left or to the right

Cultural events have repercussions for participants. Local participants exhibit a reduced inclination to move out of the municipality. In the simulation, the magnitude of this change is set based on comparison to the statistical reports and empirical research findings describing the factors influencing individual mobility[12]. No specific empirical evidence on quantitative relationships between cultural events and the probability to move have been found in the literature. However, in this project, the effect of cultural events is quantified so that it is always higher than zero and lower than effect of changes in employment status, that is the strongest predictor om movement between municipalities. The impact on tourists is not taken into account here.

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.

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 (50%)
age_min	16
age_max	70
age_skewness	0.8
share_women	0.5
budget_local_suppliers, NOK 1000	10
budget_local_cultural_suppliers NOK 1000	10
longitude	14.375319530301832°
latitude	67.28318292939502°

223 cultural events localized in Bodø were simulated.

Subsidies to the cultural sector

NOK 56.354 million were provided directly as subsidies to actors in the cultural sector in Nordland. About 50 million went to the cultural sector. We assume that 40% were allocated to the cultural sector in Bodø municipality.

Use of municipal resources

When municipal resources are removed from the ordinary budget, the quality and quantity of ordinary municipal services can be reduced. There is no statistics available to account for this effect. Spending money on Bodø2024 ECOC culture activities was perceived controversial by some population in Bodø that

[12] Andreev, L. 2017. Mobilitet og Flyttevillighet blant arbeidsledige. Arbeid og Velferd (3), p. 19; Stambøl, L.S. 1998. Regional mobilitet i arbeidsstyrken. Økonomiske analyser (8), p. 15; NOU 2000:21, En strategi for sysselsetning og verdiskaping, kap 6 Analyser av regional mobilitet på arbeidsmarked med vekt på flytting, konjunktursvingninger og næringsstruktur.

wished that this money should have being spent on schools (see MONITOR2024 Social media report). For this simulation purpose, when money are removed from the ordinary budget, 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 from its municipal budget to Bodø2024 ECOC. 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 therefore 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 for the comparative period 2023–2036:

1) Bodø with Bodø2024 ECOC (based on actual numbers on program events, tourists and visitors), and
2) Bodø without Bodø2024 (as Bodø2024 never took place).

Table 7 illustrates the differences between scenarios with and without Bodø2024.

Table 7. Differences between the assumptions for scenarios with and without Bodø2024

Aspect	*With B2024*	*Without B2024*
Bodø2024 *IKS and subsidies to the cultural sector*		
- *Existing period*	2022–2025	0
- *Average number of man-years*	11.39	0
- *Paid to the culture sector in Bodø*	59 million	0
- *Paid to other suppliers in Bodø*	49 million	0
Tourism in Bodø municipality		
- *Tourism increase (daily number of additional tourists)*	325 (34%)	38 (4%)
Cultural program events related to Bodø2024 held in Bodø municipality		
- *Audience count for cultural events*	280,427	0
Use of municipal resources		
- *Increase in propensity to move*	-1%	0

Information about public attendance for around 65% of program events that were held in Bodø, comes from the questionnaire that was sent to program events leaders after their event was finished (see

Program event report). For smaller events we have an assumption of 30 participants per day/event and for bigger events we assume public attendance of 250 people per day/event. For a smaller part of events, where we could not find enough information to estimate content, event arena and the number of days, we used a median number of 250 participants. The total audience for all the events attributed to Bodø2024ECOC and held in Bodø municipality was 280,427. The number of persons involved is much lower since the same person could attend two and more events during 2024.

Results of simulations for two alternative scenarios

The figures and tables in this section compare two scenarios: "with" and "without" Bodø2024. As illustrated by Figure 7 and Table 8, it is expected that if Modø2024 never happened, it would be 2,836 less individuals living in Bodø by 2036 (data 2023 for 2023 are actual statistics, while data starting from 2024 are simulated).

