Pay for two airports, get only one

Introduction

Berlin Brandenburg Airport *Willy Brandt* often simply referred to as Berlin Brandenburg Airport (BER) is an international airport in Schönefeld, just south of the German capital Berlin in the state of Brandenburg. Named after the former West Berlin mayor and West German chancellor Willy Brandt (1969–1974), it is located 18 kilometers (11 mi) south-east of the city center and serves as a base for easyJet, Eurowings and Ryanair. It mostly has flights to European metropolitan and leisure destinations as well as a number of intercontinental services.

The new airport replaced Tempelhof, Schönefeld, and Tegel airports, and became the single commercial airport serving Berlin and the surrounding State of Brandenburg, an area with a combined 6 million inhabitants. With pre-pandemic annual passenger numbers of around 35 million, Berlin Brandenburg Airport has become the third busiest airport in Germany surpassing Düsseldorf Airport and making it one of the fifteen busiest in Europe.

The airport has a capacity of 46 million passengers per year. Terminal 1 accounts for 28 million of this; Terminal 2, which did not open until 24 March 2022 due to the COVID-19 pandemic, accounts for 6 million; and Terminal 5, the terminal buildings of the former Berlin-Schönefeld Airport, accounts for another 12 million. Expansion buildings are planned in 2035 to be able to handle 58 million passengers annually.

The airport was originally planned to open in October 2011, five years after starting construction in 2006. However, the project encountered a series of successive delays due to poor construction planning, execution, management, and corruption. Berlin Brandenburg Airport finally received its operational license in May 2020, and opened for commercial traffic on 31 October 2020, 14 years after construction started and 29 years after official planning was begun.

(source: https://en.wikipedia.org/wiki/Berlin_Brandenburg_Airport)

Obviously, a delay of about 10 years must have serious financial consequences for the owner of this huge project: the Flughafen Berlin Brandenburg GmbH (FBB) in Schönefeld. We will investigate how the delay of this project influenced the financial situation of the FBB in such a way that people now say: "*two airports are paid for, but only one is constructed.*" In addition, we will use simulation to analyze if/how things could have been done better (looking back) and we will make simulation-based forecasts (looking forward, until 2050). Will FBB go bankrupt only a few years after the grand opening?

According to the number of passengers, the FBB was the third largest airport firm in Germany in 2019 with over 35.6 million passengers (note that these passengers were travelling from the other two airports owned by FBB: Berlin Schönefeld Airport in Schönefeld and Berlin Tegel Airport, since BER had not opened yet). Munich is ranked second with 46 million passengers and Frankfurt comes first with 70 million passengers. The evolution over time of the number of passengers, together with important financial data is presented in

Table 1. A growing number of passengers should lead to growing sales figures. The FBB is indeed the leader in Germany when it comes to sales growth, with almost 200% growth from 2006 to 2019. As a reference, the airports in Oslo, Düsseldorf and Munich had a growth of respectively 162%, 155%, and 150%. FBB reached this remarkable result with the two comparatively old airports in Tegel and Schönefeld. Given this scenario, we should expect that FBB shows a very good development of its income statement with the new airport.

Table 1: Actual data from FBB

Year	FBB Passengers [passengers/ year]	Accumulated Deficit or Profit [euro]	Tangible Assets [euro]	Liabilities [euro]	Interest costs [euro/year]
2006	18 400 000	11 500 000	706 000 000	288 300 000	2 800 000
2007	20 000 000	-18 600 000	811 900 000	322 340 000	4 100 000
2008	21 400 000	-91 900 000	1 077 500 000	313 600 000	8 500 000
2009	20 900 000	-194 300 000	1 520 900 000	790 000 000	25 500 000
2010	22 300 000	-296 400 000	2 055 700 000	978 000 000	59 000 000
2011	24 000 000	-403 200 000	2 629 000 000	1 640 000 000	82 000 000
2012	25 200 000	-603 200 000	3 160 000 000	2 312 000 000	107 000 000
2013	26 300 000	-797 200 000	3 453 000 000	2 518 000 000	120 000 000
2014	28 000 000	-1 004 200 000	3 554 000 000	2 508 000 000	107 000 000
2015	29 500 000	-1 194 200 000	3 778 000 000	2 725 000 000	102 000 000
2016	32 900 000	-1 343 300 000	3 975 000 000	3 115 000 000	109 000 000
2017	33 300 000	-1 491 900 000	4 241 000 000	3 206 000 000	109 000 000
2018	34 700 000	-1 594 300 000	4 534 000 000	3 588 000 000	103 000 000
2019	35 600 000	-1 712 600 000	4 858 000 000	4 070 000 000	106 100 000
2020	9 000 000	-2 146 000 000	4 338 000 000	4 696 000 000	94 500 000
2021	9 900 000	-2 715 200 000	4 028 000 000	5 064 000 000	93 300 000

