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Question 1

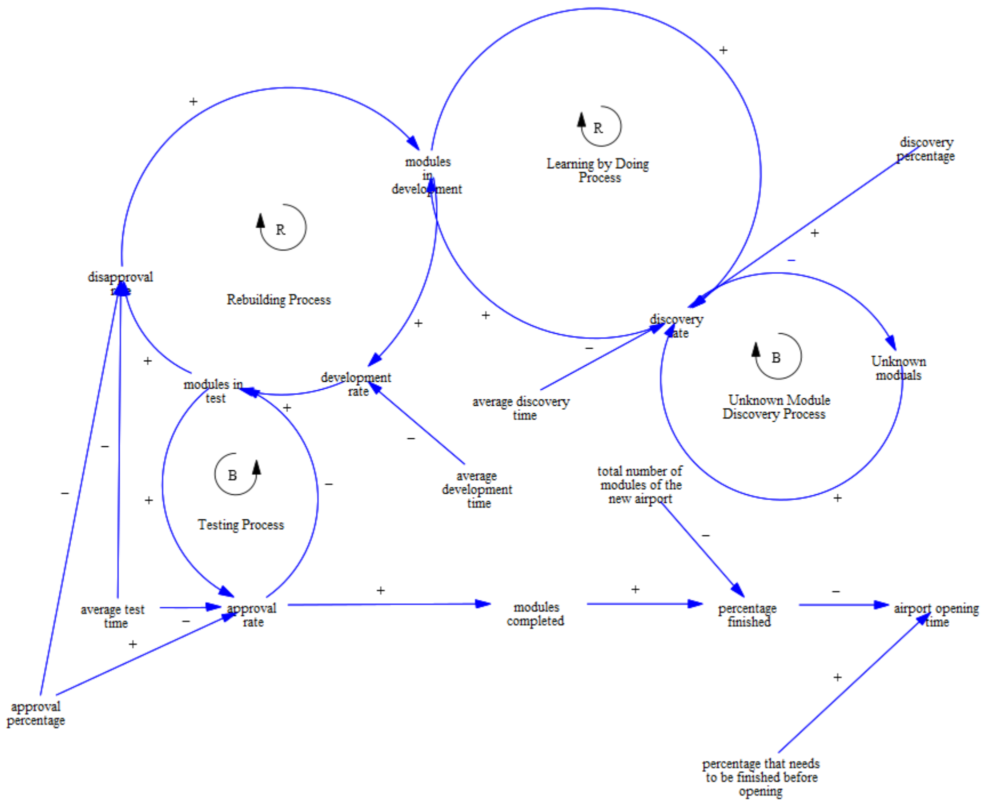

Figure 1.1: Full model for airport development

A)

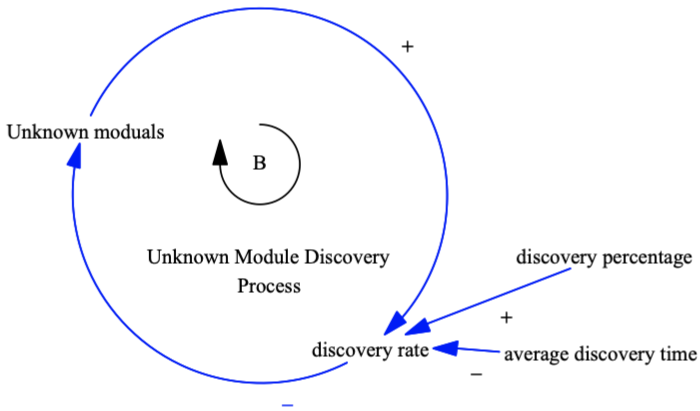

Figure 1.2: Loop 1

Loop 1 is a balancing feedback loop that consists of *Discovery Rate* and *Unknown modules*. *Discovery rate* is determined by the *average discovery time* and a *discovery percentage* that is relative to the *Modules in development*. The balancing property of the loop stems from the fact that the discovery rate has a direct and negative effect on the unknown modules, which negatively influences the discovery rate itself. The rate at which new modules can theoretically be discovered depends on the unknown modules and the average discovery time. For this reason, an increase in the discovery rate will ultimately lead to an eventual decrease in the discovery rate.

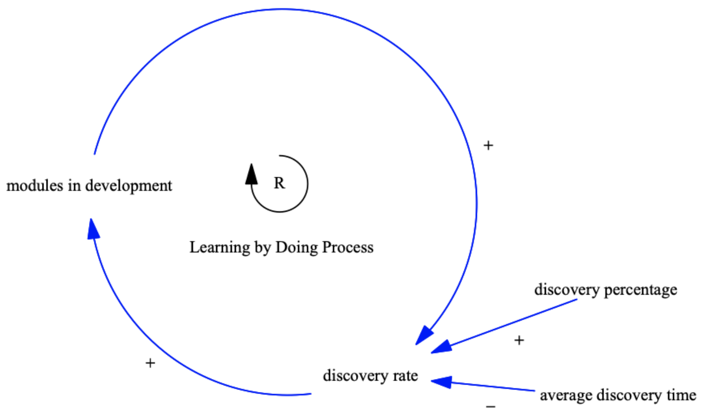

Figure 1.3: Loop 2

Loop 2 is a reinforcing feedback loop that consists of the *Discovery rate* and *Modules in development.* The discovery rate is also positively affected by the *Discovery percentage,* which is a proportion of the *modules in development*. The modules in development multiplied by *discovery percentage* represent the so-called learning-by-doing effect, meaning that engaging in module development can lead to discovering entirely new modules. A higher discovery rate leads to a larger number of modules in development, amplifying the discovery rate as a result of this aforementioned learning effect. If there were no existing limits or bottlenecks to constrict this process, the discovery rate would continue to grow exponentially, demonstrating the reinforcing nature of the feedback loop.

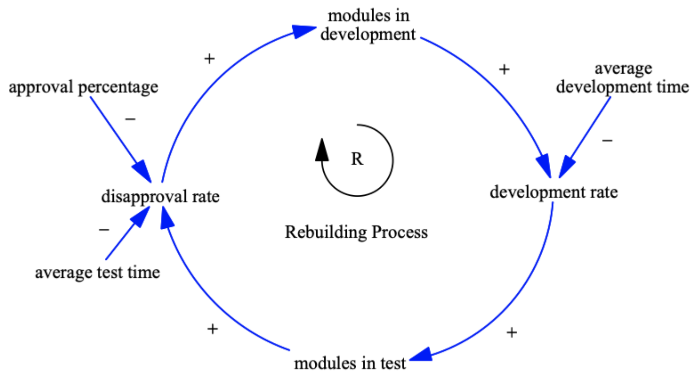

Figure 1.4: Loop 3

Loop is a reinforcing feedback loop composed of the *Modules in development, Development rate, Modules in test,* and *Disapproval rate.* We classified the loop as reinforcing because disapproved modules are recycled back into the development phase. The development rate increases/decreases proportionately with the modules in development, and the development rate is the sole source of modules in test. The modules that do not pass the test process (disapproval rate) flow back into development modules, thus increasing this variable's value. No components within this loop have a negative relationship with the next one.

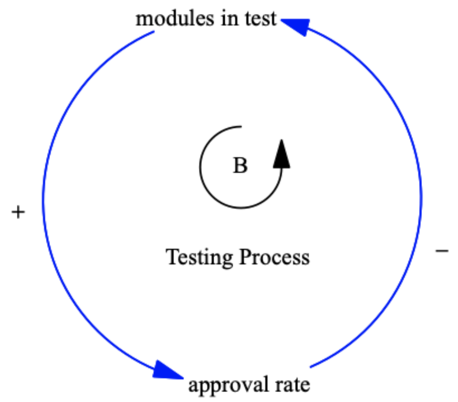

Figure 1.5: Loop 4

Loop 4 is a loop that consists only of the *Modules in test* and *Approval rate*. It is balancing because an increase in the first variable (modules in test) also increases the other (approval rate), which directly draws from the first, thus decreasing it.

B)

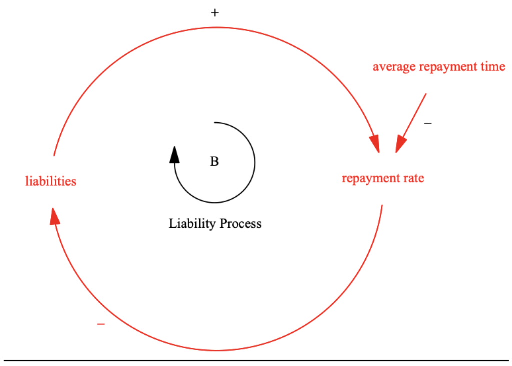

Figure 1.6: Loop 5

Loop 5 is made up of the *Liabilities* and the relevant *Repayment rate*. This feedback loop is balancing. The mechanism behind the balancing behavior is very similar to *Loop 4*. Assuming that the airport is in a position where they are able to pay off their debt, more liabilities lead to a higher repayment rate. Since the *repayment rate* directly reduces their liabilities, the repayment rate itself will subsequently diminish.

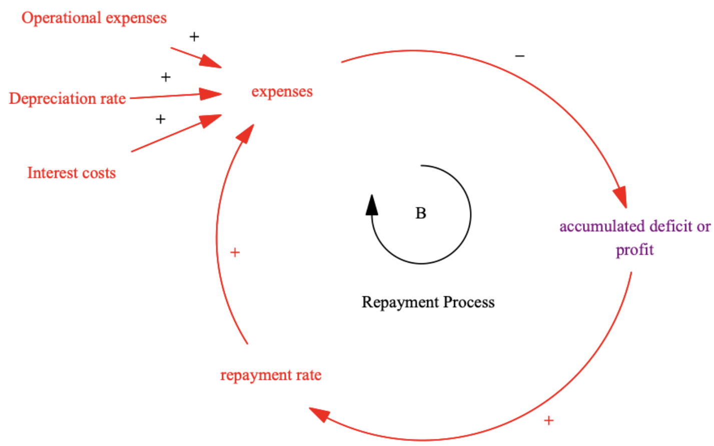

Figure 1.7: Loop 6

Loop 6 is a balancing feedback loop. The variables in this loop include the *Accumulated deficit or profit, Repayment rate,* and *Expenses.* The behavior is balanced because the repayment rate adds to the overall expenses. The expenses influence whether the airport makes a profit or not, as well as the size of any realized profit. Since the accumulated profits are finite, drawing from them to complete one repayment will limit their capacity to make the next. In short, when the accumulated profit rises, so does the repayment rate, which in turn chips away at the accumulated profit.

