USER'S MANUAL

DEACM

February, 2016

Revision Sheet

Release No.	Date	Revision Description
Rev. 0	02/2016	First Version of the Manual

USER'S MANUAL

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1.0 GENERAL INFORMATION

1. GENERAL INFORMATION

1.1 System Overview

The DEACM stands for Data Envelopment Analysis for Capital Management and is a web application that is intended to help solve problems related to Capital Management.

The application is based on a Doctoral Thesis of the researcher Ney Paranaguá that proposed the concept of *relative size* and show how to use it to solve problems regarding Capital Management.

The Doctoral thesis proposes a series of mathematical models for optimization problems regarding Capital Management, that are difficult, error prone and time consuming to execute them by hand and make sense of the results, specially with a big amount of data. The DEACM application implements these mathematical models and make it easy to input data, execute the proposed models and analyze the results.

The major functions performed by the application are:

- **Input or load data**: this feature enables the user to input data using a web interface and manually type in the matrix of DMUs (Decision Making Units) with it's associated data: inputs, outputs and costs. It's also possible to import a .csv file with the DMUs data along with the capital management model and it's parameters in case of a bigger data.
- **Execute base models (DEA and KAO's)**: this feature frees the user for the need of giving the values of the DEA and KAO's efficiency as input arguments for each DMU. This feature saves time and avoid errors in input data.
- **Execute capital management models**: this feature enables the user to select a capital management model, give the parameters for that specific model and executes it. It automates the execution of the mathematical models proposed by Ney Paranaguá, in his Doctoral thesis.

1.2 Project References

https://en.wikipedia.org/wiki/Data_envelopment_analysis

C. Kao and H.-T. Hung, Data envelopment analysis with common weights: the compromise solution approach, Journal of Operational Research Society, 56 (2005), pp. 1196–1203.

P. Ney, A. M. Carlos and R. A. Mariana. Relative size and l2-efficiency: two new concepts based on DEA to guide management of capital.

1.3 Authorized Use Permission

The software was intended for educational/research usage and we are not responsible for illegal or misusage of the software and or it's features, texts, images, sound, code or any media, statement or information made available by the software.

The software is free for use. Any activity made using the software or it's related information or media is your responsibility.

1.4 Acronyms and Abbreviations

DEACM - name of the application and stands for Data Envelopment Analysis for Capital Management
DEA - stands for Data Envelopment Analysis and it's a mathematical model used to measure the efficiency of DMUs.
KAO - it's a reference to the model proposed by C. Kao and H.-T. Hung for commons weights based on DEA.
DMU - stands for Decision Making Unit and it's the name given for each entity with inputs and outputs in the DEA model.

2.0 SYSTEM SUMMARY

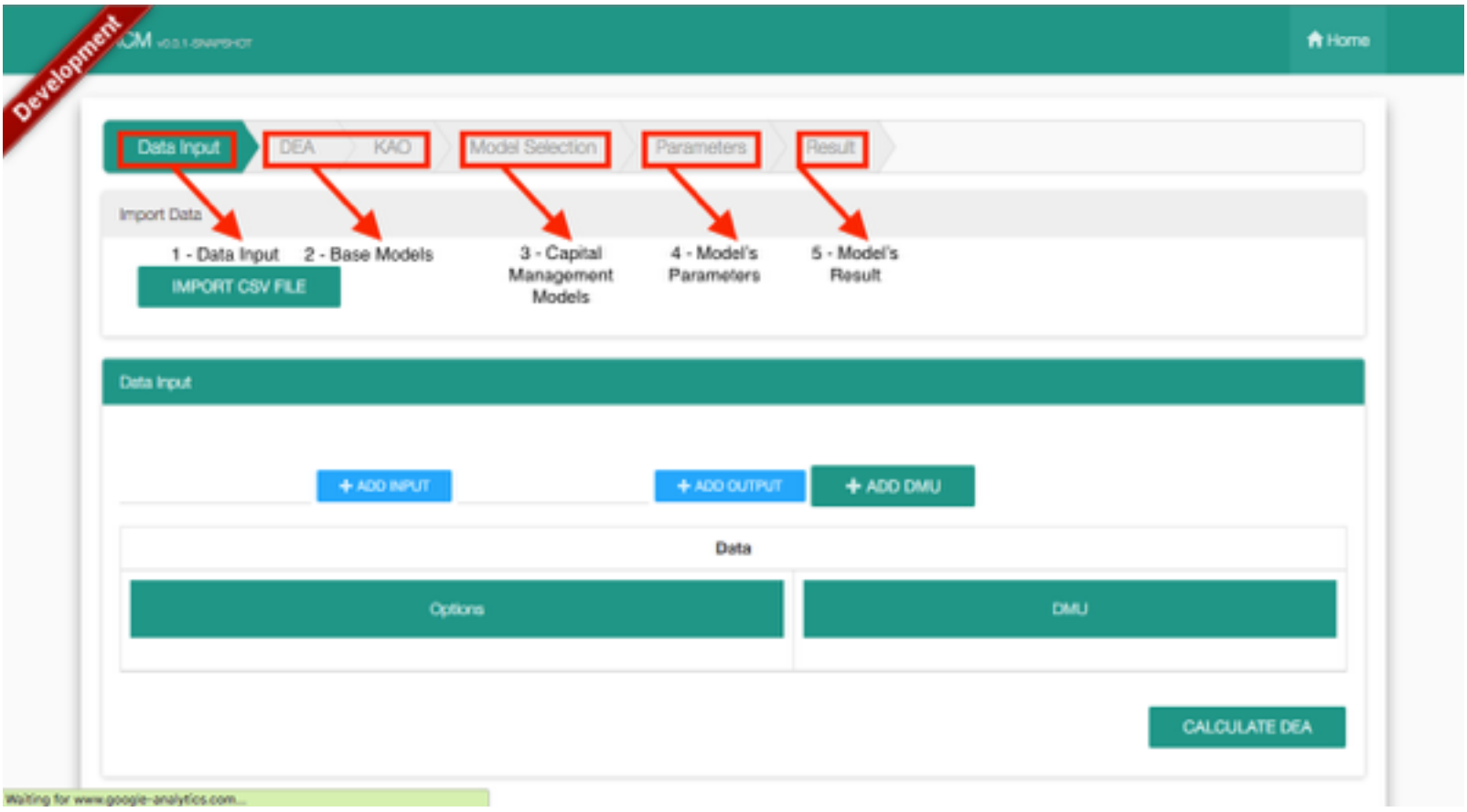
2. SYSTEM SUMMARY

The main goal of the DEACM application is to help the user to solve problems related to capital management. The capital management here is any economic activity carried out by one or more DMU's involving saving or investment of resources. To help solving these problems, the application allows the user to preview the output of controlled modifications on the budget, relative size and efficiency scores.

For instance, in the case of a downturn of the economy, some decreasing of the relative size and/ or efficiency may be wanted to save capital. In general, motivated by different economic scenarios, a manager could establish a number of objectives and directions for the company and use the application to test and preview different scenarios to achieve those goals based on three parameters relating efficiency, capital and relative size.

2.2 Data Flows

The DEACM application follows a step-by-step user interaction to perform it's functions, as shown in the following screen.