(Please note that the interest costs have gone down *after 2013, which is quite surprising as Liabilities continued to increase. We will therefore assume in the simulation that the interest percentage has* decreased *in the last decade. See also footnote 1 on the next page, and the "BER starter kit.mdl".)*

An optimistic editorial statement of the chief executives of FBB in the annual report of 2018 backs a positive expectation:

> *"The air traffic location of the capital city region is continuing to develop very dynamically. Therefore, the Airport Company can look back at a successful fiscal year 2018 with substantial growth in the core business. The operative results (EBITDA) of the Berlin airports achieved a new record value in 2018."*

However, the figures of the income statements of the FBB tell us a completely different story. EBITDA means Earnings *Before* Interests, Taxes, Depreciation, and Amortization. So, this is basically, the sales revenues minus operating expenses. However, when we *include all expenses* and accumulate them over the years, we get *substantial losses* (see Table 1 "accumulated deficit or profit"):

- In the first period, from 2006 to 2011, the deficit accumulated to almost 400 million.
- In the second period, from 2012 to 2019 (before COVID-19), when it was clear that the deadline of 2011 would not be met, the deficit accumulated to almost 1.7 billion.

- In the third period, the airport was opened, but passengers could not fly because of COVID-19 restrictions. This did not make the deficit any better and it accumulated further to 2.7 billion.

Thus, the statement that a positive result with record value was reached in 2018, seems to be a misleading statement about the real situation of the FBB in 2018. It does not consider the huge accumulated deficit, and it simply ignores that the operations should cover depreciation of assets and interest costs as well, because the operations are not possible without the infrastructures.

To finance the huge cost overruns of the BER, the FBB took substantial new loans (see Table 1 "Liabilities"). This increased the interest costs to a great extent. In the early years interest costs were about 2.8 million euro, rising to 93 million in 2021[1] even with a *decreasing* interest percentage during that period (see Table 1 "Interest costs").

Depreciations on assets also increased enormously. Depreciation costs depend on the value of tangible assets (see Table 1 "Tangible Assets"). Depreciation costs started at around 21 million euro in 2006, rising to over 120 million in 2021.[2]

Until the new airport opened, both the sales revenues per passenger and the operational expenses per passenger were relatively low (respectively 11 euro per passenger and 10 euro per passenger). The reason for these low revenues and expenses are the regulations in Germany that link the fees that airports may get to the cost that they have to cover. Berlin-Tegel and Schönefeld are comparatively old airports that offer a modest service quality, and the overheads are much lower because the assets have been written off, and interests were low. It is expected that when the new airport opens, the sales revenues can rise to 32 euro per passenger (but only if the new airport is 100% finished). However, also the operational expenses per passenger are expected to increase (to 20 euro per passenger).

FBB has some sales revenues from freight transport as well. But this is only a minor part compared to the sales revenues coming from passengers. It will be really difficult to increase freight transport because night flights are not allowed at the new airport. In addition, new infrastructures on the airport and for the traffic to the airport would be needed. As such, we will neglect revenues (and costs) coming from freight transport in the simulation.

The first column in Table 1 contains the number of FBB passengers per year. Note that these are not unique passengers (some travelers may use the airport several times a year, some may be using the airport once in a lifetime). The years 2020 and 2021 show a steep decrease in number of passengers due to COVID-19. It is expected that the number of passengers will increase again in 2022 and the years that follow, however, the trend (slope) will be lower than before the pandemic as business travel has been permanently influenced by new routines developed during the pandemic (more online meetings, less business trips). To model the number of FBB passengers per year (from 2020 to 2050) we will therefore use a so-called pandemic effect, which will be explained further in the "BER starter kit.mdl".

[1] Here I assumed a constant interest percentage of Liabilities of 5% per year from 2006 until 2011, after which it decreased annually with 0.3% until 2020. From 2020 until 2050 I have assumed a constant percentage of 2.3%
[2] Here I assumed a constant depreciation percentage of Tangible Assets of 3% per year.

Based on the description of the FBB presented above (and more data that will be presented on the next pages), you need to develop a simulation model that will run from 2006 to 2050. This model will therefore include the entire development project of the new airport and its use in the future. The financial situation of the FBB will be simulated and evaluated. Furthermore, different scenarios will be tested and evaluated. These scenarios are meant to analyze what could have been done differently (and better) in the past, and what could be done in the future to avoid potential bankruptcy of the FBB.