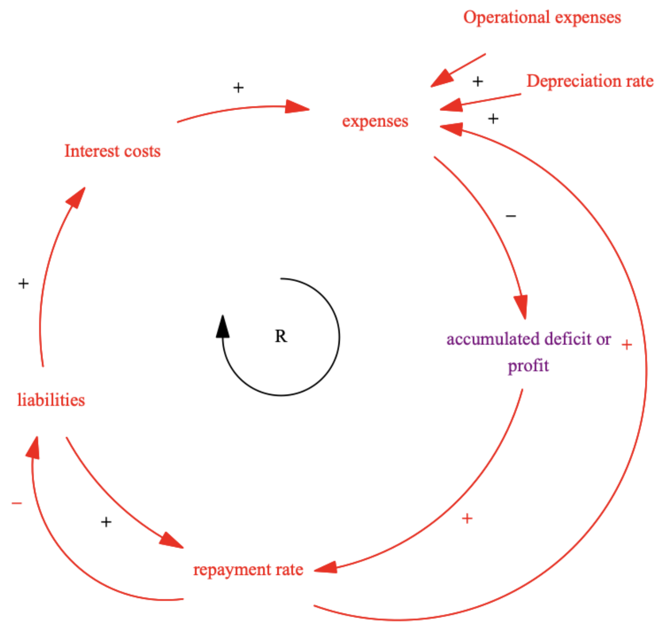

Figure 1.8: Loop 7

Loop 7 is a reinforcing feedback loop that consists of the *Liabilities, Accumulated deficit or profit, Interest costs, Expenses,* and *Repayment rate.* If any of the included variables experience either an increase or decrease, that effect will pass through the loop and eventually come full circle to affect the variable with the same polarity as before. For example, if the liabilities go up, expenses will do the same. This negatively affects both accumulated profit and repayment rate, which can prevent the airport from repaying their liabilities. If this happens, liabilities can continue to pile up while simultaneously ramping up interest costs, making it all the more difficult to make repayments. Higher accumulated profits cause the same reinforcing behavior in the opposite direction. For that reason, we classified the loop as reinforcing.

Full model:

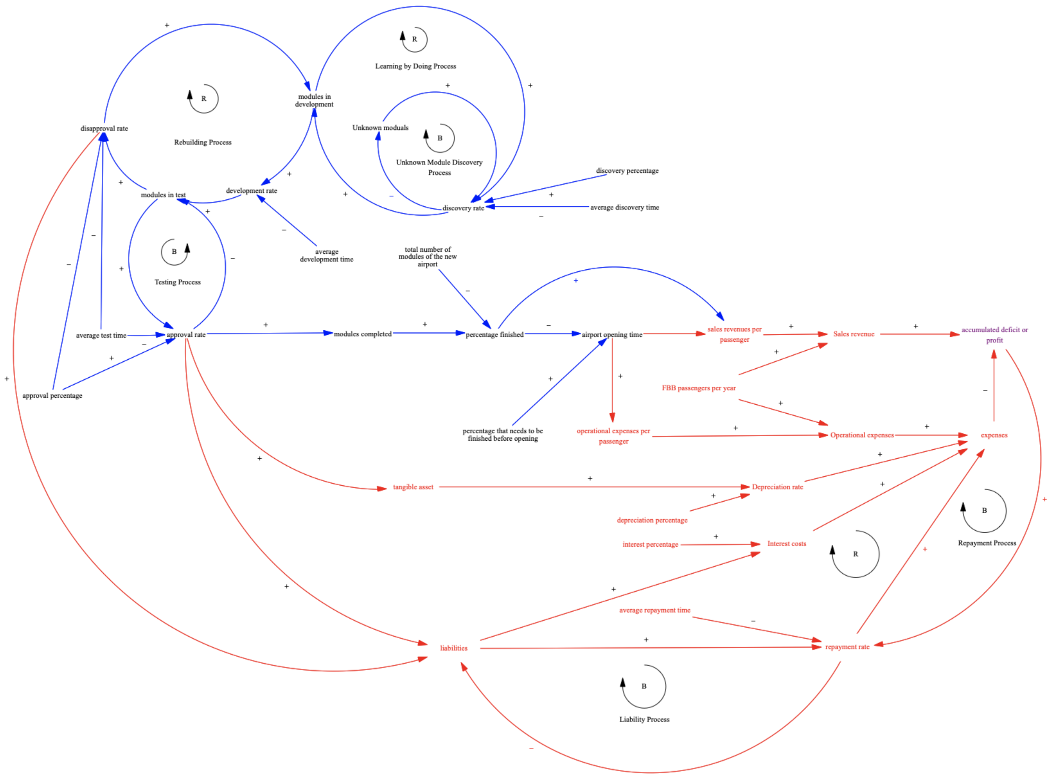

Figure 1.9: Full Model

Question 2

A)

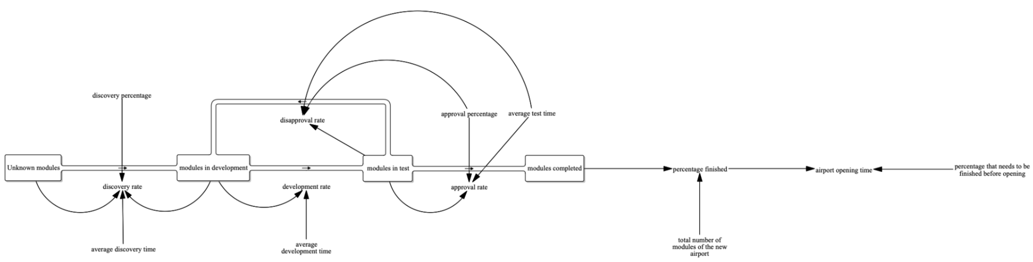

Figure 2.1: Stocks and Flows for the Airport development

List of equations:

- **Unknown Modules:** Initial value: 550

$$= (-\boldsymbol{discovery\ rate})$$

Where:

$$discovery\ rate = IF\ THEN\ ELSE(modules\ in\ development*$$

$$discovery\ percentage <= (\frac{Unknown\ modules}{average\ discovery\ time}),$$

$$modules\ in\ development*discovery\ percentage,$$

$$\frac{Unknown\ modules}{average\ discovery\ time})$$

- **Modules in development:** Initial value: 200

$$= \boldsymbol{disapproval\ rate + discovery\ rate - development\ rate}$$

Where:

$$\boldsymbol{disapproval\ rate = modules\ in\ test*\frac{(1-approval\ percentage)}{average\ test\ time}}$$

And:

$$development\ rate = \frac{modules\ in\ development}{average\ development\ time}$$

- **Modules in test:** Initial value: 0

$$= \boldsymbol{development\ rate - approval\ rate - disapproval\ rate}$$

Where:

$$approval\ rate = modules\ in\ test*\frac{approval\ percentage}{average\ test\ time}$$

- **Modules completed:** Initial value: 0

$$= \boldsymbol{approval\ rate}$$

B)

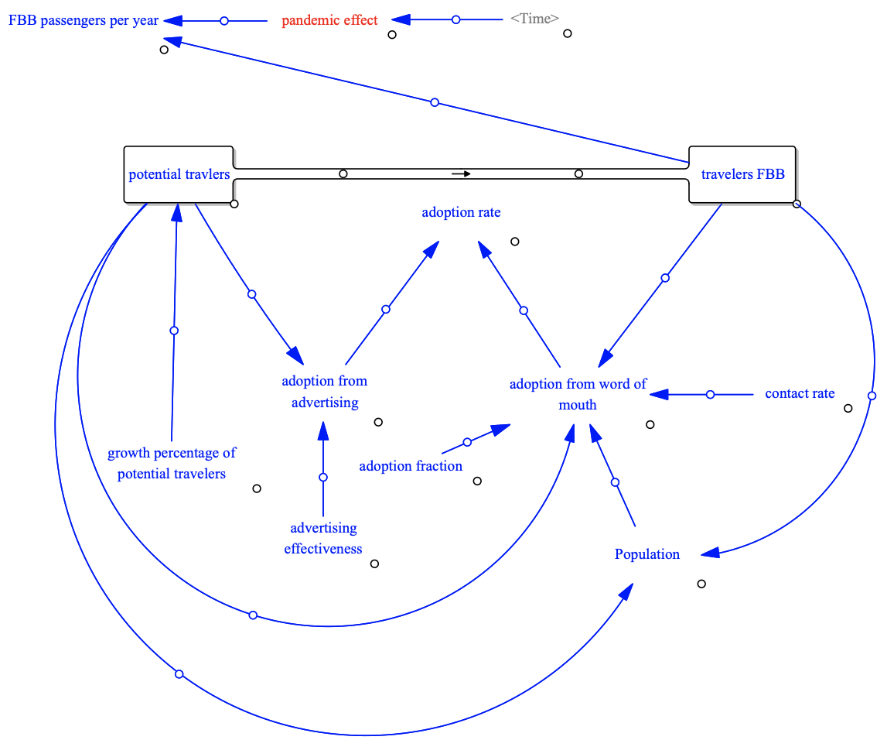

Figure 2.2: Bass diffusion model

Based on the bass diffusion model, FBB travelers are determined by the adoption rate. Normally, the adoption rate is influenced by the adoption from advertising and adoption from word of mouth. Although most importantly, whether FBB can acquire travelers depends on the advertisement's effectiveness and contact rate. For instance, if the effectiveness of advertisement had been low, it might not happen that "word of mouth" would provide the same effectiveness when it comes to acquiring travelers and vice versa. Word of mouth could be affected by various factors that we are not presenting in this model. However, one would suggest to

FBB that a positive customer experience would also catalyze the effectiveness of word of mouth.