Each step depends of the result of the previous one and it's results are forwarded to the following step. The steps are:

1. **Data Input**: this is the first step, where the user manually type in the data or import a csv file.
2. **Base Models**: it's composed of the two steps, DEA and KAO, which are the basis for the proposed models for Capital Management. In these step, the application calculates the DEA and KAO's efficiencies for each DMU.
3. **Model Selection**: in this step, the user selects the Capital Management model to be executed.

4. **Parameters:** in this step, the user give the parameters for the chosen Capital Management model.
5. **Result**: it's the last step, where the application shows the result of the execution of the selected step with the given parameters.

The details of each step is presented in the following section.

3.0 GETTING STARTED

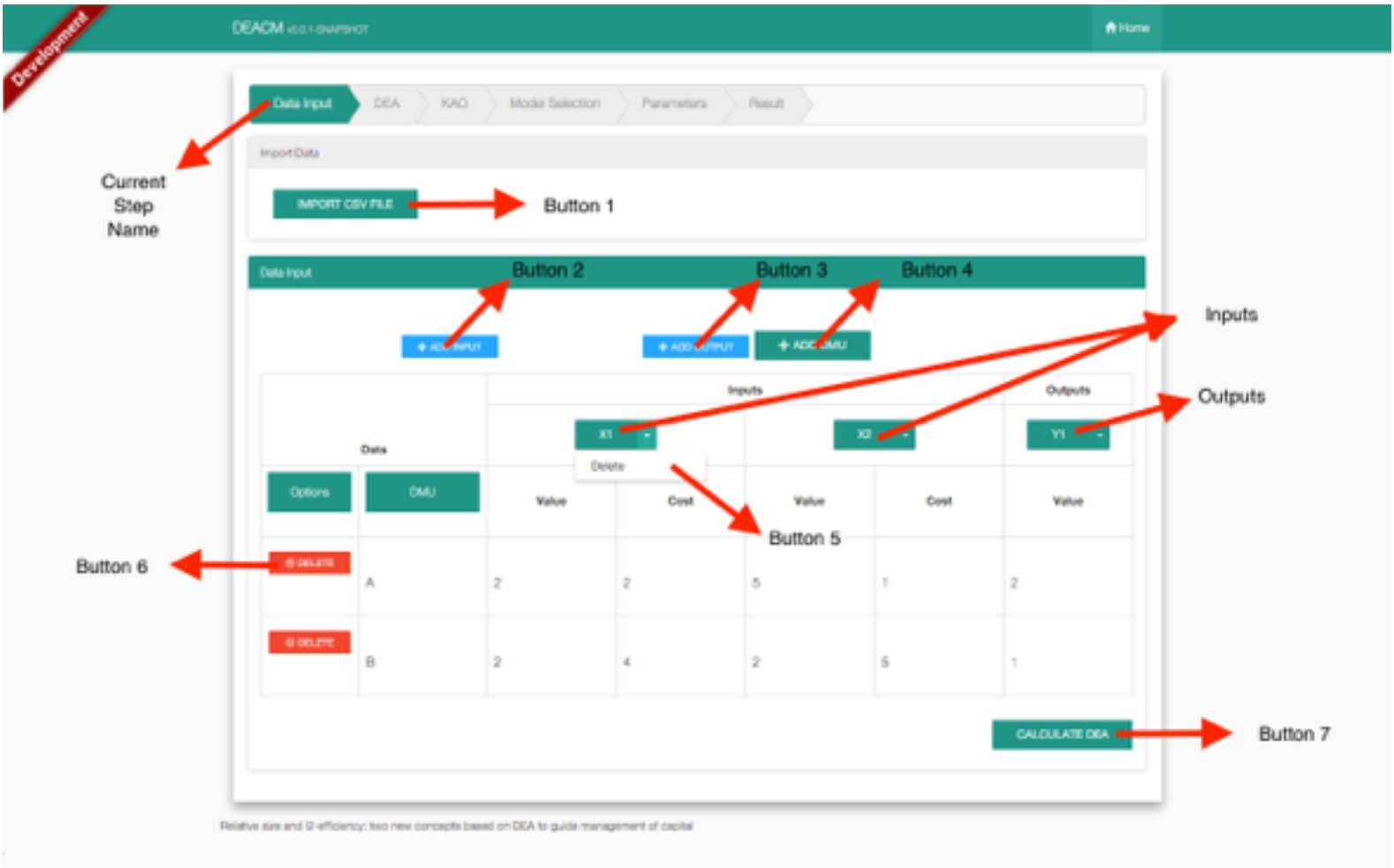
3. GETTING STARTED

The DEACM application follows a step-by-step style of user interaction where the following step depends on the previous one to execute. The steps, in the corresponding order, are: Data Input, DEA, KAO, Model Selection, Parameters and Result.

Inside each step, it's possible to go back to the previous step by clicking on the step name at the top bar or by clicking at the go back button. The following sections contains the explanation of each step of the DEACM application and how to use it, along with some special cases.

3.1 Data Input

This is the first step of the application where the user enters the data. The data is a matrix where the lines correspond to a single DMU and the columns are inputs, outputs and it's corresponding data. The following image correspond to this step and explain each element:



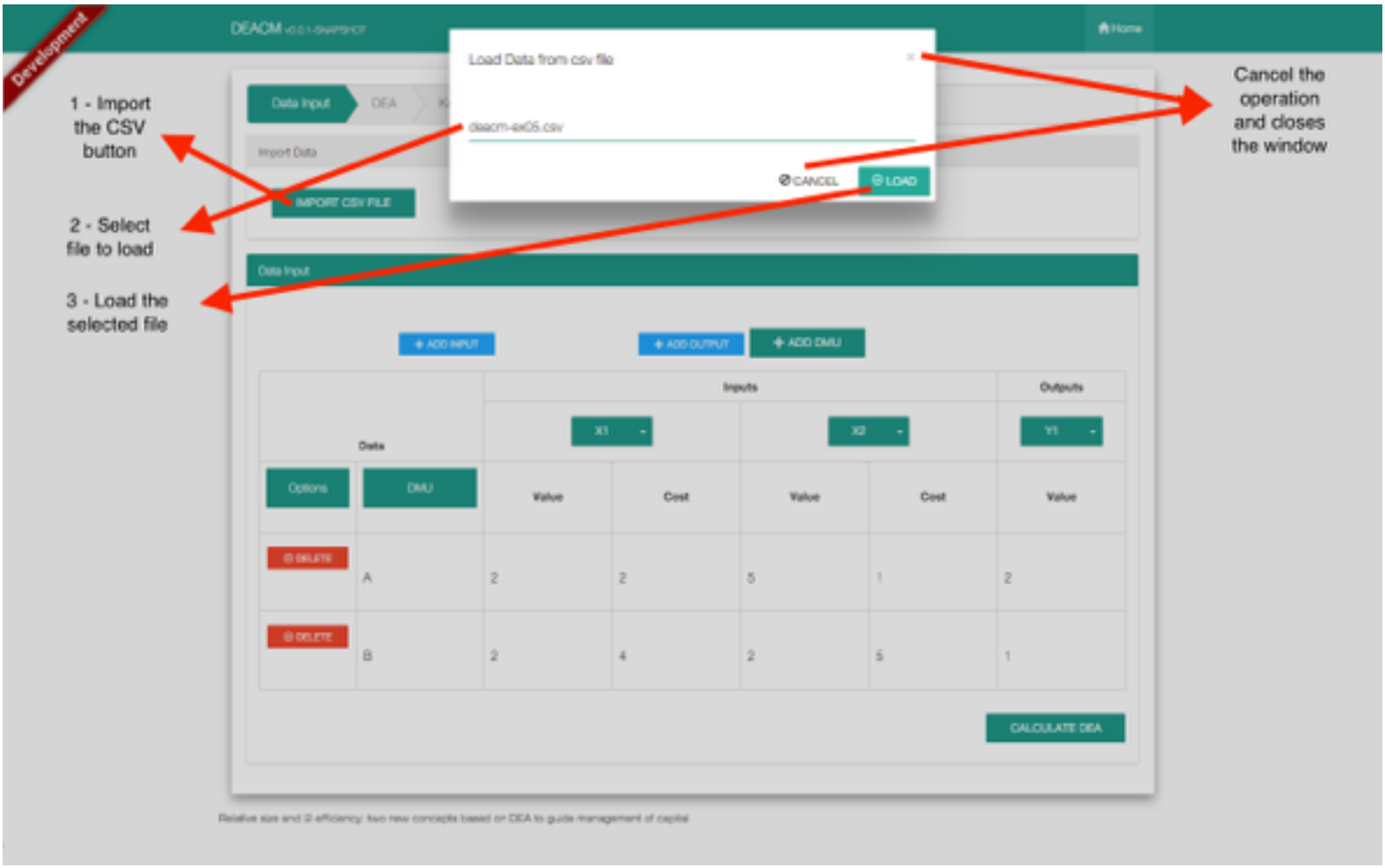
- **Button 1**: Using this button, the user can import a CSV file with the data. The specification of the file is in the appendix of this document.
- **Button 2**: This button adds a new input to the matrix of data.
- **Button 3**: This button adds a new output to the matrix of data.
- **Button 4**: This button adds a new DMU to the matrix of data.
- **Button 5**: This button deletes the selected input or output.
- **Button 6**: This button deletes the selected DMU.