Please answer the questions below in the right order and read all the tips and hints provided in the text above and in the questions that follow carefully. Answering the questions in the right order will finally help you evaluate the financial situation of the FBB and find recommendations for the future.

Question 1: Causal loop diagramming (total 15 points)

Question 1a – Make a causal loop diagram of the airport development project. Show the diagram in your term paper and explain/describe your loop(s) (max 10 points).
Hint: use the words written in italic below (question 1a) in your causal loop diagram, you do not have to include additional variables

Developing a huge airport like the BER is usually divided into several building blocks. We will call these building blocks "modules". From the start of the development project until the end, these modules can be in one of these four stages: *unknown modules, modules in development, modules in test, modules completed.* On the first day of the project, the airport development team is not aware of all the modules that need to be developed/constructed, hence the "unknown modules". The so-called *discovery rate* of these unknown modules is a gradual process, and it depends on the minimum of the following two processes:

1. How fast unknown modules theoretically can be discovered (which depends on the unknown modules and the *average discovery time*, modeled as a first-order material delay*)*
2. How fast the team is learning by doing: as soon as modules are in development, they can lead to the discovery of new modules (the discovery rate therefore also depends on the modules in development multiplied by the *discovery percentage*)

The *development rate* depends on the number of modules in development and the *average development time.* The development rate is modeled as a first-order material delay. After modules are developed, they are tested. Testing can have two outcomes: either the modules are approved (*approval rate*) which means that they are completed, or they are disapproved (*disapproval rate*) which means that go back to stage of modules in development. Whether modules are approved or disapproved depends on the *approval percentage.* The approval and disapproval rate are modeled as first-order material delays, using an *average testing time*. The *total number of modules of the new airport* is 750. Initially, there are 200 modules in development, while no modules are being tested and no modules are completed. Therefore you can assume that 550 modules are unknown at the start of the simulation.

The *percentage finished* represents the number of modules that is completed (and thus approved) divided by the total number of modules of the new airport. When the percentage

finished is higher than or equal to the *percentage that needs to be finished before opening*, it is time to open the airport *(airport opening time).*

Question 1b – Extend your causal loop diagram made in question 1a with the impact of the airport development project on the financial situation of FBB. Show the new and extended causal loop diagram in your term paper. Explain/describe your loop(s) (max 5 points).
Hint: use the words written in italic below (question 1b) in the extension of your causal loop diagram, you do not have to include additional variables

As soon as the airport is opened, the *sales revenues per passenger* can be increased. Before opening, sales revenues are very low because passengers still have to use the old airport. After opening the sales revenues can be increased, but when the airport opens "prematurely" (for example when only 85% of the airport is finished), the sales revenues per passenger are also only 85% of what these revenues could be. If the airport opens after 85% of the modules are completed, it will continue developing the remaining 15% after opening. The sales revenues per passenger will then increase accordingly, every time (part of) the remaining modules is completed. *Sales revenues* are defined by the sales revenues per passenger times the *FBB passengers per year*. In this causal loop diagram you can assume that the FBB passengers per year is an exogenous variable but it will become endogenous in Question 2. Sales revenues have a positive influence on the *accumulated deficit or profit*. (Note that when the accumulated deficit or profit is negative, FBB is not making any money.) The *expenses* of the airport (which have a negative influence on the accumulated deficit or profit) are influenced by four types of costs:

1. *Operational expenses:* these costs depend on the FBB passengers per year: the *operational expenses per passenger* times the FBB passengers per year (note that the expenses per passenger will also go up after the new airport is opened).
2. *Depreciation rate*: as soon as modules are approved, they are part of the *tangible assets*, which are subject to depreciation. So, the approval rate (and the value per module) has a positive effect on the *tangible assets.* The higher the level of tangible assets, the higher the *depreciation rate* will be. (The depreciation percentage is assumed constant.)
3. *Interest costs:* the development project requires money and therefore FBB needs to take up loans (*liabilities*) that lead to interest costs. Both the approval and disapproval rate have a positive influence on *liabilities*. This is because (dis)approved modules have a certain value and this value needs to be paid for (the value per module and the value per reworked module are provided in the "BER starter kit.mdl" but do not have to be included in the causal loop diagram). Yet, FBB does not have to pay for everything. There is a percentage of assets funded by shareholder equity. This is 40%, which means that 40% of the value of (dis)approved modules will not be paid by the FBB. Note, that the higher the interest percentage that needs to be paid over the liabilities, the higher the interest costs.
4. *Repayment rate:* Liabilities can be repaid but only when the accumulated deficit or profit is high enough (higher than zero). The average repayment time of liabilities is 5 years.