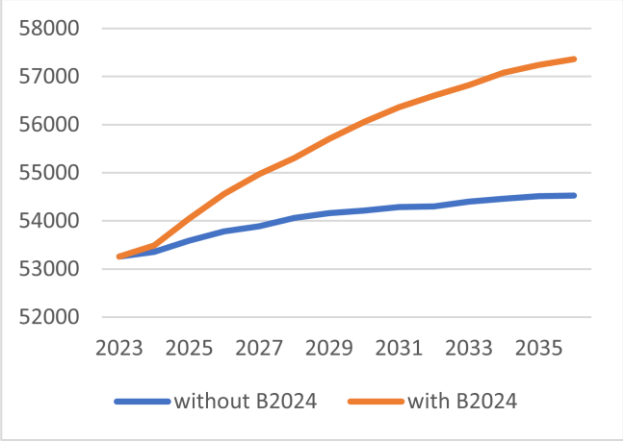

Figure 7. Simulated population growth

Table 8. Simulated population growth

year	Without B2024	With B2024	Difference
2023	53259	53259	0
2024	53360	53493	133
2025	53587	54048	461
2026	53780	54558	778
2027	53886	54975	1089
2028	54063	55308	1245
2029	54159	55704	1545
2030	54214	56056	1842
2031	54288	56363	2075
2032	54300	56605	2305
2033	54403	56826	2423
2034	54464	57082	2618
2035	54513	57245	2732
2036	54527	57363	2836

This growth is mostly due to reduced migration out of Bodø. Figure 8 shows that in the scenario "with Bodø2024", out-migration will be reduced by, on average, 184 individuals per year due to increased overall satisfaction with living in Bodø and more employment opportunities in culture- and tourism-related industries. As shown in Figure 9, in-migration numbers by will rise on average by 39 individuals per year due to the effects of Bodø2024.