- **Button 7**: This button go to the next step which is calculate the DEA.

3.1.1 Importing data

The application supports the import of a CSV file with the input data along with the model to execute and the data associated to the model. The format of the CSV file for each model is in the appendix of this document.

To import a CSV file, you need to click on the **Button 1 - Import CSV File**, **select the CSV** file and click the **Load button**, as shown in the image above. If the given file is correct, the application load it's contents, automatically executes the DEA, KAO and Model Selection steps and return to the Parameters step, so the user can change the parameters and execute the model. If the file is not in the expected format, the application prompt an error message.



3.1.2 Adding an input

To add an input, just type in the name of the input on the input box next to the **Button 2 - Add Input** and click on it. If there is any error, the application will show an error message, otherwise it will add a new column on the table with the given input name.

3.1.3 Adding an output

To add an output, just type in the name of the output on the input box next to the **Button 3 - Add Output** and click on it. If there is any error, the application will show an error message, otherwise it will add a new column on the table with the given output name.

3.1.4 Adding an DMU

To add a DMU, just click the **Button 4 - Add DMU**. The application will add a new line on the table with the DMU name in blank. Now click on the input box in the new line of the table and type in the DMU name.

3.1.5 Deleting an input

To delete an input, click on the arrow icon next to the input name in the table and select the option delete. This is shown in the figure as **Button 5**.

3.1.6 Deleting an output

To delete an output, click on the arrow icon next to the output name in the table and select the option delete. This is shown in the figure as **Button 5**.

3.1.7 Deleting an DMU

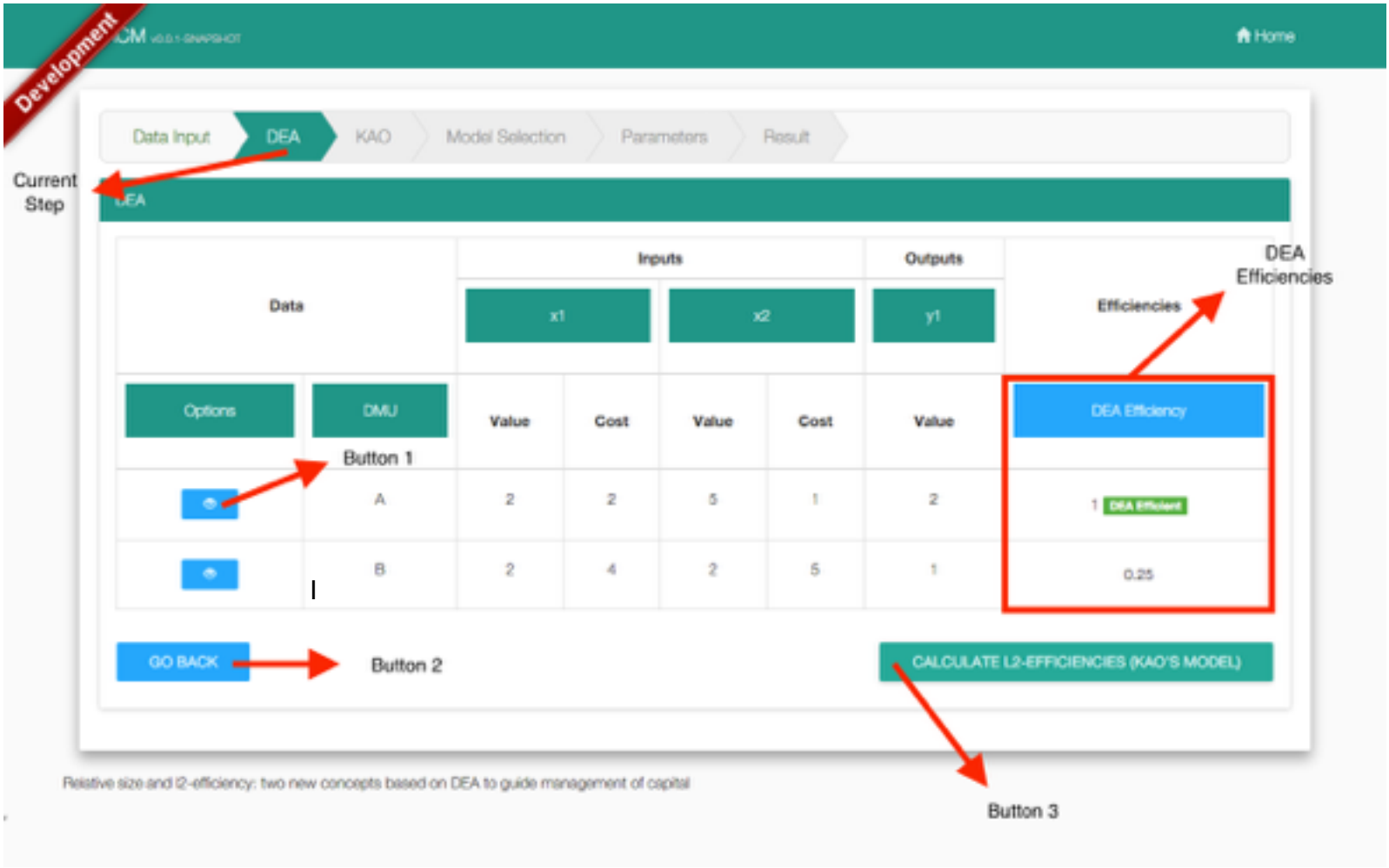
To delete an DMU, click on the **Button 6 - Delete** of the corresponding line of the table data.