List of Equations:

- ***Travelers FBB***

$$= \boldsymbol{adoption\ rate}$$

Where:

$$adoption\ rate = adoption\ from\ advertising + adoption\ from\ word\ of\ mouth$$

And:

$$adoption\ from\ advertising = advertising\ effect * potential\ travelers$$

And:

$$adoption\ from\ word\ of\ mouth = potential\ travelers * adoption\ fraction * contact\ rate * \frac{travelers\ FBB}{Population}$$

And:

$$Population = potential\ travelers * travelers\ FBB$$

- **Potential Travelers**

$$= (-adoption\ rate) + (potential\ travlers * \underline{growth\ percentage\ of\ potential\ travelers})$$

C)

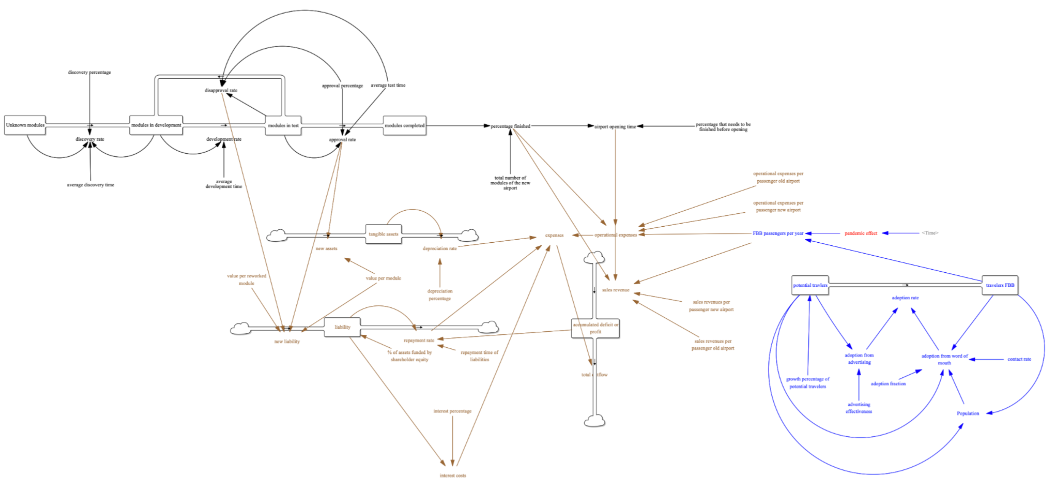

Figure 2.3: Full model with financial situation

List of Equations:

- **Sales revenue**

$$= (1 - airport\ opening\ time) * (sales\ revenue\ per\ passenger\ old\ airport * FBB\ passengers\ per\ year) + (airport\ opening\ time * FBB\ passengers\ per\ year * sales\ revenue\ per\ passenger\ new\ airport * percentage\ finished)$$

- **Operational Expenses**

$$= (1 - airport\ opening\ time) * (FBB\ passengers\ per\ year * operational\ expenses\ per\ passenger\ old\ airport) + (airport\ opening\ time * FBB\ passengers\ per\ year * operational\ expenses\ per\ passenger\ new\ airport * percentage\ finished)$$

- **Tangible assets**

$$= new\ assets - depreciation\ rate$$

Where:

$$new\ assets = approval\ rate * value\ per\ module$$

And:

$$depreciation\ rate = depreciation\ percentage * tangible\ assets$$

- **Liability:**

$$= (\boldsymbol{new\ liability}) * (1 - \text{"}\boldsymbol{\%\ of\ assets\ funded\ by\ shareholder\ equity}\text{"}) \boldsymbol{- repayment\ rate}$$

Where:

$$new\ liability = approval\ rate * value\ per\ module + (dissaproval\ rate * value\ per\ reworked\ module)$$

And:

$$repayment\ rate = IF\ THEN\ ELSE(accumulated\ deficit\ or\ profit <= 0, 0, MIN(accumulated\ deficit\ or\ profit, \frac{liability}{repayment\ time\ of\ liabilities}))$$

- **Accumulated profit or Deficit**

$$= \boldsymbol{sales\ revenue - total\ outflow}$$

where:

$$total\ outflow = expenses = depreciation\ rate + interest\ costs + operational\ expenses + repayment\ rate$$

D)

We will now go through each of the respective graphs for *Accumulated deficit or profit, Liabilities,* and *FBB passengers per year*, ranging from the year 2006 to 2040, and comment on their implications for FBB's financial situation.

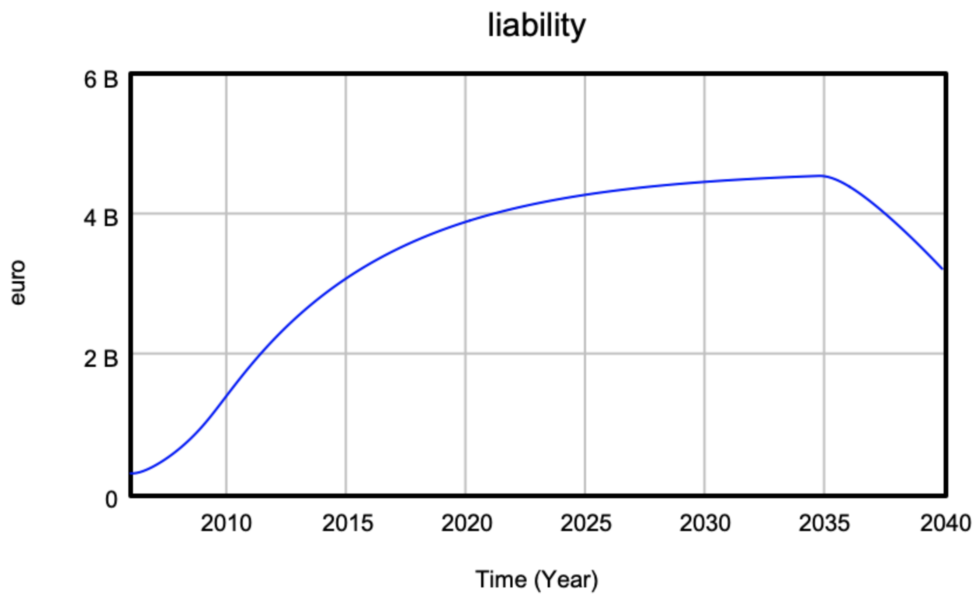

Figure 2.4: Liability

The graph above shows that FBB´s liabilities grew at an increasing rate from 2006, with the growth rate remaining steep until around 2011. This was due to the high rate at which new modules were tested and approved during this period. The discovery and implementation of new modules have multiple associated rates, modeled as a first-order material delay. This means that the outflow of stocks connected to these rates is proportional to the level of the stock. Therefore, at the start of the simulation, FBB is likely to discover and approve more modules, as many modules are to be discovered and implemented. The regular flow of approved modules results in a significant increase in tangible assets, contributing to the rise in liabilities early in the simulation.

In 2009 the stock for the remaining unknown modules was close to empty. At approximately the same time, the number of modules in development was approaching its peak. After this, the rate that new modules were being added started to decline, which explains why the curve for liabilities began to lose some of its steepness. However, this process is slow; it took years before the curve started to resemble a horizontal line.

It was not until the end of 2034 that the liabilities ceased to grow and FBB was able to start repayment of their debt. The downward shift that we observe here corresponds with the time the curve for accumulated profit or deficit begins to stagnate from its steady increase.

The period where we saw a steep and positive curve in liability growth can be seen as a negative indication because this also entails higher interest costs. As a result, the airport's ability to realize an accumulated profit is postponed. The downside is that accumulated interest costs will ultimately be higher as they could not repay their liabilities earlier. A higher level of debt also makes them less robust to changes in outside circumstances. The covid pandemic is a good example of such unexpected changes. Fluctuations in interest costs are also an essential factor. On the flip side, committing to more liabilities suggests that they are making investments that have the potential to put them in a stronger position to generate revenue in the future.

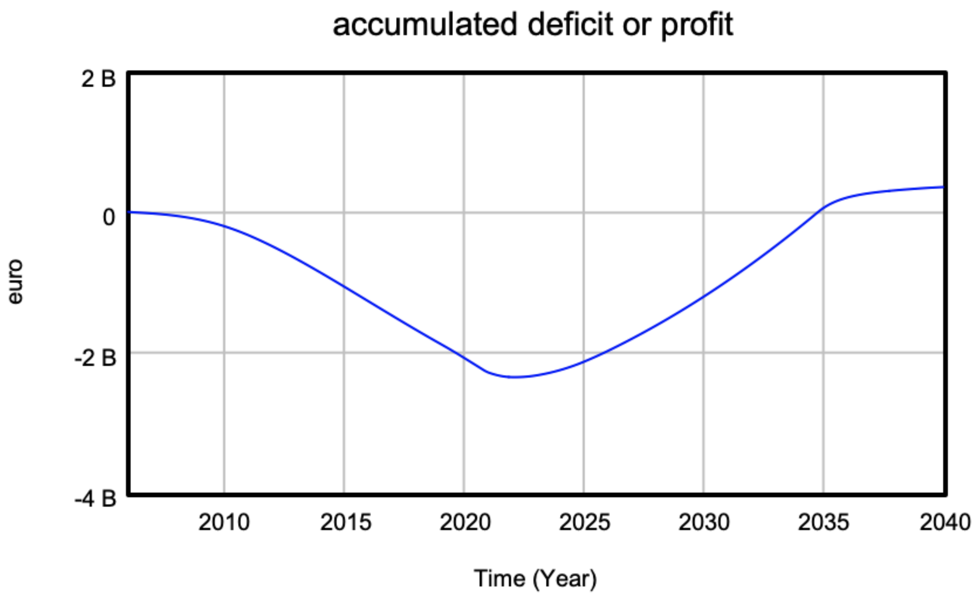

Figure 2.5: Accumulated deficit or profit

The airport enters a period of an increasing accumulated deficit from the start of the simulation. This is explained by the fact that the new airport does not open until 2020. Until this point, the new liabilities funding the construction of the new airport caused the total expenses to exceed the revenue their existing airport could generate. A state of accumulated deficit puts them in a weak financial position, especially when their annual results are also negative like they were in the years before they opened the new airport. Even so, one would assume that this is expected when they are amidst a large-scale building project that requires considerable time and investments.

One may have anticipated that the curve would shift towards a positive trend in 2020, but unfortunately, the pandemic emerged simultaneously as the new airport opened. This delayed the time when their annual revenue could surpass costs, which we can observe in the graph. Therefore, the pandemic kept the airport in a weak financial position for longer than expected.

Once they opened up again after the pandemic shut-down, the stream of passengers saw a significant increase. By this point, FBB had developed nearly all of the necessary modules, supporting their ability to bring in revenue. As a consequence, liabilities grew at a slower rate than before, allowing them to make a profit. So, even though they are still in an accumulated deficit, the airport's financial position is starting to improve because they are consistently achieving an annual profit.

In 2035, they reached a point of accumulated profit and began repaying their liabilities, stagnating the positive development in accumulated profit that had taken place in the recent years before that. This is a good sign for their financial position because they can finally start to reduce the interest costs and accumulate value that strengthens their ability to suffer unexpected losses in the future. Several of the loops described in question 1 could be at play here, but it is difficult to pinpoint exactly how they contribute to shaping the curve. A situation of accumulated deficit will always have some negative implications for their financial situation because the airport is bound by the fact that they do not repay liabilities until they reach an accumulated profit. The reinforcing effect of loop seven may be relevant because the liabilities cannot see a reduction until this point and are thus only left with the option of staying the same or increasing. After they achieve accumulated profit in 2035, the same reinforcing effect may start to benefit them.