Question 2: Developing a system dynamics model (total 30 points)

To get you started with the simulation model, a "BER starter kit.mdl" is already prepared for you. You can find this "BER starter kit.mdl" on It's Learning. You have to build the rest of the model using the variables already included in the starter kit and new variables, stocks, and flows based on the description provided in this term paper assignment. This starter kit contains the following information:

- Green exogenous variables with their right values and units.
- One red variable "pandemic effect" modeled as a lookup function of time
- Five orange variables that contain the values presented in Table 1. Also these orange variables are modeled as a lookup function of time. Please note that you should **not** use these orange variables in any way in your model. They are in the starter kit to make it easier for you to compare your simulated values with their real counterparts, thereby allowing you to check whether your model is behaving correctly. Simulation results are never a perfect match to real results, so you will see deviations between simulated and real numbers. But you should check whether the behaviors over time of simulated and real variables are somewhat similar from the years 2006 to 2021 (because we do not have real values from 2022 to 2050).[3] Please also note that Vensim will give you a warning when you check the units of your model. These warnings are connected to the red and orange variables. Don't worry about these warnings. You can ignore them.

Question 2a: Model the airport development project in Vensim (10 points)

In question 1a you developed a causal loop diagram of the airport development project. Use the text provided in question 1a and your insights derived from answering question 1a to develop a stocks and flows diagram in the BER starter kit-model that is provided and use the appropriate green exogenous variables where needed. Show the stocks and flows as a figure in your term paper. Provide a list of the equations of the stocks that you defined to make the model work.

Question 2b: Model travelers and passengers in Vensim (5 points)
(Please note that although this is presented as a separate question, the models you make in question 2a and 2b should be connected.)

An airport cannot function without passengers, so we need to model the FBB passengers per year. *FBB passengers per year* is determined by the multiplication of *travelers FBB* and the pandemic effect. To figure out the number of *travelers FBB* you can use the Bass Diffusion Model as inspiration. Instead of potential adopters, we will use *potential travelers*, and instead of adopters, we will use *travelers FBB*. The various constants (advertising effectiveness, adoption fraction, etc.) are given in the starter kit. Initially, there are 12 240 000 potential travelers and 18 400 000 travelers FBB. Potential travelers are passengers that have never traveled with FBB before but may be persuaded to do so. Travelers FBB are passengers that have traveled with FBB before, and will probably travel

[3] In the appendix of this term paper description you will find my simulation results of the base case compared to the real results.

again, if pandemic and other environmental rules allows them to do so. The difference between the normal Bass Diffusion Model and the model that you are making, is that the population of *potential travelers* ("potential adopters") is expected to grow each year with a *growth percentage* of 14.35% per year. Develop a stocks and flows diagram to model travelers and passengers and use the green exogenous variables where needed. Make connections between the model made in question 2a. Show the stocks and flows as a figure in your term paper. Provide a list of the equations of the stocks that you defined to make the model work.

Question 2c: Model the financial situation in Vensim (10 points)
(Please note that although this is presented as a separate question, the models you make in question 2a, 2b, and 2c should be connected.)

In question 1b you developed a causal loop diagram of the financial situation of FBB. Use the text provided in question 1b and your insights derived from answering question 1b to develop a stocks and flows diagram and use the green exogenous variables where needed. Make connections between the models made in question 2a and 2b. Show the stocks and flows as a figure in your term paper. Provide a list of the equations of the stocks that you defined to make the model work.

Question 2d: Run and upload the model and evaluate the "base case" (5 points)

Once you have answered questions 2a, 2b, and 2c, you can run the model from 2006 to 2040. *(Hint: if you made the model correctly, your base case simulation should be relatively similar to the actual numbers presented in Table 1, and the airport should open around October 2020).* After you run the model, save your model and attach this model as a separate file to your term paper (you need to upload it as a separate file or zip-file in Wiseflow). How do you evaluate the financial position of the FBB? Show the graphs of the simulated accumulated deficit or profit, liabilities, and FBB passengers per year in your term paper and use the behavior over time depicted in these graphs in your answer.

Question 3: Use the model to answer the following questions (total 10 points)

Question 3a: Is the quote from the annual report of 2018 a lie? (max 5 points)
In the beginning of this term paper the following quote from the annual report of 2018 was presented: "The operative results (EBITDA) of the Berlin airports achieved a new record value in 2018." Is this a lie? You have to use the model to figure this out, but you probably need to include new variables.

Question 3b: How many modules will be reworked from 2006 to 2050? (max 5 points)
The main reason for all the delays in the airport development project is the rework (modules that are disapproved and need to go back to the development phase). What is the total number of modules that are expected to be reworked from 2006 to 2050? (Modules that need to be reworked one time, count for one, modules that need to be reworked two times, count for two, etc.) You have to use the model to figure this out, but you need to include new variables.