3.1.8 Go to next step

To go to the next step, just click on the **Button 7 - Calculate DEA**. If there's any error with the given data, then the application will show an error message, otherwise, it will go to the next step Calculate DEA.

3.2 DEA

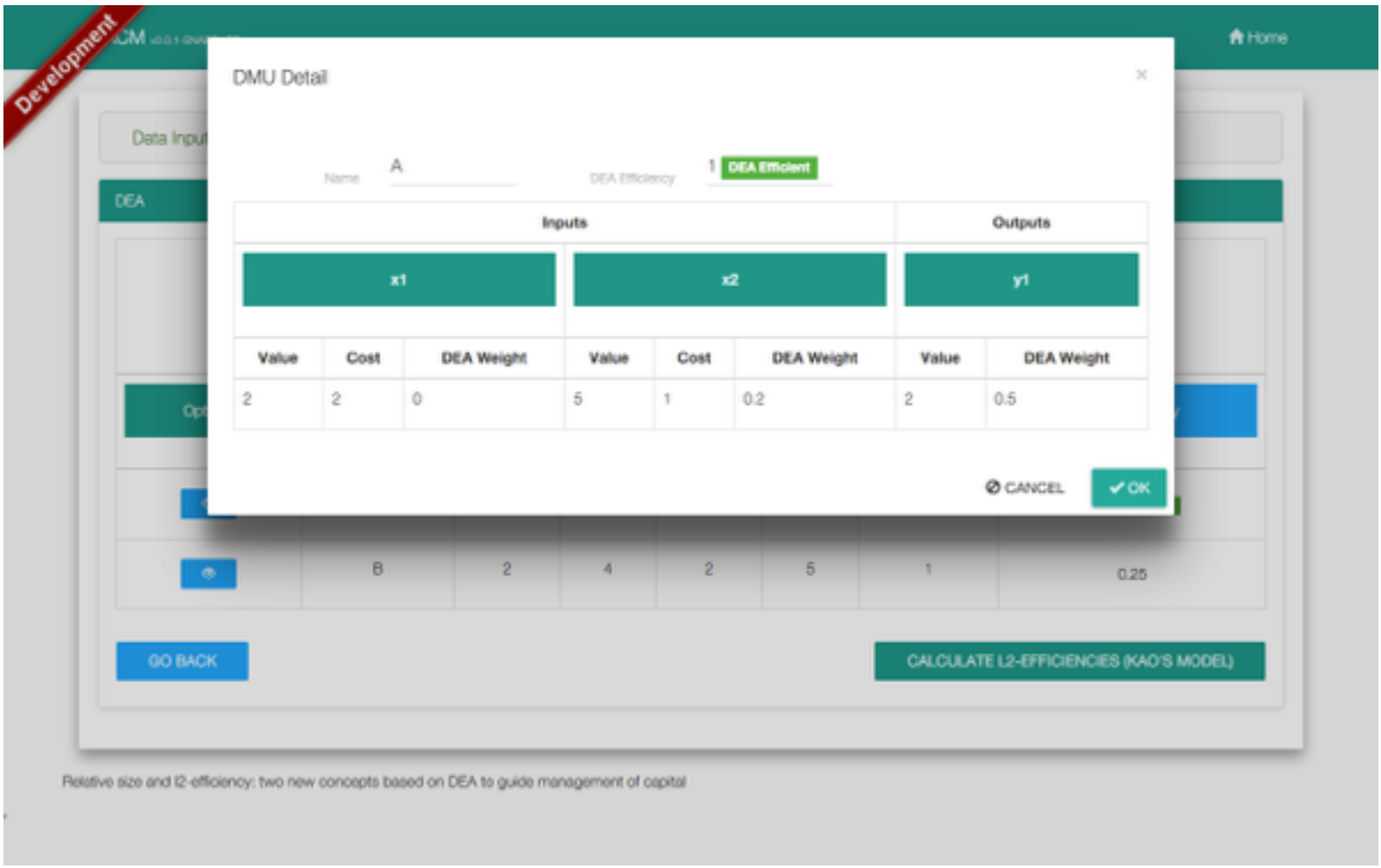
This is the second step where the application calculates the first basis model, the DEA model. This step do not require any input or action by the user, it just shows the calculated DEA efficiency for each DMU given in the previous step, so that the user can easily follow the calculations ahead and check the values as shown in the following image:



- **Button 1**: Shows the detail of the selected DMU.
- **Button 2**: Go back to the previous step.
- **Button 3**: Go to the next step Calcule L2-Efficiencies (KAO's Model)

3.2.1 DMU Details

To check the DMU detail, you just need to click the **Button 1** and a modal window will apear with the details of the selected DMU as shown in the following image.



3.2.2 Going Back

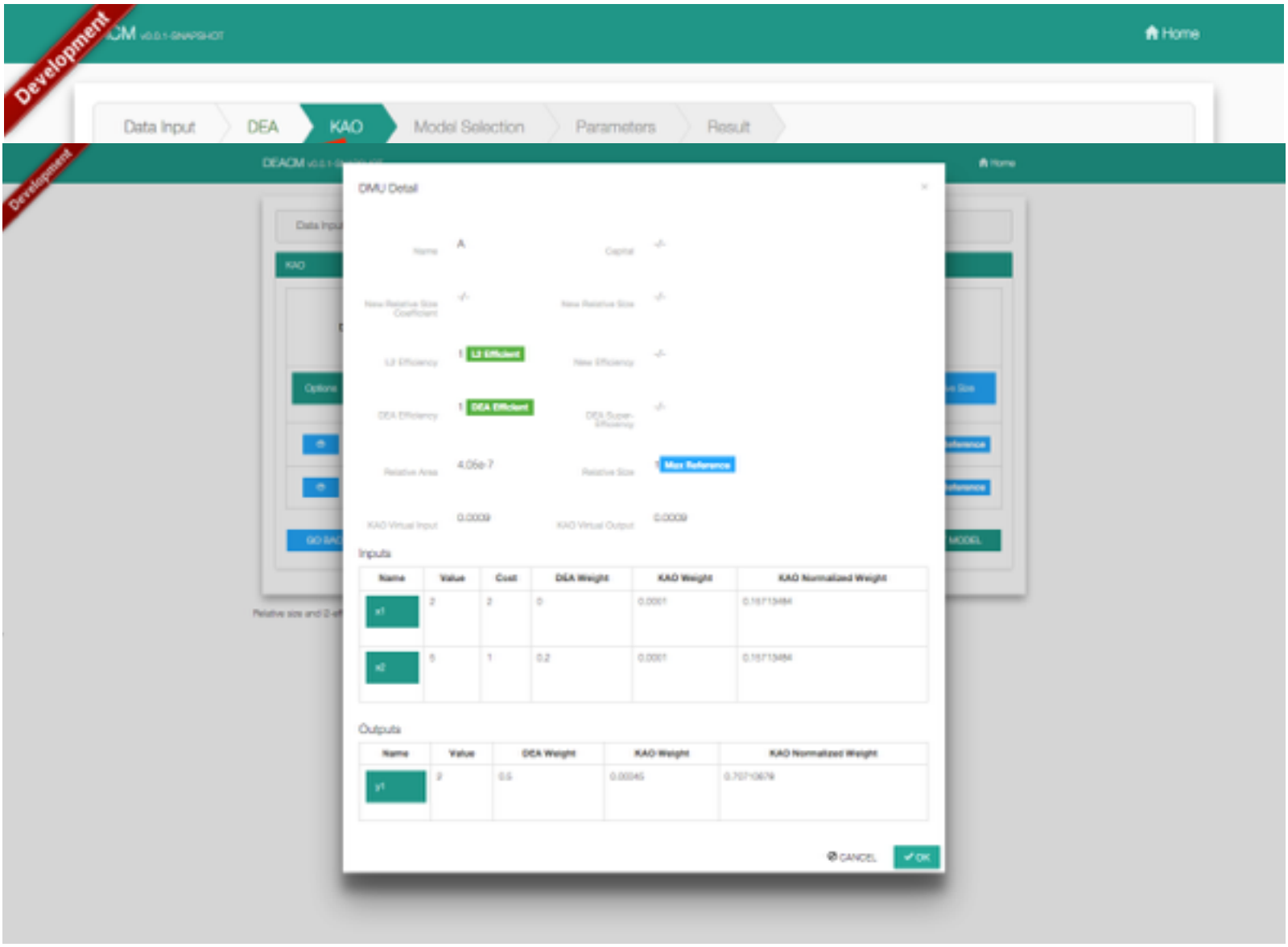
To go back to the previous step **Data Input**, you just need to click on the **Button 2 - Go Back** or click on the Data Input label at the bar with all step names.