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

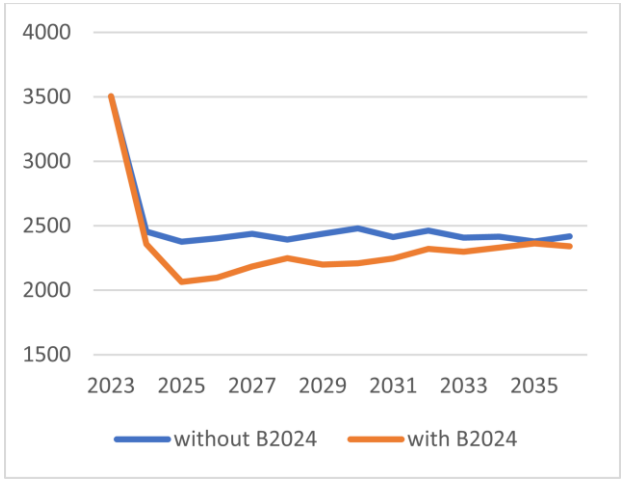

Figure 8. Migration out of Bodø

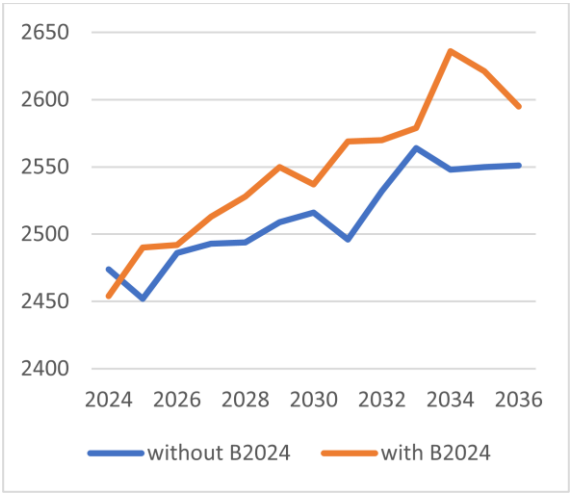

Figure 9. Migration from other regions to Bodø

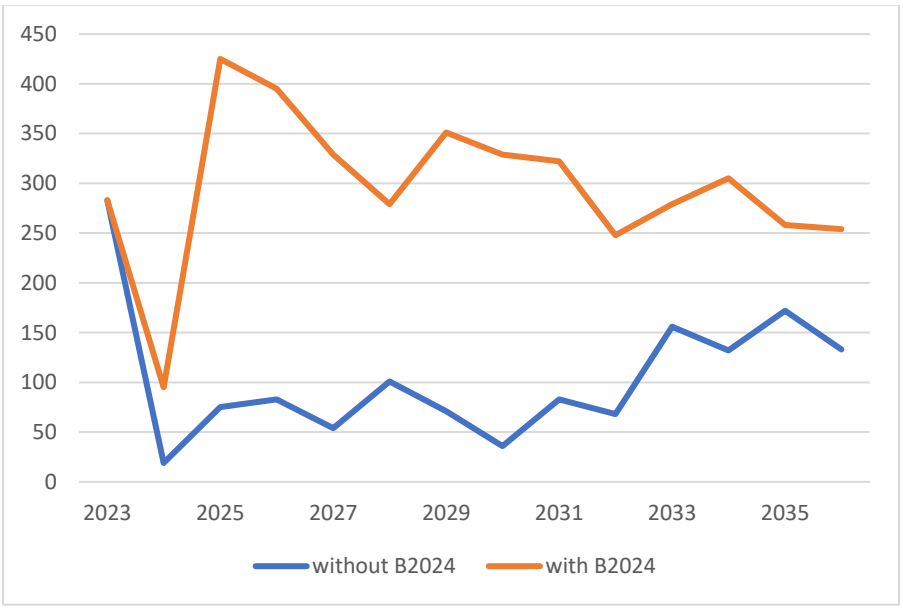

Figure 10. Net migration to Bodø

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. While the number of deaths is not different between the two scenarios, the number of births is expected to be on average 25 persons higher during next 12 years as a consequence of Bodø 2024.