Question 4: Looking back (max 10 points)

In this question we will explore if/how things could have been done differently during the airport development project by simulating different scenarios, using different values of the exogenous variables.

Question 4a: Would it have been possible to open the airport in 2011 and if so, what would this mean for the financial situation of FBB? (max 5 points)

To answer this question you can change the values of (one or more of) the green exogenous variables that influence the airport development project. Try to find a combination of values that allows the airport to open in 2011 (either in January or in December, as long as it is in 2011) under the same conditions as in the base case, that is: the airport opens when 85% of the models are completed.

Provide a list of the exogenous variables you changed in your report and describe their new values. Evaluate these new values (are they realistic? why/why not?). Also include the graph of the new accumulated deficit or profit in the term paper and discuss the results (does this make the situation better for the FBB? why/why not?)

Question 4b: Go slow to go fast (total 5 points)

Start with your original model (made in question 3). A lot of trouble in the airport development project was caused by the discovery of unexpected, unknown modules. Every time such an additional (unknown) module is discovered, it delays the project (because more work needs to be done in the same amount of time). This caused the approval percentage to be relatively low (55%), causing even more unexpected work (that is: rework). "Go slow to go fast" is a typical expression in product development projects to explain that if you think harder and longer in the beginning of the project, you can save time in the end of the project. What would have happened to the project if the average discovery time would be *increased* with 50% (taking more time to figure out how the unknown modules impact the modules already in development) which would cause an increase of the approval percentage of 50% as well? What would this mean for the airport opening time and the financial situation of FBB? Is this indeed "going slow to go fast"? Discuss your answer by showing graphs of the modules in development, completed modules, accumulated deficit or profit and liabilities.

Question 5: Looking forward: the green trend (15 points)

Start with your original model (made in question 3). As you probably noticed, the base case assumes that the number of travelers (and consequently, travelers FBB) keeps increasing over the years. This may not be a realistic assumption, considering the increasing focus of society on sustainability. This green trend will probably cause potential travelers and travelers FBB in the future to reconsider their travel plans and choose alternative ways of transport. (We assume here that when these travelers choose alternative ways of transport, they will never use the plane again.) Let's assume that the percentage of both travelers and

travelers FBB that "goes green" starts to increase with 0.1% each year from 2023 to 2050. You can model this by using the following equation:

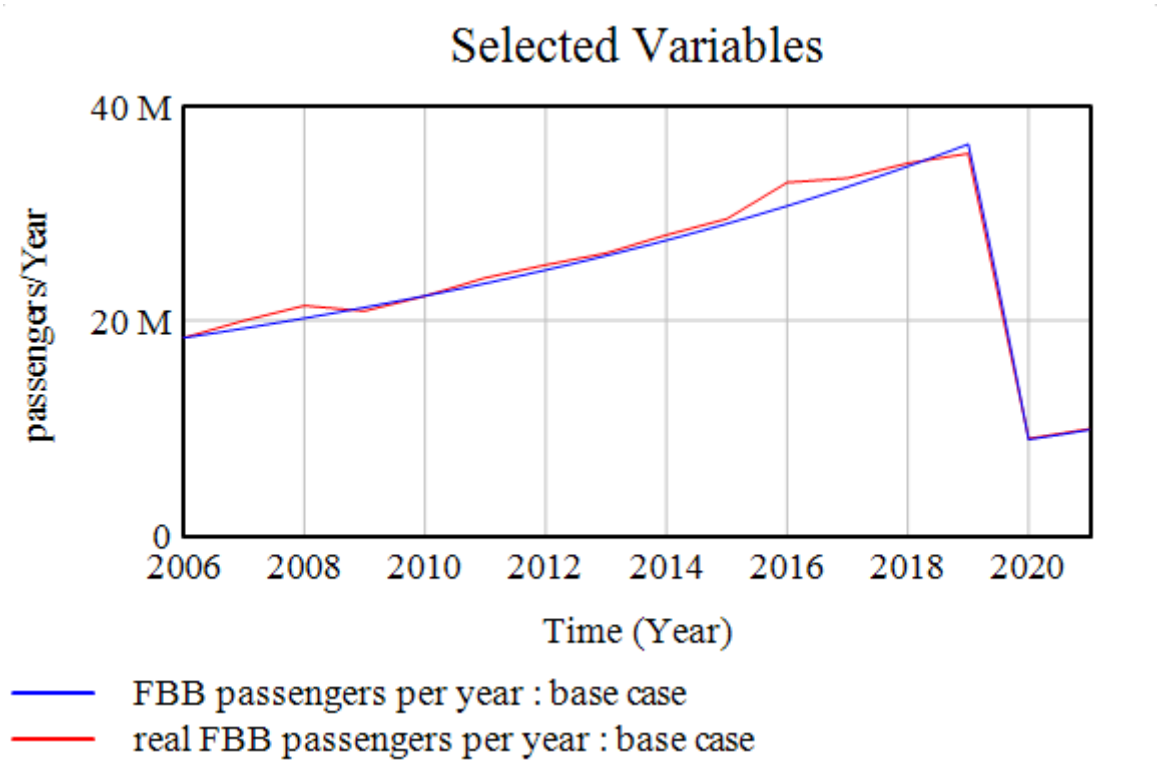
go green percentage = RAMP(0.001, 2023, 2050)