3.2.3 Go to next step

To go to the next step KAO, you just need to click on the **Button 3 - Calculate L2-Efficiencies (KAO's Model)**.

3.3 KAO

This is the third step where the application calculates the second basis model, the KAO model. This step do not require any input or action by the user, it just shows the calculated DEA and KAO efficiencies along with the Relative Size and Relative Area for each DMU given in the previous step, so that the user can easily follow the calculations ahead and check the values as shown in the following image:



- **Button 1**: Shows the detail of the selected DMU.
- **Button 2**: Go back to the previous step.
- **Button 3**: Go to the next step Choose Capital Management Model.

3.3.1 DMU Details

To check the DMU detail, you just need to click the **Button 1** and a modal window will apear with the details of the selected DMU as shown in the following image.

3.3.2 Going Back

To go back to the previous step **DEA**, you just need to click on the **Button 2 - Go Back** or click on the DEA label at the bar with all step names.

3.3.3 Go to next step

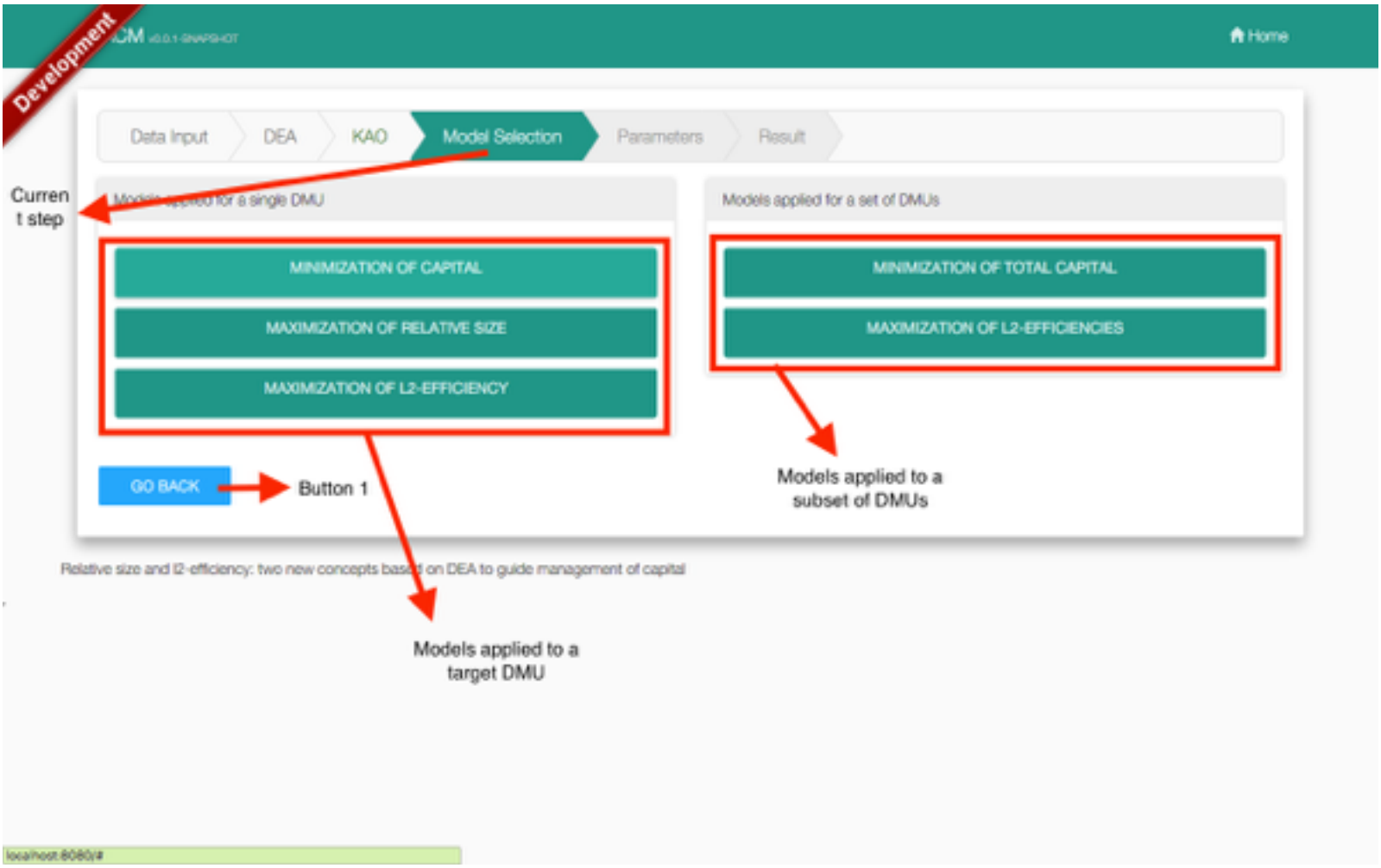
To go to the next step Choose Capital Management Model, you just need to click on the **Button 3 - Choose Capital Management Model**.

3.4 Model Selection

This is the fourth step where the user selects the capital management model to execute. The available Capital Management model are splitter into two groups:

- **Single DMU**: within this group are those models that are applied to a single target DMU. The available models in this group are:
  - **Minimization of Capital**: this model shows the minimum capital that needs to be applied to a target DMU constrained by a factor for it's relative size and for it's efficiency. These factors could increase or decrease the DMU's size and/or efficiency. The application depends on the user.
  - **Maximization of Relative Size**: this model shows how much the relative size of a target DMU is likely to grow/shrink according to the available capital and a efficiency factor.
  - **Maximization of Efficiency**: this model shows how much the efficiency of a target DMU is likely to grow/shrink according to the available capital and a relative size factor.
- **Subset of DMUs**: within this group are those models that are applied to a target subset of DMUs. The available models in this group are:
  - **Minimization of Capital**: this model shows the minimum capital that needs to be applied to a target subset of DMUs constrained by a factor for the relative size for each DMU and a factor for the distance between the KAO and DEA efficiencies. These factors could increase or decrease the DMU's size and/or efficiency. The application depends on the user.
  - **Maximization of Efficiency**: this model shows how much the efficiency of a target subset of DMUs is likely to grow/shrink according to the available capital and a relative size factor for each DMU.