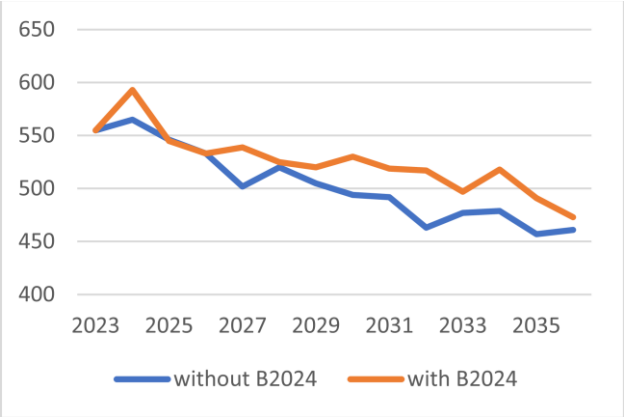

Figure 11. Yearly number of births

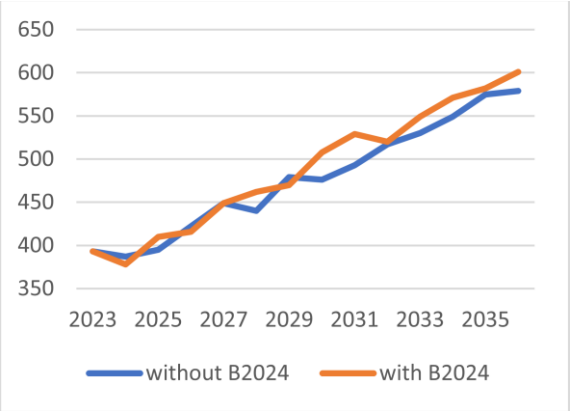

Figure 12. Yearly number of deaths

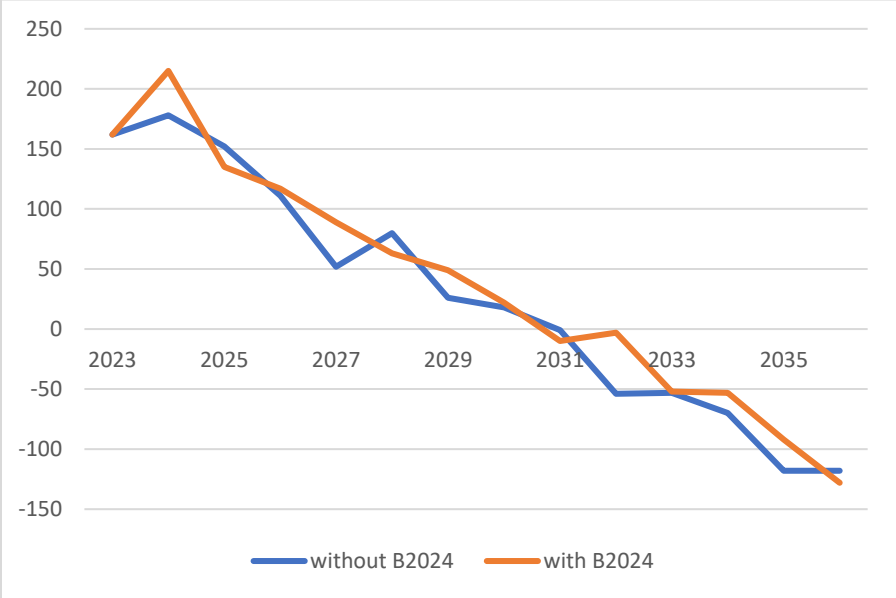

Figure 13. Excess of births over deaths

Bodø2024 will also lead to an increase in the number of retired individuals, resulting in approximately 425 more retirees (see Figure 14).

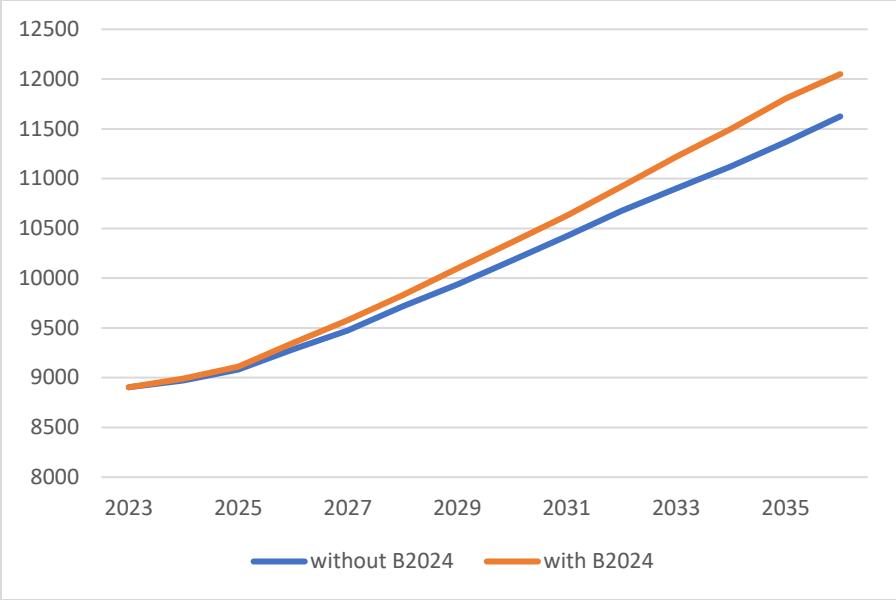

Figure 14. Number of retirees in Bodø

As Bodø2024 results in the creation of some additional job openings in Bodø, it is expected that Bodø 2024 will result in a lower level of unemployment in 2024 (Figure 15). This takes into account both the job opportunities created directly in the Bodø2024 organization and the increasing demand for labour in the cultural and tourism-related sectors. The simulations show that while Bodø2024 contributes to the unemployment reduction in 2024/25, the unemployment numbers will be slightly higher after 2026 because of Bodø2024. Probably it is because of some of the new job opportunities opened in 2025 will not be sustainable and disappear when Bodø2024 project is over. However, the numbers are so small that these findings on unemployment effects remain inconclusive.