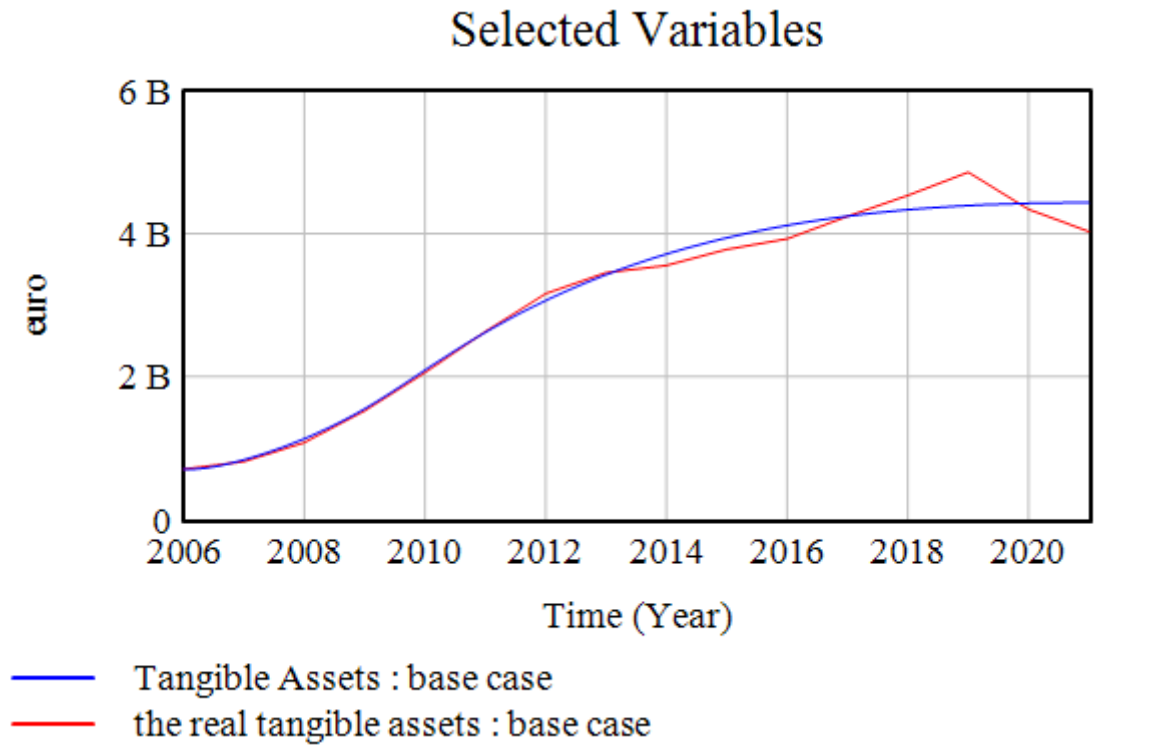
You need to change the model to include this percentage in the right place. Simulate this green scenario. What is your conclusion about this green trend based on the simulation results? Show and discuss graphs of the FBB passengers per year, the accumulated deficit or profit, and liabilities in the term paper.