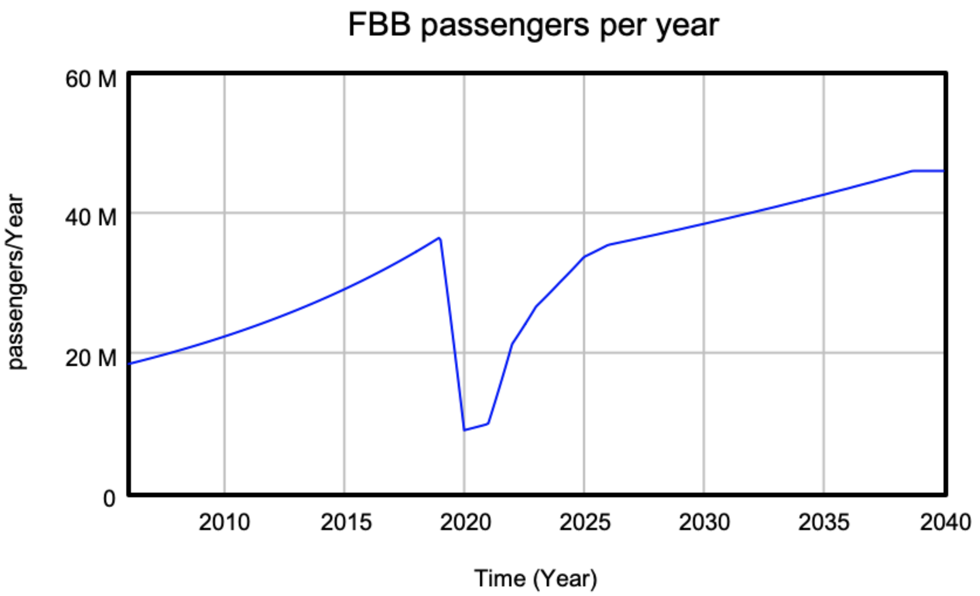

Figure 2.6: FBB passengers per year

The graph shows a substantial increase in passengers per year in the early part of the simulation, continuing until the sudden decrease due to the pandemic shutdown in 2020. After the airport reopened in 2020, there was a high growth in passengers. For the rest of the simulation, there is a steady increase in passengers, but at a lower rate than the pre-pandemic levels. This is due to the addition of the variable *pandemic effect*, which simulates the change in people´s travel habits, such as a decrease in business trips. The airport eventually meets its passenger capacity of 46 million, as indicated by the trend line moving horizontally.

The passengers are a crucial source of value for the airport, so the graph is an important but not definitive indicator of their financial situation. Accumulated profit or deficit, as well as other factors like revenue and expenses per passenger, depreciation costs, and interest costs, all need to be considered to understand the airport´s financial position.

The sudden and steep drop in passengers during the covid pandemic put the airport in a weakened position, especially given their accumulated deficit and high level of liabilities.

In conclusion, the airport is financially precarious for a prolonged simulation period. The accumulation of deficits and growing liabilities make them vulnerable to unexpected changes in market conditions. The pandemic further delayed their ability to profit and repay their liabilities. They don't begin repaying their debt until the end of 2034. The steep growth in liabilities early on in the simulation, while necessary for completing the new airport, also results in higher interest costs and a weaker financial position

Question 3

A)

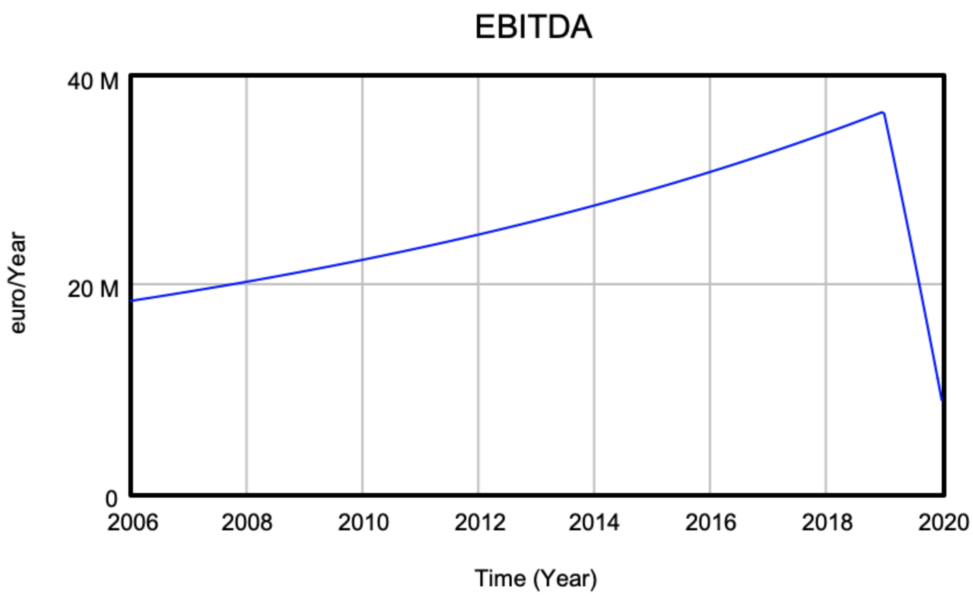

Figure 3.1: EBITDA

To decide if the quote from the annual report is a lie, we added a new variable called $EBITDA$, computed as $sales\ revenue - operational\ expenses$.

The graph above shows EBITDA from the simulation period 2006 to 2020 and confirms that EBITDA was at a record high value of 34,5 million Euros at the start of 2018. The statement in the annual report is, therefore, not a lie.

B)

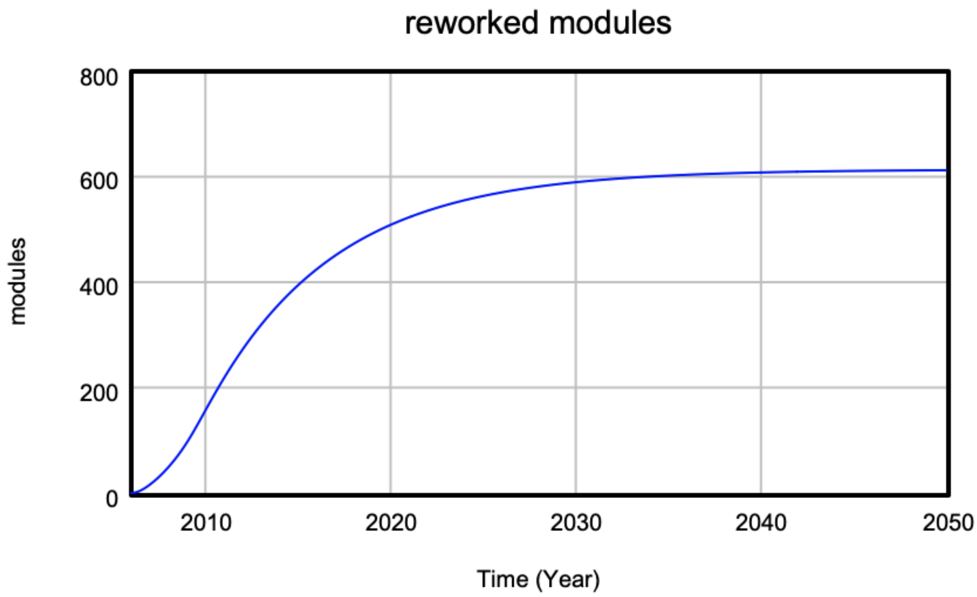

Figure 3.2 amount of reworked modules

To find the total amount of modules that have been reworked from 2006 to 2050, we added a new stock called *Reworked Modules*, which has an inflow from *disapproval rate*. This allows us to count one model multiple times if it has been disapproved numerous times and will give us the total number of reworked modules. In the simulation period 2006 to 2050, FBB is expected to rework a total of 612 modules.

Question 4

A)

Using the values listed in the table for the green exogenous variables, the airport could open in 2011.

Discovery percentage	0,65
Average discovery time	0,3
Average development time	1,25
Approval pertentage	0,65
Average test time	0,25
Airport opening time	***2011,79***

Table 4.1 Values Changed

The values of these variables have "improved" by the following percentages:

- ***30%*** (The learning by doing effect is amplified by 30%)
- ***25%*** (At baseline, they are able to discover unknown modules 25% faster than before)
- ***285%*** (On average, modules require 2 years and 3 months less time spent on development)
- ***100%*** (On average, modules spend half the time in the testing stage before a decision of approval/disapproval is made).

In a hypothetical scenario, such improvement could be attributed to the employment of individuals with higher competence who may have received better education or have a proven track record in the relevant field. These employees may require higher salaries.

Higher competence alone may not be sufficient to produce such impressive results, so the airport would also need to employ more workers, invest more in overtime costs, and increase their expenditure on relevant resources. The variable that has been subjected to the most significant change is the *average development time*. The development time has been reduced from 3 years and 6 months to 1 year 3 months. A weakness of this proposal is that the airport is somehow approving a more significant portion of their modules while spending a third of the time on development and discovering new modules faster. Again, we would have to attribute the feasibility of this advancement to the improved quality and quantity of the workforce that we described earlier, along with an increased amount of resources allocated to this section of the project. Without actual experience working with airport development, it is hard for us to determine if this is a feasible scenario or not confidently. Construction projects typically require multiple processes like planning, permit acquisition, procurement, and actual construction. Maybe with the right amount of skilled individuals and resources committed to the task, this can conceivably be achieved, as 15 months is still a decent amount of time.

In summary, this scenario might feasibly be accomplished, but not without increased expenses associated with module development.

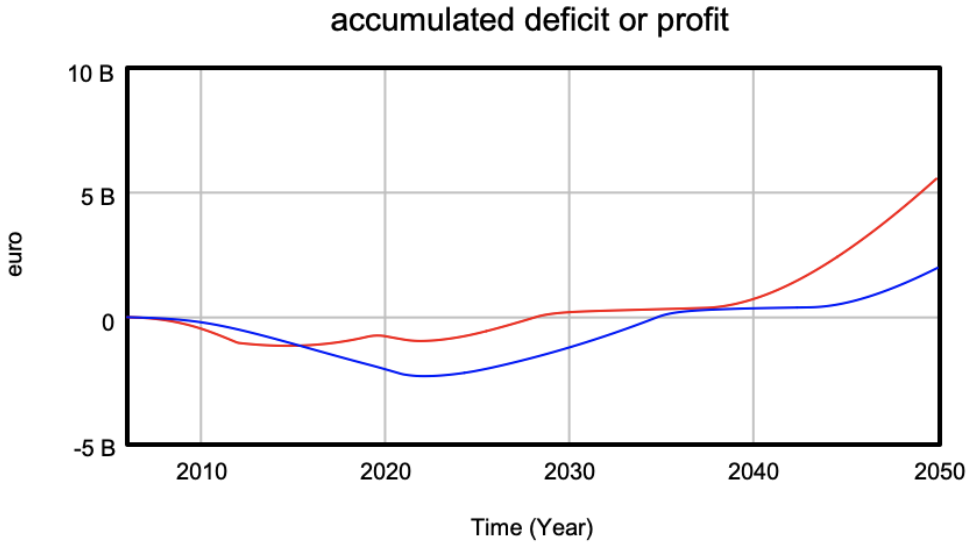

Figure 4.1 Base case: blue, Adjusted: red

As illustrated by the graph, these changes introduced significant improvements in their financial situation over the years. They realize an accumulated profit many years earlier and do not reach nearly as extreme of a depth in accumulated deficit as they manage to do in the base scenario. However, the improvements are unrealistic as we exclusively introduced improvements to the circumstances we simulate. In reality, there would be several associated cons that follow with the changes we made, like substantially higher costs directly associated with the project, much larger liabilities, and increased interest costs.