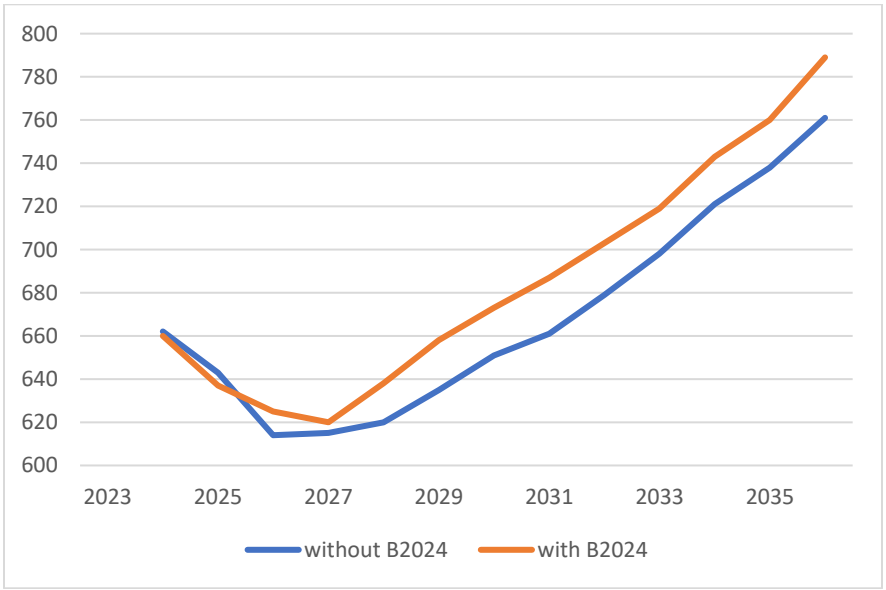

Figure 15. Number of unemployed

More young people, couples and families opt to remain in or move to Bodø as a result of Bodø2024. Thus, 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 16 - 18). As a result of Bodø2024, Bodø municipality will probably need additional 184 places in kindergartens, 394 places in primary and low secondary schools and 70 places in upper secondary schools by 2036.

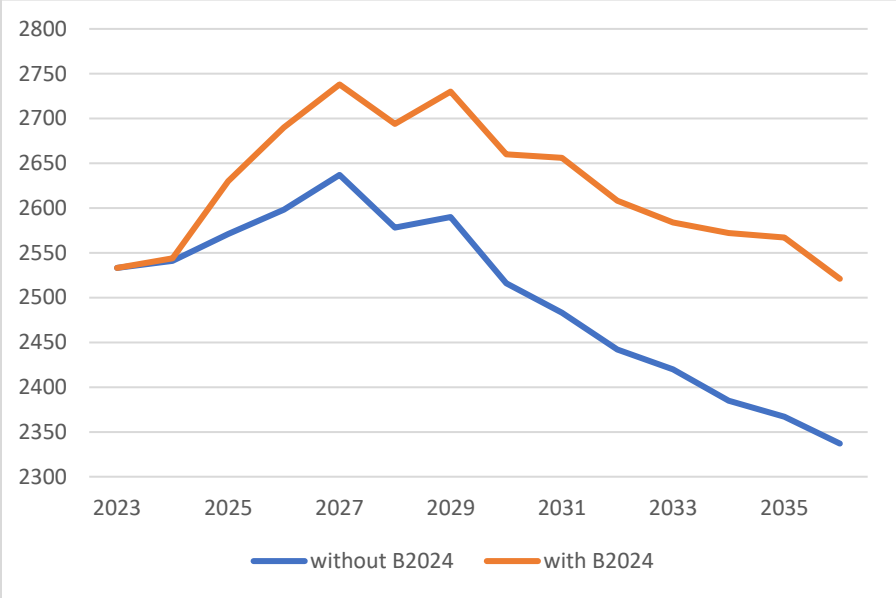

Figure 16. Demand for kindergarten places

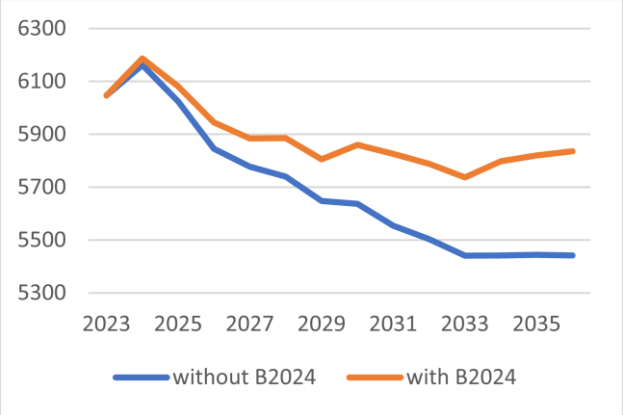

Figure *17.* Pupils in primary and low secondary schools

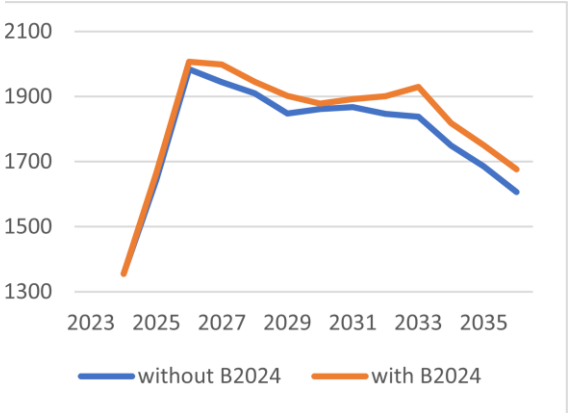

Figure 18. Pupils in upper secondary schools

Finally, it is expected that direct expenditures related to the Bodø2024 ECOC, 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 organizations operating in Bodø (Table 9).