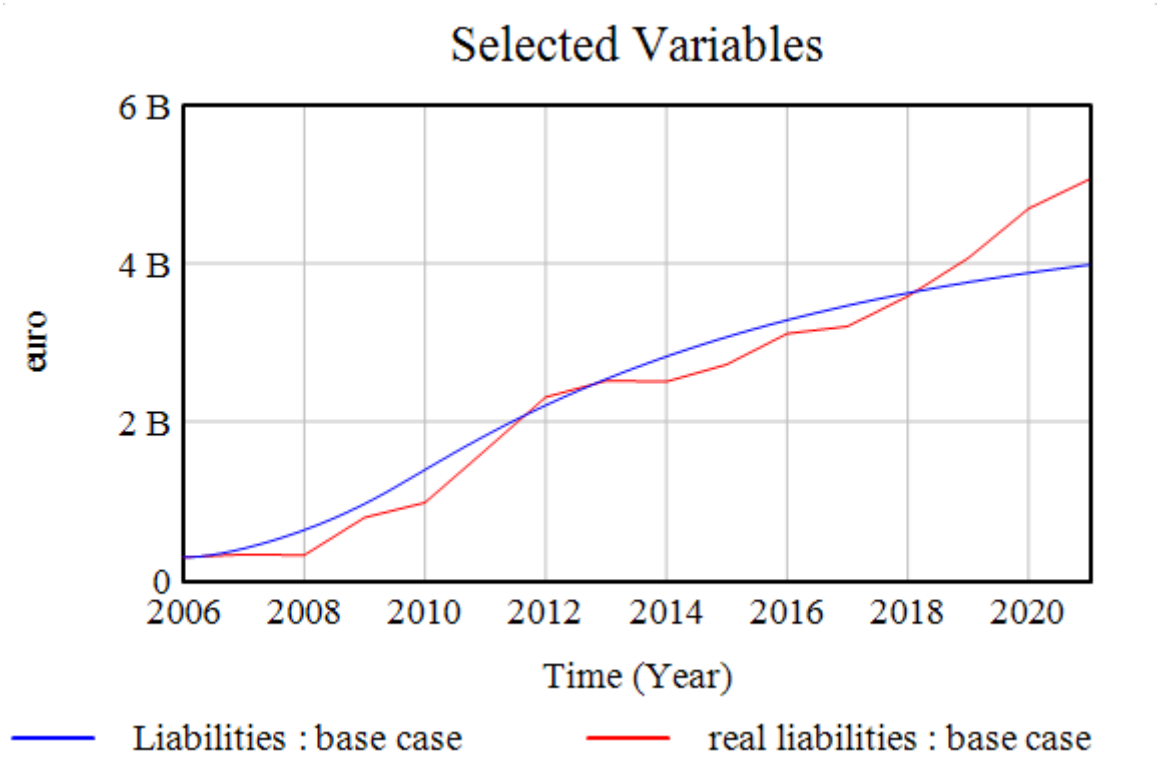
Question 6: Find other future options for FBB (total 20 points)

Continue with the model made in Question 5. Assuming this green trend becomes the new norm, the situation does not look very positive for FBB. Can you think of other ways to influence the financial situation of the FBB in a positive way? Model two improvement ideas, describe their influence on the accumulated profit and describe why/how they may work in reality. Note that you are allowed here to add stocks, flows and variables to your model. If you do add new variables, stocks and flows to your model, please include this new model as an attachment to your term paper.

Appendix: real vs simulated numbers (base case) from 2006-2021






Selected Variables
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4 B
2 B
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euro
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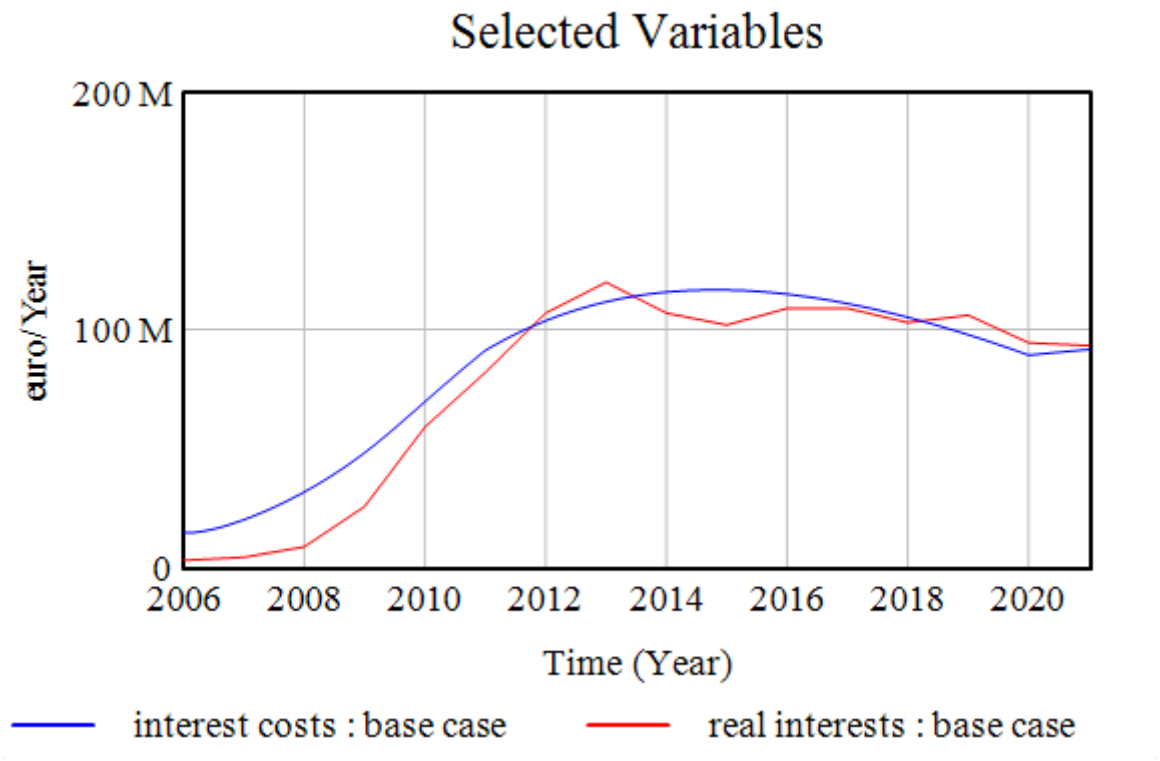
2008
2010
2012
2014
2016
2018
2020
Time (Year)
Liabilities : base case
real liabilities : base case