B)

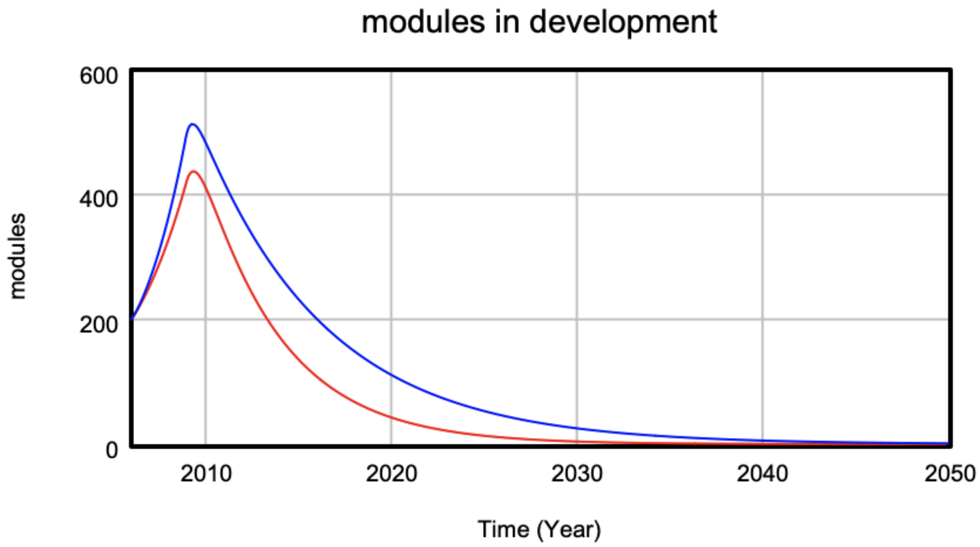

Figure 4.2 Base case: blue, Adjusted: red

The comparison of these two graphs leads us to the conclusion that the alternative scenario (Question 4b model) has a much lower accumulated number of modules in development than the base scenario (Question 3 model). This benefits the airport's financial situation because it significantly reduces the costs associated with module development.

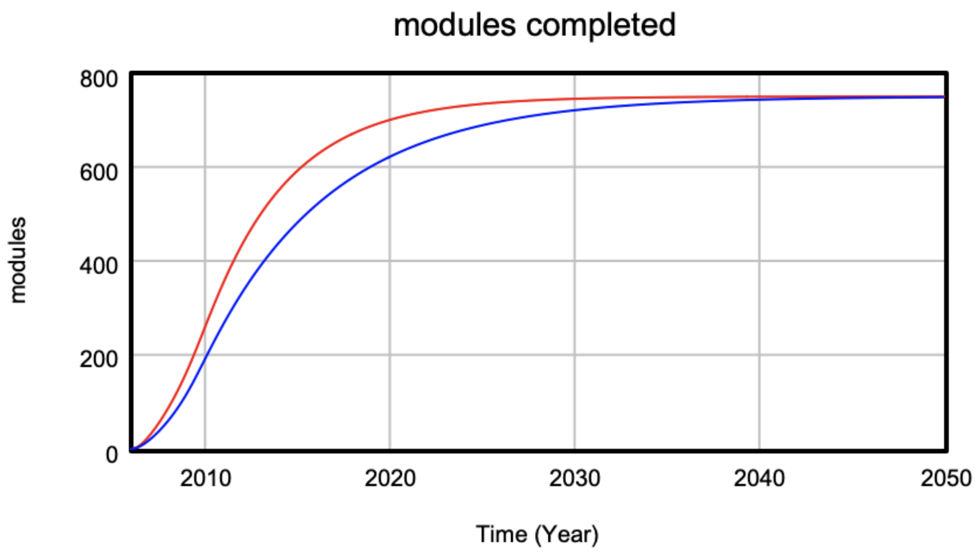

Figure 4.3 Base case: blue, Adjusted: red

The "go slow to go fast" approach successfully serves its intended purpose in this example. In the alternative scenario, they are able to complete modules much faster than in the base scenario. This becomes apparent when we see that the red line (alternative scenario) is steeper and reaches its goal many years before the blue line (base scenario). So, going slow ultimately leads to faster progress in terms of module development for the airport.

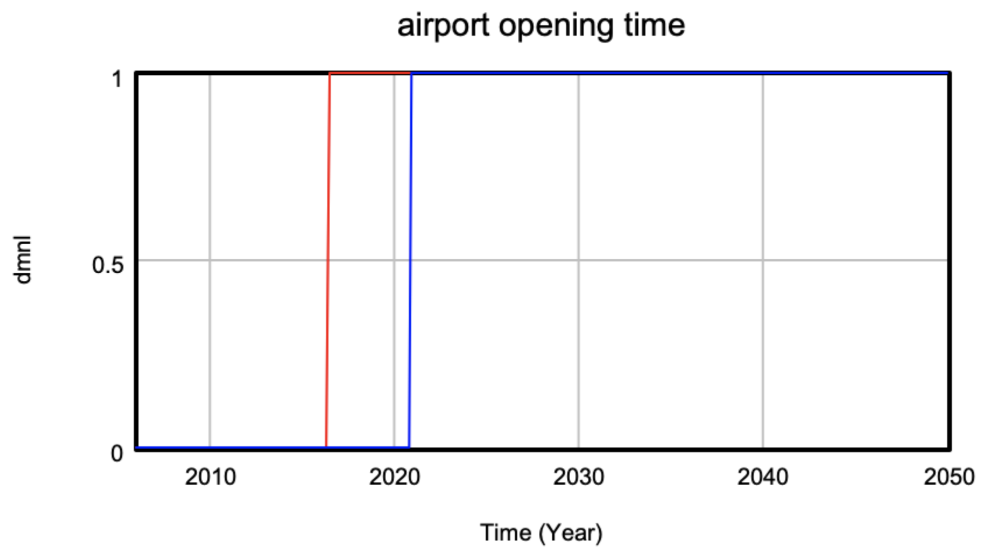

Figure 4.4 Base case: blue, Adjusted: red

The effectiveness of this approach is further reinforced by the difference in airport opening times between the two scenarios. In the alternative scenario, the airport opened in 2016, whereas in the base scenario, it opened in 2020.

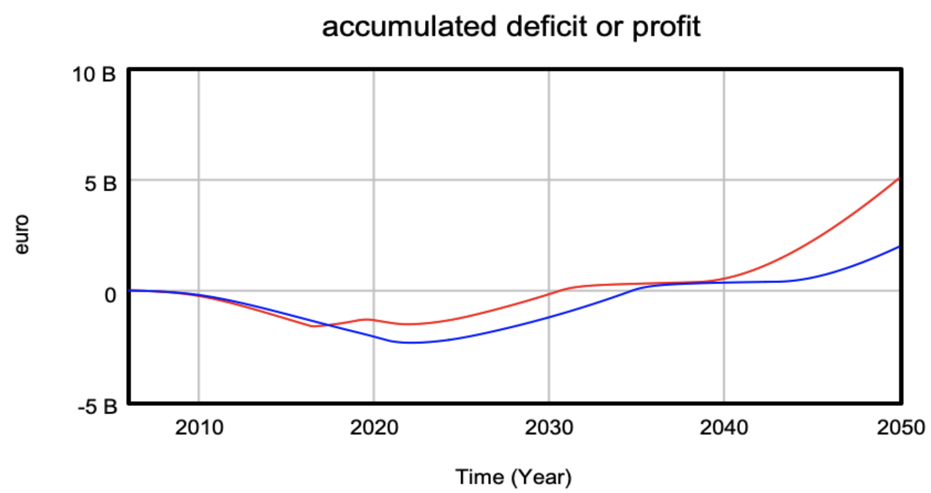

Figure 4.4 Base case: blue, Adjusted: red

The combination of these benefits leads to a more favorable financial situation for the airport. The graphs show that the alternative scenario has a maximum accumulated deficit of about 1.6 billion euros, compared to 2.35 billion euros in the base scenario. The airport also realizes an accumulated profit much earlier in the alternative scenario (2030) than in the base scenario (2034). Furthermore, the alternative scenario shows a period of steep growth in accumulated profit that is not observed within the simulation period in the base scenario.

Question 5

By implementing the increasing focus on sustainability in our model, we added the given equation "Go green" to our model, which deducts 0.1% from the value of the stock *potential travelers* and *FBB travelers*. The graphs below show the simulated base case for FBB from 2006 to 2050 with blue lines, and the go green scenario depicted as red lines. We will go through the stock's *Liability, Accumulated Deficit or Profit,* and *FBB Passengers Per Year and* conclude how the go green scenario affects FBB based on the simulation results.

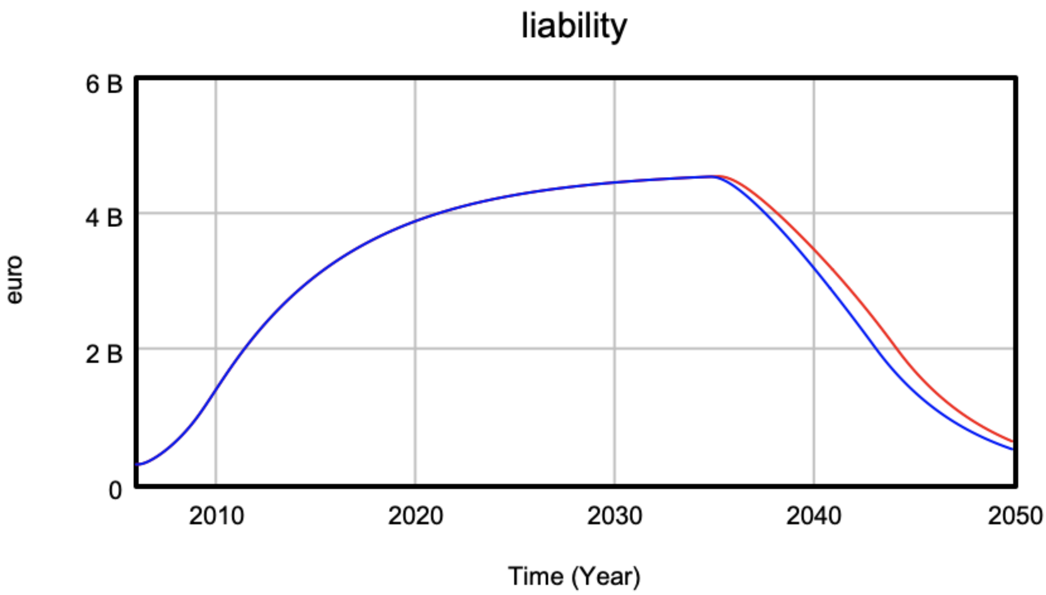

Figure 5.1 Base case: Blue, Go green: Red

The simulated graph shows the base case depicted in blue and our new simulated case with the go green effect in red.