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

	WITHOUT B2024	WITH BODØ 2024	DIFFERENCE
2024	107893	107969	76
2025	110040	110142	102
2026	112240	112303	63
2027	114409	114550	141
2028	116645	116869	224
2029	118968	119131	163
2030	121371	121523	152
2031	123892	124007	115
2032	126312	126476	164
2033	128909	128955	46
2034	131537	131498	-39
2035	134191	134104	-87
2036	136893	136813	-80

Compared to the scenario without Bodø 2024, the Bodø2024 ECOC can generate additional NOK 1.040 billion over the 13 years simulated (80 million per year on average). Of these, the actors that we previously defined as belonging to the cultural sector, increase their turnover by NOK 360 million, manly during the first five years during and after 2024.

Conclusion

Using the statistical data for 2014–2024, 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 organizations 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 2024 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 organizations present in a municipality, including culture-related organizations, 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 2024–2036: one based on actual data from B2024 ECOC achievements and one as if Bodø2024 ECOC never happened. The simulation results suggest that about 2,800 more individuals will be living in Bodø as a result of Bodø2024. 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 organizations/firms operating in Bodø. Bodø2024 will generate a total of NOK 1.040 billion over the 13 years simulated (an average of 80 million per year). Among other consequences of Bodø2024, are lower out-migration, additional births, and growing number of children in kindergartens and schools. However, this development assumes that Bodø2024 legacy is maintained.

References

Andreev, L. 2017. Mobilitet og Flyttevillighet blant arbeidsledige. *Arbeid og Velferd* (3), p. 19.

Benthall, S. 2016. Philosophy of computational social science. *Cosmos and History: The Journal of Natural and Social Philosophy*, 12(2), 13–30.

Cioffi-Revilla, C. 2010. MASON computational science. *Computational Statistics*, 2(3), 259–271.

Dabbaghian, V., and V. K. Mago. 2014. Theories and Simulations of Complex Social Systems. Intelligent Systems Reference Library. Springer.

Forrester, J. W. 1961. *Industrial dynamics*. Cambridge, MA: MIT Press.

Goebel, R., J. Siekmann, W. Wahlster, and F. Squazzoni. 2009. *Epistemological aspects of computer simulation in the social sciences.* Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics).

Hamill, L., and N. Gilbert. 2015. *Agent-based modelling in economics*. Chichester, UK: John Wiley & Sons, Ltd.

Jackson, P. J. 2014. "Software solutions for computational modelling in the social sciences." In Intelligent Systems Reference Library, 5–17.

Lettieri, N. 2016. Computational social science, the evolution of policy design and rule making in smart societies. *Future Internet*, 8(2), 19–26.

Levitt, R. E. 2012. Using simulation to study, design and invent organizations. *Journal of Organization Design*, 1(3), 58–63.

Stambøl, L. S. 1998. Regional mobilitet i arbeidsstyrken. *Økonomiske Analyser* (8), p. 15.

Stambøl, L. S. 2000. Analyser av regional mobilitet på arbeidsmarkedet med vekt på flytting, konjunktursvingninger og næringsstruktur. I *En strategi for sysselsetting og verdiskaping, Norges offentlige utredninger* (NOU) 2000:21, Finansdepartementet. Oslo, Akademika 2000, 487–509.

Vinogradov. 2024. Bodø2024: Simulating bestcase and worst-case scenarios Monitor 2024: Effects of Bodø as European Capital of Culture 2024. *Nord University R&D-Report no. 106*.

Vinogradov, E., B. Leick, and B. K. Kivedal. 2020. An agent-based modelling approach to housing market regulations and Airbnb-induced tourism. *Tourism Management*, 77.

Wilensky, U., and W. Rand. 2015. *An introduction to agent-based modelling*. Cambridge: The MIT Press.