Selected Variables
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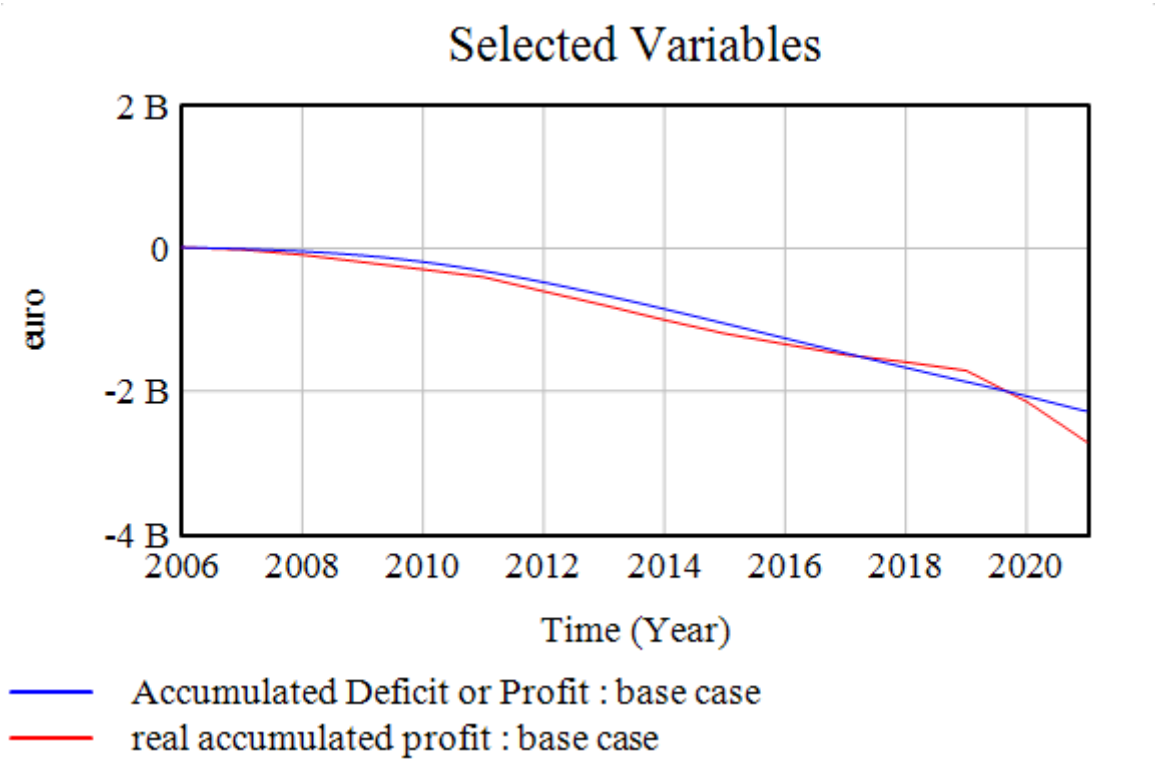
100 M
0
euro/Year
2006
2008
2010
2012
2014
2016
2018
2020
Time (Year)
interest costs : base case
real interests : base case


Selected Variables
2 B
0
-2 B
-4 B
euro
2006
2008
2010
2012
2014
2016
2018
2020
Time (Year)
Accumulated Deficit or Profit : base case
real accumulated profit : base case