In the go green scenario, we can see that FBB starts repaying debt at a later stage with a lower rate in the go green scenario compared to the base case. This is due to the reduction in profit caused by the incremental increases in the *go green* variable, causing the increase in passengers per year to reduce over the simulation period. The difference in *liabilities* and *repayment rates* between the two scenarios is shown in the two graphs below:

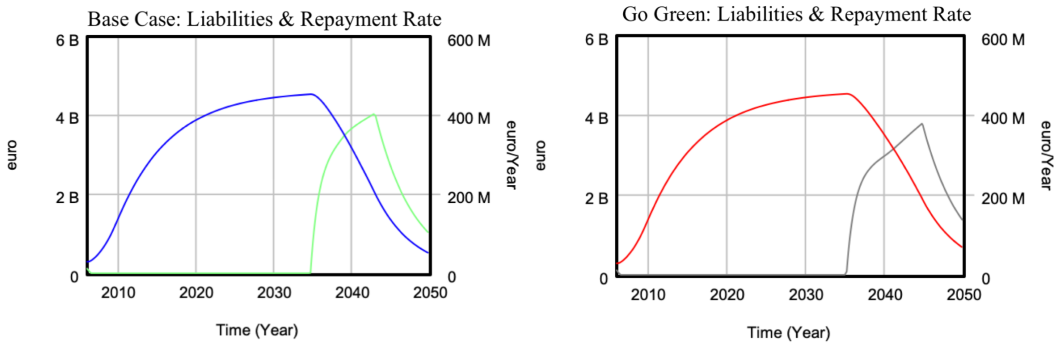

Figure 5.2 Base case: liabilities in blue, repayment rate in green
Go green: liabilities in red, repayment rate in black

From the graphs, we can see that the go green affects FBB´s ability to repay debt. The repayment rate in the base case is both steeper and reaches its maximum point earlier, therefore repaying debt at a higher rate. The go green effect causes FBB to have a lower profit over the simulation period due to more time with high interest costs.

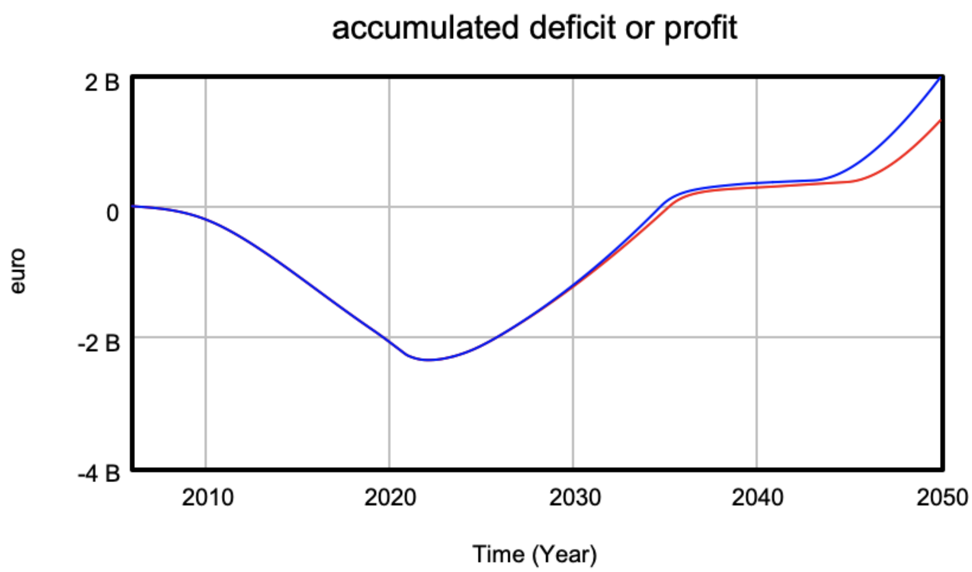

Figure 5.3 Base case: Blue, Go green: Red

The simulated graph shows that the impact of the go green trend incrementally starts to take effect as the simulation progresses. The go green scenario directly impacts FBB sales revenue with fewer passengers flying, but it will also reduce operational expenses proportionally.

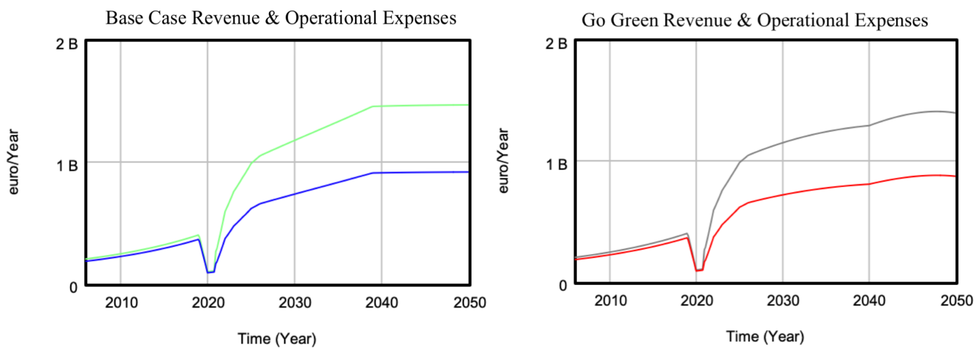

Figure 5.4 Base case: Revenue: green, operational costs: blue
Go green: Revenue: black, operational costs: red

Here we see a comparison between the stock's *Revenue* and *Operational expenses* for both scenarios. The plots confirm that the go green effect leads to a proportional reduction in *sales revenue* and *operational expenses* from the reduced number of passengers. Because of this, the stock *accumulated profit or deficit* will not be significantly impacted by the go green effect when only considering sales revenue and operational costs. We can also see that in the base case, the sales and cost are horizontal at the end of the simulation. This is due to the capacity constraint of the airport of 46 million annual passengers. This will also reduce the difference in *accumulated profit or deficit* between the scenarios.

The main reason for the difference is the stock *liabilities,* which, as discussed, will decrease at a later time and rate in the go green scenario compared to the base case. This leads to more years with high interest costs and repayment, limiting FBB´s profitability in the simulation period. This entails that FBB does not experience the same rate of increase in accumulated profit by 2050.

<u>FBB passengers per year</u>

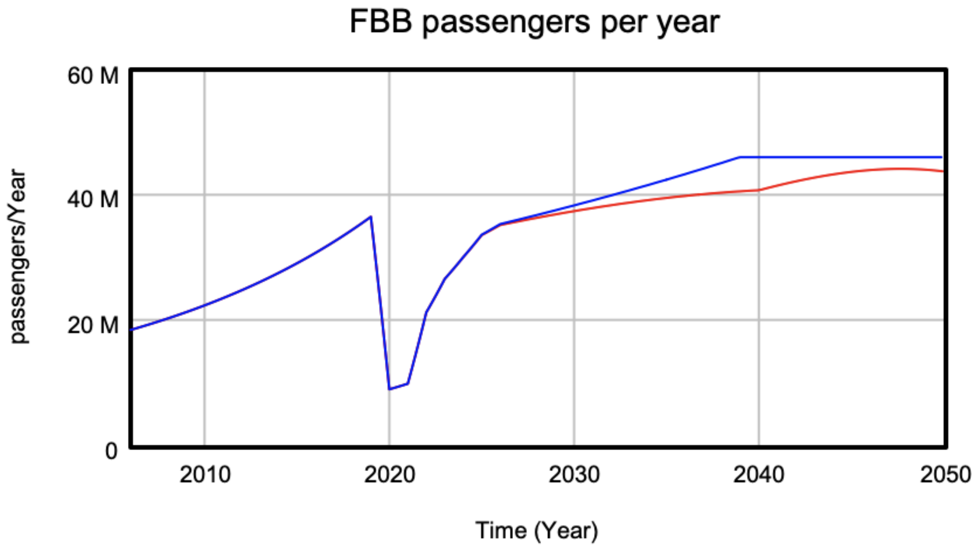

Figure 5.5 Base case: Blue, Go green: Red

The graph illustrates the difference in passengers per year in the base case and go green scenario. The go green effect directly reduces passengers per year, which increases over the simulation period. In the base case, FBB reaches the airport´s capacity of 46 million in 2039, while the go green scenario does not hit the capacity level under the simulation period. For the go green scenario, the increase in passengers per year happens slower until 2040, when there is a sudden positive change in the trend.

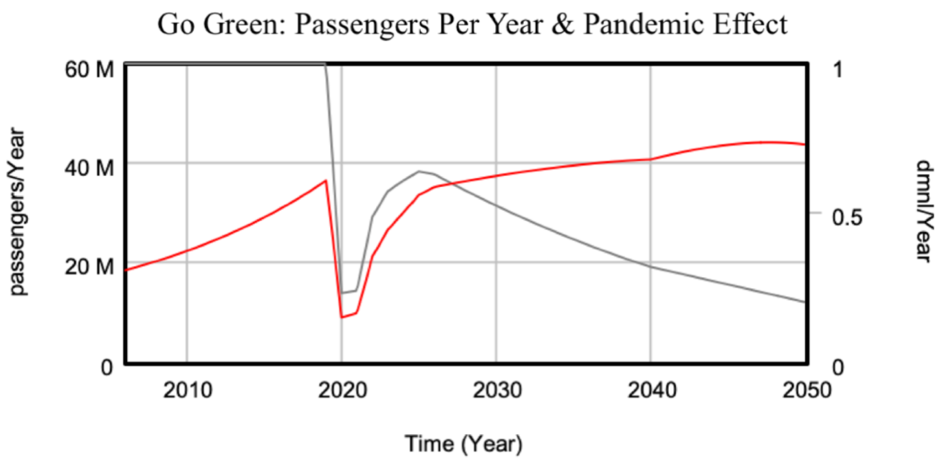

Figure 5.6 Passengers Per Year: Red, Pandemic effect: Black

The *Pandemic Effect* variable affects the reduction in *Passengers Per Year* due to a decrease in business trips after the pandemic. This variable decreases yearly at an approximately stable rate from 2025 to 2040 and then at a lower rate from 2041 to 2050. The lower rate from 2041 lets the stock *Travelers FBB* be multiplied with a higher percentage yearly after 2040, compared to the speed of decrease from before 2041. This leads to a higher passenger increase per year, which the graph illustrates. However, the graph also shows that this effect is reduced towards the end, limiting the growth of passengers. This may be because the go green variable is increasing to a level that counteracts the reduction in the pandemic effect.