The following image explains the screen elements:



3.4.1 Going Back

To go back to the previous step **KAO**, you just need to click on the **Button 1 - Go Back** or click on the KAO label at the bar with all step names.

3.4.2 Go to next step

To go to the next step, you need to click on the model's name, then the application will take you to the next step according to the model that you've selected.

3.5 Parameters

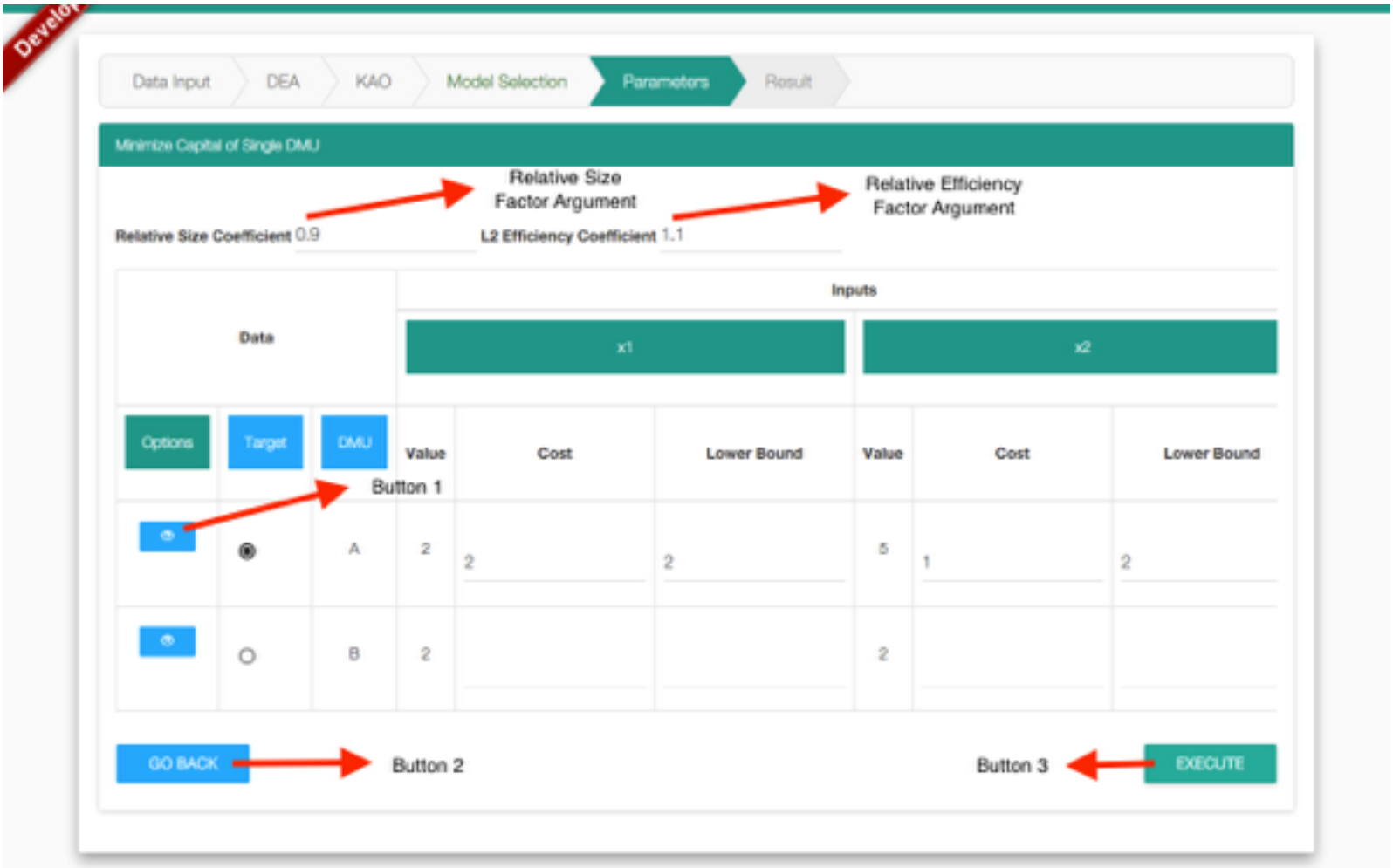
This is the fifth step where the arguments for the specific model are set. Since the Capital Management models are a optimization problem and fundamentally a mathematical model, depending on the given arguments, the problem can be infeasible. Another possibility, for all models, is that depending on the arguments, the number of variables and constraints of the model can be too high for the solver give a solution that the problem is considered infeasible. In both cases, the application shows an error message, but the interpretation of the model's argument, it's feasibility and results are up the user.

The following list is a detail of each model, with it's arguments and screen elements explanation.

- **Single DMU Models:**
  - **Minimization of Capital:** this model requires two arguments:
    - **Relative Size Coefficient**: it's a number, representing a factor that will be used to determined the new size of a target DMU. For example, the number 0.9 means that the size can be decreased in 10%. The number 1 means the size will be the same and the number 2 means it will be doubled.
    - **L2 Efficiency Coefficient**: it's a number, representing a factor that will be used to determined the new l2 efficiency (KAO's Efficiency) of a target DMU. For example, the number 0.9 means that the efficiency can be decreased in 10%. The number 1 means the efficiency will be the same and the number 2 means it will be doubled.

This model also requires the user to select a single target DMU by clicking on the radio box on the column "target" of the table that contains all the DMUs. For the target DMU, it's also required the costs of each input, along with the lower bounds of each input and output.

After all parameters are set, you are ready to execute the model. To execute it, just click on the **Button 3 - Execute** on the bottom right of the screen. If there's any missing information or wrong parameters, the application will show an error message, the same goes if the execution leads to an infeasible problem. The following image shows the screen elements as described:

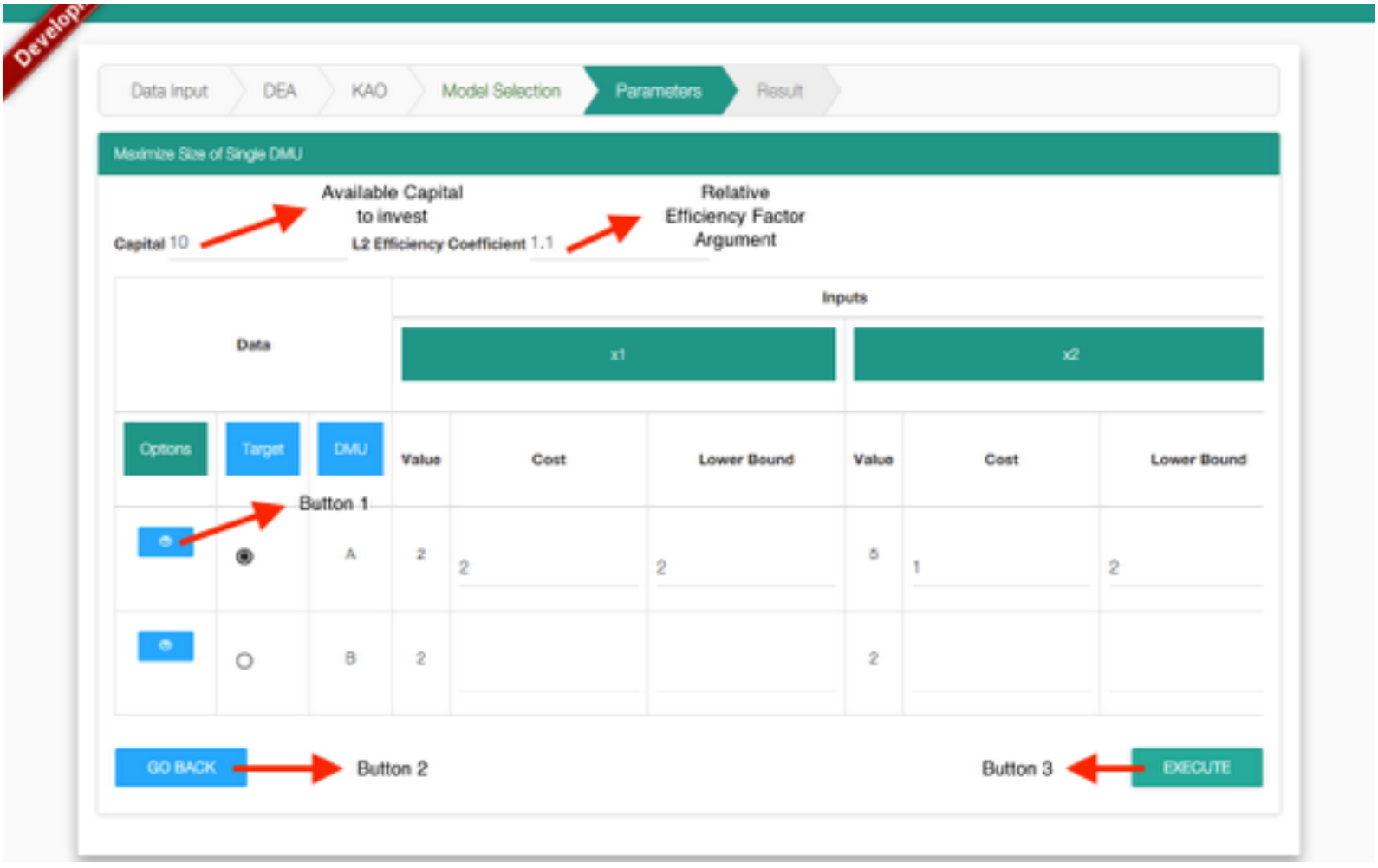


- **Button 1**: The Button 1 shows the DMU details, just as in the previous steps.
- **Button 2**: The Button 2 go back to the previous step, just as in the previous steps.

  - **Maximization of Relative Size**: this model requires two arguments:
    - **Capital**: it's a number, representing the available capital to invest at the target DMU. For example, the number 10, means 10 monetary units available to invest at the target DMU.
    - **L2 Efficiency Coefficient**: it's a number, representing a factor that will be used to determined the new l2 efficiency (KAO's Efficiency) of a target DMU. For example, the number 0.9 means that the efficiency can be decreased in 10%. The number 1 means the efficiency will be the same and the number 2 means it will be doubled.

This model also requires the user to select a single target DMU by clicking on the radio box on the column "target" of the table that contains all the DMUs. For the target DMU, it's also required the costs of each input, along with the lower bounds of each input and output.

After all parameters are set, you are ready to execute the model. To execute it, just click on the **Button 3 - Execute** on the bottom right of the screen. If there's any missing information or wrong parameters, the application will show an error message, the same goes if the execution leads to an infeasible problem. The following image shows the screen elements as described:

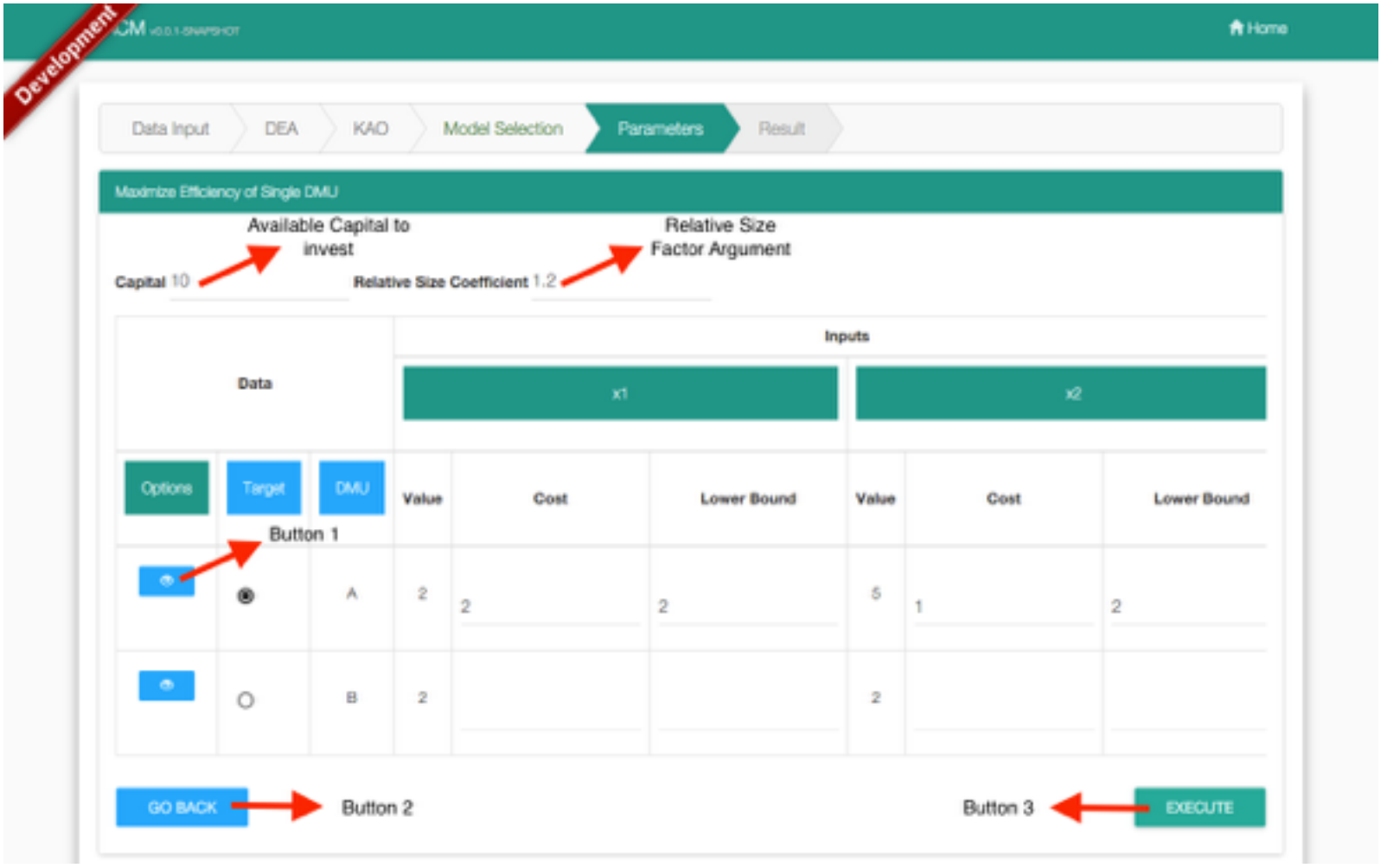


- **Button 1**: The Button 1 shows the DMU details, just as in the previous steps.
- **Button 2**: The Button 2 go back to the previous step, just as in the previous steps.