In conclusion, the *go green* scenario negatively impacts the financial situation of FBB. In this scenario, FBB repays its debt at a later stage with a lower rate than the base case. This is due to the reduction in profits from a reduction in passengers per year. As a result, FBB has a more extended period with a high debt level, resulting in higher interest costs, negatively impacting the ability to make a profit and pay down its liabilities.

Question 6

In this section, we will simulate and describe results based on our proposed alternative courses of action. These propositions mainly aim to increase FBB's ability to generate revenue. The alternatives include:

- Air Cargo
- Green Investments

One potential method of increasing revenue is by allowing cargo shipments to be made via the airport. FBB would function as a hub for cargo transport, besides their regular operations involving commercial airlines. Commercial airlines also tend to operate cargo and utilize the plane's belly as cargo storage. "At Finnair we only have bellyhold, meaning we only use aircraft that are also carrying passengers."[1] Hence, we assume that FBB has good reason to invest in cargo

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1 The Complexities of Air Cargo Revenue Management – Joseph Vito DeLuca https://www.kambr.com/articles/the-complexities-of-air-cargo-revenue-management

infrastructure, which will enable airlines to operate not only commercials but cargo as well. Airlines tend to maximize their revenue, thus, operating a commercial plane with its belly filled due to the economy of scale would generate more revenue than a commercial plane without cargo.

Based on *Airport Matters* forecasts – "For the year 2030, we forecast 334.682 million ton-km air freight assuming global average growth in GDP per capita of 3,2 % (IHS Markit). This leads to expected freight growth of on average 5 % per year."[2] Annual freight growth rates for FBB are expected to increase by 5% yearly until 2047, which will present a promising opportunity for FBB to improve their financial situation. And 5% is also assumed as the average annual growth rate of the revenue generated from cargo service in the following modeling part. As for the initial revenue generated as soon as FBB starts to provide the cargo transportation service, given the *Term paper description v2* document description, *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. In addition, new infrastructures on the airport and for the traffic to the airport would be needed.* We thereby assume that initially, the income from cargo service would account for 7% of the total revenue coming from passengers as long as all the necessary new modules for cargo transportation service are accomplished. And according to the *sales revenue per passenger new airport* and *operational expenses per passenger new airport* given in the starter.kit in which the expense to revenue ratio is 62.5%, we here assume the expense to revenue ratio is 60%. In terms of the additional infrastructure building process for cargo transportation, we imitate the airport building process which incorporates variables like unknown modules, modules in development, modules in test, etc. The values and functions of all the newly created variables and stocks are demonstrated as follows.

- New Variables
  - cargo discovery rate
    - = IF THEN ELSE(cargo modules in development * discovery percentage of cargo module <= (cargo unknown

[2] Global cargo gravitation model: airports matter for forecasts p229

modules / average discovery time for cargo modules) , cargo modules in development * discovery percentage of cargo module , cargo unknown modules/average discovery time for cargo modules)

- cargo disapproval rate
  - = cargo modules in test * (1 - approval percentage of cargo modules) / average test time of cargo modules
- cargo development rate
  - = cargo modules in development/average development time for cargo modules
- cargo approval rate
  - = cargo modules in test * approval percentage of cargo modules / average test time of cargo modules
- cargo percentage finished
  - = cargo modules completed / total number of cargo modules
- cargo service opening time
  - =IF THEN ELSE (cargo percentage finished >= percentage needs to be finished for cargo modules, 1 , 0)
- initial income
  - = 0 + STEP (1e+08,2042.3) - STEP (1e+08,2043.3)
- expenses growth rate
  - = average growth percentage * extra expenses per year
- initial expense
  - = 0 + STEP (4.5e+07,2042.3) - STEP (4.5e+07,2043.3)
- new modules for cargo
  - = 0 + STEP (20,2037) - STEP (20,2038)
- new modules in development for cargo
  - = 0 + STEP (30,2037) - STEP (30,2038)
- income growth rate
  - = extra income per year * average growth percentage
- discovery percentage of cargo module

        - = 0.5
    - average discovery time for cargo modules
        - = 0.7
    - average development time for cargo modules
        - = 2
    - approval percentage of cargo modules
        - = 0.95
    - average test time of cargo modules
        - = 0.3
    - total number of cargo modules
        - = 50
    - percentage needs to be finished for cargo modules
        - = 0.85
    - average growth percentage
        - = 0.041
- New Stocks
    - cargo unknown modules
        - Initial Value: 0
        - = new modules for cargo - cargo discovery rate
    - cargo modules in development
        - Initial Value: 0
        - = cargo disapproval rate + cargo discovery rate+new modules in development for cargo - cargo development rate
    - cargo modules in test
        - Initial Value: 0
        - = cargo development rate - cargo approval rate-cargo disapproval rate
    - cargo modules completed
        - Initial Value: 0
        - = cargo approval rate
    - extra expenses per year
        - Initial Value: 0

        - = expenses growth rate + initial expense
    - extra income per year
        - Initial Value: 0
        - = income growth rate + initial income

Thus, we assume that 50 modules in total are needed for the new infrastructure of cargo transportation service. As for the proper time for investing in new infrastructure, we believe FBB is not supposed to invest in additional projects until the *accumulated profit or deficit* turns positive in the financial statements. From the graph of *accumulated deficit or profit* generated from problem 5 we can observe that the *accumulated deficit or profit* will become positive in approximately 2035, after which it continues to experience another fast-growing two-year period. Then from around 2037, it starts to increase stably. Thus, we decide that FBB should start investing in both air cargo infrastructure and green infrastructure in 2037, which we will discuss later in this paper.

To hold the entire manufacturing process of cargo infrastructure not to commence until 2037, we used the STEP function in the inflows of the two most essential stocks, which are *cargo unknown modules* and *cargo modules in development*. For the inflow of *cargo unknown modules*, we named it as *new modules for cargo* whose function is *= 0 + STEP(20,2037) - STEP(20,2038),* which means it remains zero until 2037 when 20 new modules are injected into the stock and extracted one year later to make sure there are only 20 unknown modules in total during the whole manufacturing process. Likewise, we make the function of *new modules in development for cargo*, the inflow of stock *cargo modules in development*, as *=0+STEP(30,2037) - STEP(30,2038),* which denotes the initial amount of modules under construction as 30. After we ran this model, we can see that with these fabricated exogenous variables, the FBB airport will be able to provide the cargo transportation in around 2042 as shown in the graph below.

And when we look at the exact data in the table, we can see that the opening time for cargo transportation service in BER is specifically year 2042.3, which we then used to formulate the functions of *initial income* and *initial expenses* as follows:

- initial income
    - = 0 + STEP (1e+08,2042.3) - STEP (1e+08,2043.3)
- initial expense
    - =0 + STEP (4.5e+07,2042.3) - STEP(4.5e+07,2043.3)
    -

2042.27	0
2042.28	0
2042.29	0
2042.3	0
2042.3	1
2042.31	1
2042.32	1
2042.33	1
2042.34	1

Table 6.1 Opening Time

The data table of cargo service opening time

We still implement the same methodology as we used before to constrain the commencement time of *initial income* and *initial expense* which is to inject the data in year 2042.3 and extract them one year later using STEP function. Then, after accumulating the *extra income per year* and *extra expenses per year* to *sales revenue* and *expenses,* respectively, and meanwhile taking into account the fact that *cargo disapproval rate* and *cargo approval rate* would also contribute to *new liability* and *new assets*, now we are able to run the nested model. The outcome of the accumulated deficit or profit can be seen below.

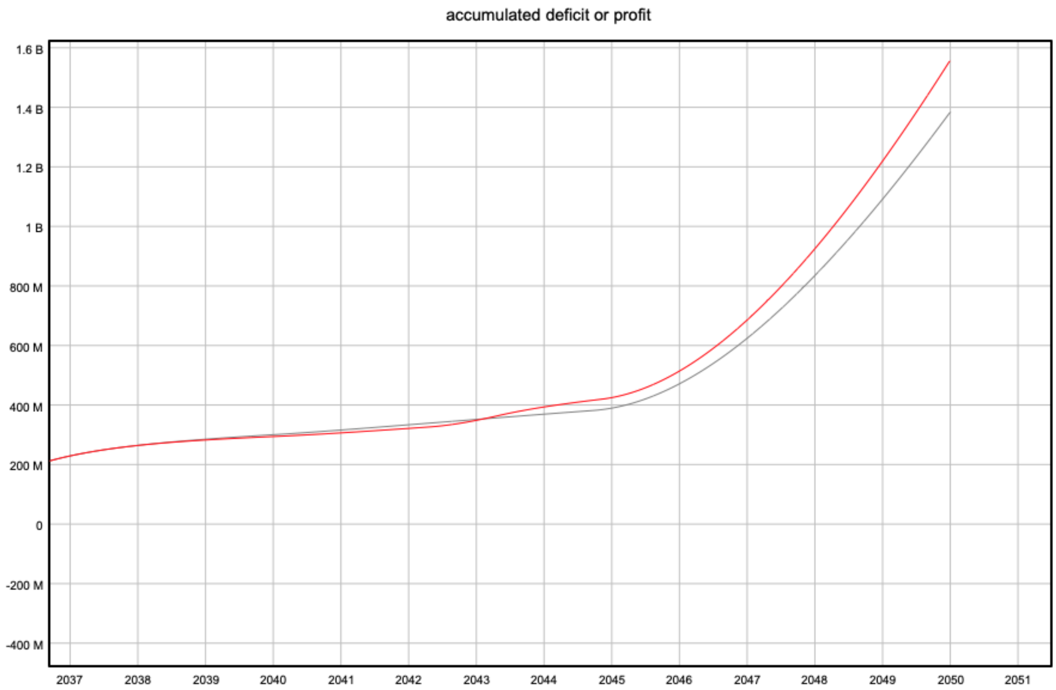

Figure 6.1 Base Case: Gray , With Cargo Service: Red

From the graph above, we can see that since the commencement of investment in cargo infrastructure, the accumulated deficit or profit still demonstrates an increasing trend but not as rapid as it shows in the base case due to the additional repayment rate to the new debt raised to finance the investment project. However, after the opening of the cargo transportation service, which takes place in around April of 2042, the extra profit brought from the cargo service will soon negate the adverse effect from the new liabilities and lead the accumulated profit to surpass that in the base case in approximately June of 2043 which is over one year after BER start to provide the cargo transportation service.

Although it seems quite promising for the accumulated profit after we introduce the cargo service for BER, it's apparently incapable of overturning the general decreasing trend of accumulated profit caused by the *go green effect* in the long run since the income generated from cargo service only accounts for a small proportion of that coming from passengers. Hence, if we want to solve this problem from the root, it's necessary to develop a schema targeting directly the *go green effect*. That's why our second idea is to invest in green infrastructure, which can attract more passengers and offset the loss of customers due to the *go green effect*.

Green Investment:

Taking the Go Green trend from question 5 into consideration. Traveling by conventional fossil fuel-driven aircraft will become less and less appealing to customers due to the negative impact they have on the environment. In recent years, increasing efforts in research and development to make aviation more sustainable have been made. Hydrogen has been identified as a viable alternative fuel source for the future. According to the study *Sustainable Aviation – Hydrogen Is the Future: Hydrogen as an Alternative Fuel for Aviation*: " To reduce pollution and make aviation more sustainable, fossil fuels are being replaced by renewable energy sources. Hydrogen is recognized as a clean fuel, as it can be consumed without polluting the air ". By investing in building infrastructure to support sustainable aviation, FBB could potentially generate value by accounting for travelers' growing concern regarding the environmental side effects of flying. By doing so, the airport has an opportunity to mitigate the Go Green effect, or even reverse it. The downside is that the necessary investments would require FBB to commit to substantial long-term liabilities, which can compromise their financial ability.

In order to take into consideration the mitigation or offset of the *go green effect* arising from the new investment in green facilities by FBB, for the modeling purpose, we hereby make the essential assumption that as soon as the green facilities are put into implementation, the decreasing trend of FBB passengers caused by the go green effect will no longer exist. To translate this assumption to Vensim language, we modified the functions of stocks *potential travelers* and *travelers FBB* as follows:

- Potential Travelers
    - Initial Value: 1.224e+07
    - = -adoption rate + potential travelers * growth percentage of potential travelers - IF THEN ELSE (green part opening time =1 , 0 , RAMP (0.001, 2023, 2050) * potential travelers)
- Travelers FBB
    - Initial Value: 1.84e+07

- = adoption rate - IF THEN ELSE (green part opening time =1 , 0 , RAMP (0.001, 2023, 2050) * travelers FBB)

The two modifications can guarantee that both potential travelers and travelers FBB maintain being affected by the *go green effect* until the binary variable *green part opening time* turns 1 which means the green facilities are ready to be put in use. All the new variables and stocks and their corresponding values and functions can be seen as follows.The *go green effect* undershoots the base case

- New Variables
    - new modules for green
        - = 0 + STEP (20,2037) - STEP (20,2038)
    - green discovery rate
        - = IF THEN ELSE (green modules in development * discovery percentage of green module <= (green unknown modules / average discovery time for green modules) , green modules in development * discovery percentage of green module , green unknown modules / average discovery time for green modules)
    - new modules in development for cargo
        - = 0 + STEP (30,2037) - STEP (30,2038)
    - green development rate
        - = green modules in development/average development time for green modules
    - green disapproval rate
        - = green modules in test * (1-approval percentage of green modules) / average test time of green modules
    - green approval rate
        - = green modules in test * approval percentage of green modules / average test time of green modules
    - green percentage finished
        - = green modules completed / total number of green modules

- green part opening time
    - = IF THEN ELSE (green percentage finished >= percentage needs to be finished for green modules, 1 , 0)
- discovery percentage of green module
    - = 0.5
- average discovery time for green modules
    - = 0.6
- average development time for green modules
    - = 2
- approval percentage of green modules
    - = 0.9
- average test time of green modules
    - = 0.3
- total number of green modules
    - = 80
- percentage needs to be finished for green modules
    - = 0.85

- New Stocks
    - green unknown modules
        - Initial Value: 0
        - = new modules for green - green discovery rate
    - green modules in development
        - Initial Value: 0
        - = green disapproval rate + green discovery rate + new modules in development for cargo - green development rate
    - green modules in test
        - Initial Value: 0
        - = green development rate - green approval rate - green disapproval rate
    - green modules completed
        - Initial Value: 0
        - = green approval rate

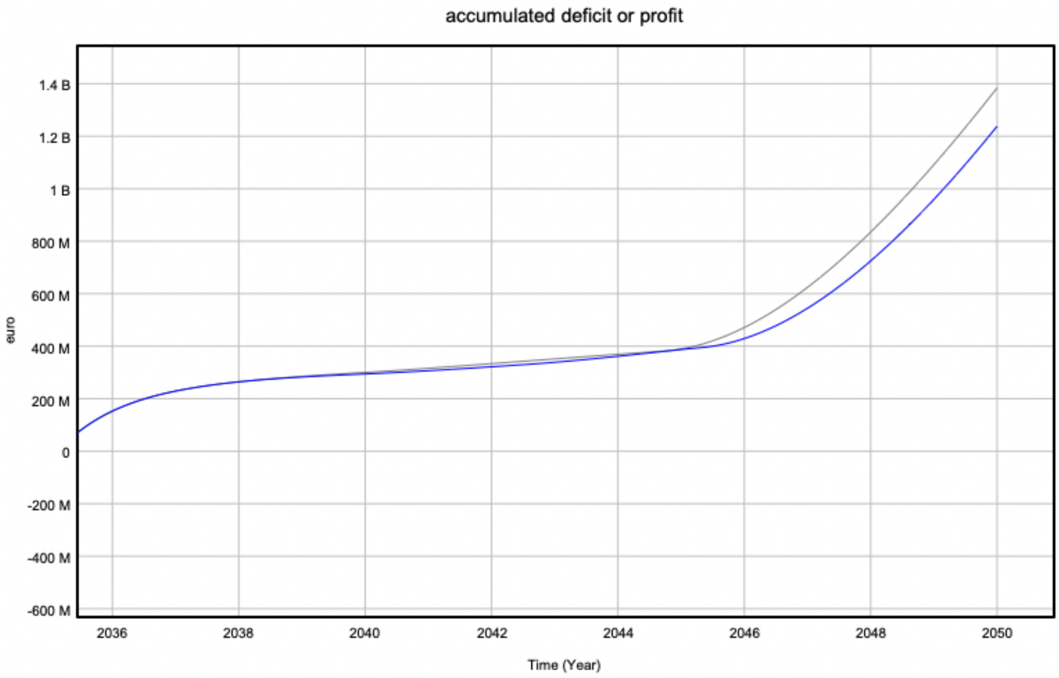

Figure 6.2 Base Case: Gray , With Green Investment: Blue

Modeling the case of green investments (Figure 6.2), overall the accumulated profit does not vary significantly from the base case. Shortly after the investments FBB will generate less profit compared to the base case and this trend will continue to 2050, since these green investments tend to be capital heavy and require additional loans which cannot be offsetted by the extra revenue generated from the green investment.

However, eventually we predict green investments on the long run will have the potential to strengthen FBB's market share, meanwhile maintaining and greatly enlarging the company's future profit. From the graph below we can see that with the green investment, *FBB passengers per year* would remain the airport capacity, 46 million after 2044. By contrast, the circumstances of the base case are not so positive since it shows a decreasing trend from 2048. Thus, there is strong evidence that if we extend the simulation time span, the *accumulated deficit or profit* under the *green investment case* will significantly exceed that under the *base case*.

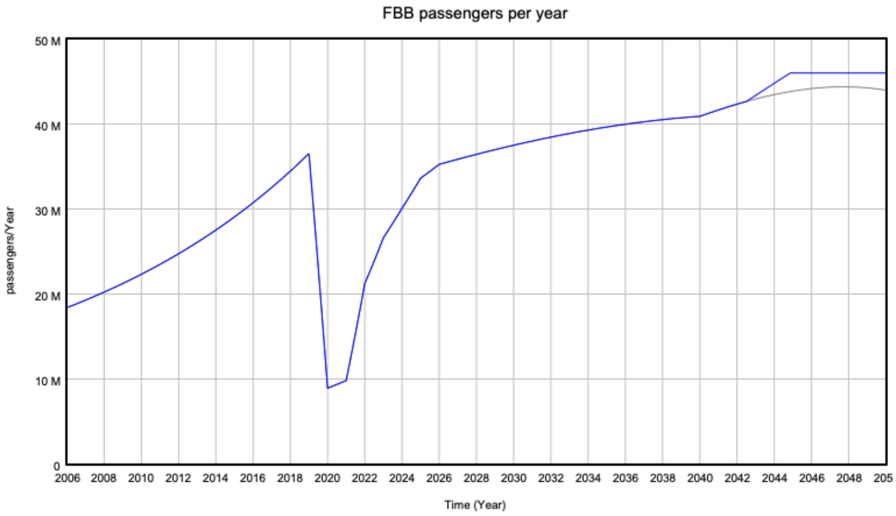

Figure 6.3 Base Case: Gray , With Green Investment: Blue

What if the FBB goes with green investments and also invests into air cargo? Investing into both projects implies that FBB would face more risks, and the company has to be cautious when making such decisions. Certainly, FBB's accumulated profit would be lower by €20-30 Million after the investments yearly. We predict that this trend will be reversed in 2049 when the blue line crosses the base case, and eventually, FBB will be able to contribute €20-30 Million more yearly. Hence one can suggest to FBB to take the opportunity to invest in such projects. However, when it comes to planning new projects, we must say that the company needs to be vigilant in order to keep a healthy project timeline and set priorities in order to make the projects successful and financially vital.

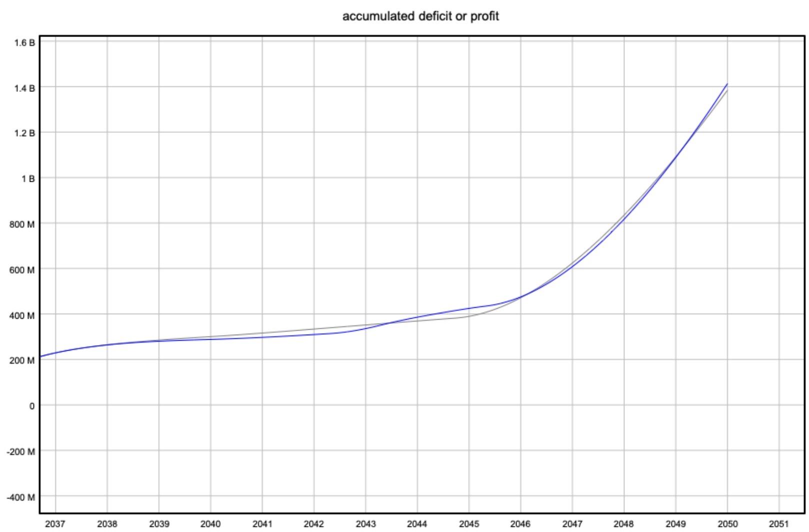

Figure 6.4 Base Case: Gray , With both Projects: Blue

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