- **Maximization of Efficiency**: this model requires two arguments:
  - **Capital**: it's a number, representing the available capital to invest at the target DMU. For example, the number 10, means 10 monetary units available to invest at the target DMU.
  - **Relative Size Coefficient**: it's a number, representing a factor that will be used to determined the new l2 efficiency (KAO's Efficiency) of a target DMU. For example, the number 0.9 means that the efficiency can be decreased in 10%. The number 1 means the efficiency will be the same and the number 2 means it will be doubled.

This model also requires the user to select a single target DMU by clicking on the radio box on the column "target" of the table that contains all the DMUs. For the target DMU, it's also required the costs of each input, along with the lower bounds of each input and output.

After all parameters are set, you are ready to execute the model. To execute it, just click on the **Button 3 - Execute** on the bottom right of the screen. If there's any missing information or wrong parameters, the application will show an error message, the same goes if the execution leads to an infeasible problem. The following image shows the screen elements as described:



- **Button 1**: The Button 1 shows the DMU details, just as in the previous steps.
- **Button 2**: The Button 2 go back to the previous step, just as in the previous steps.

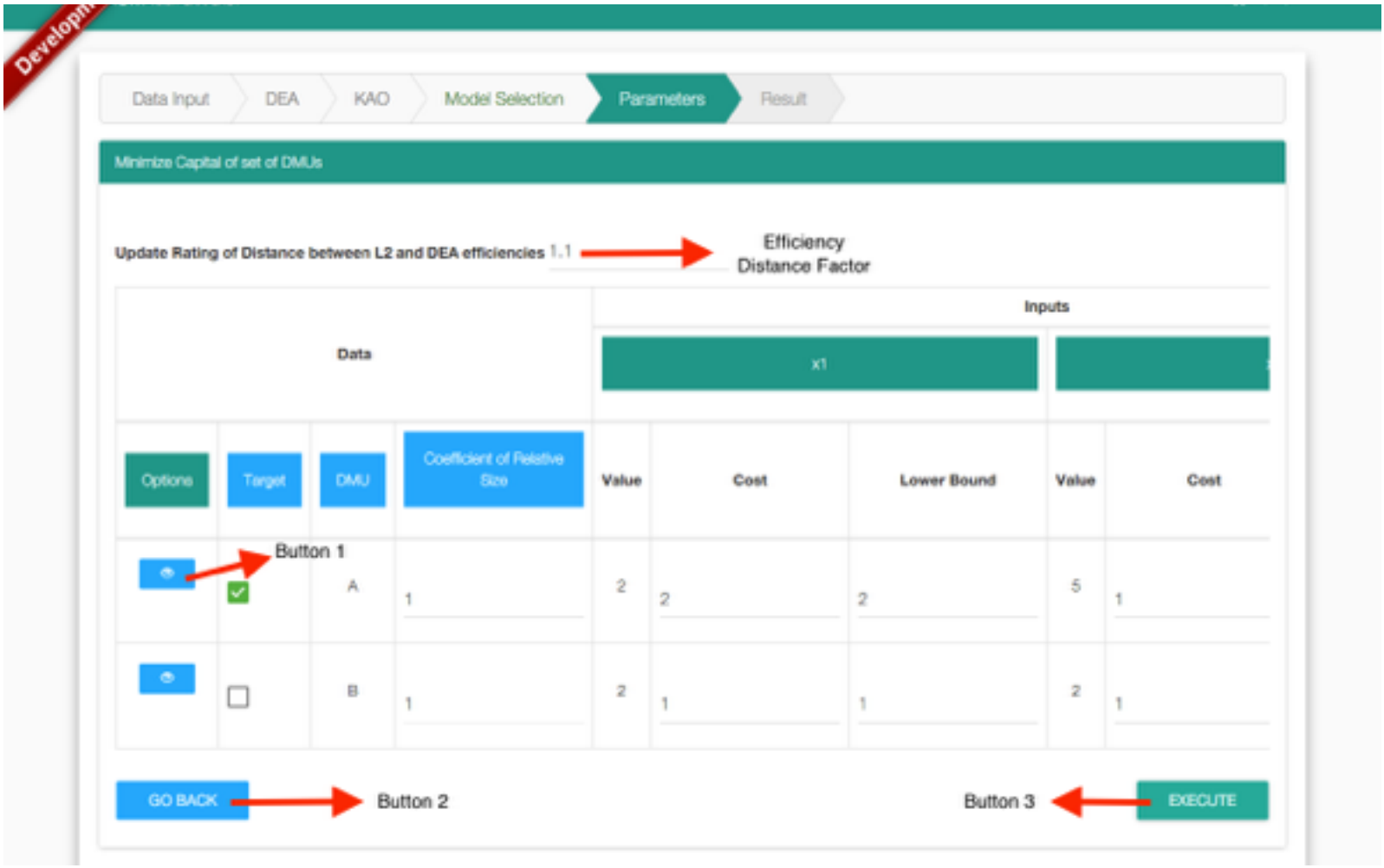
- **Subset of DMUs Models**: This models work the same way as the others, but they refer to a target subset of DMUs. Both models also have to different ways to execute, which are:
    - **DEA Super Efficiency Model**: executing the model in this model, will cause the application to use the DEA Super Efficiency for each DMU of the target subset. To execute the application with the DEA Super Efficiency, just click on the Execute button and a pop message will prompt you, as shown in the following image:

    - **Altruistic or Selfish**: these are the two approaches that the models proposed in the Doctoral thesis can run. In the altruistic mode, all DMUs of the target subset help the entire set of DMUs, while in the selfish mode, the DMUs of the target subset cooperate to help themselves. To choose between the two approaches, just click on the Execute button and a pop message will prompt you, as shown in the following image:

    - **Minimization of Capital**: this model requires two arguments:
        - **Update Rating of Distance between L2 and DEA efficiencies**: it's a number, representing a factor that will be used to increase or decrease the distance between the DEA and KAO's efficiencies. For example, the number 0.9 means that distance will be decreased in 10%. The number 1 means the distance will be the same and the number 2 means it will be doubled.
        - **Relative Size Coefficient**: it's a number, representing a factor that will be used to determined the new l2 efficiency (KAO's Efficiency) of a target DMU. For example, the number 0.9 means that the efficiency can be decreased in 10%. The number 1 means the efficiency will be the same and the number 2 means it will be doubled. This parameter must be set for each target DMU.

To select a target DMU, just click on the check box on the column "target" of the table that contains all the DMUs. For the target DMU, it's also required the costs of each input, along with the lower bounds of each input and output.

After all parameters are set, you are ready to execute the model. To execute it, just click on the **Button 3 - Execute** on the bottom right of the screen. If there's any missing information or wrong parameters, the application will show an error message, the same goes if the execution leads to an infeasible problem. The following image shows the screen elements as described:

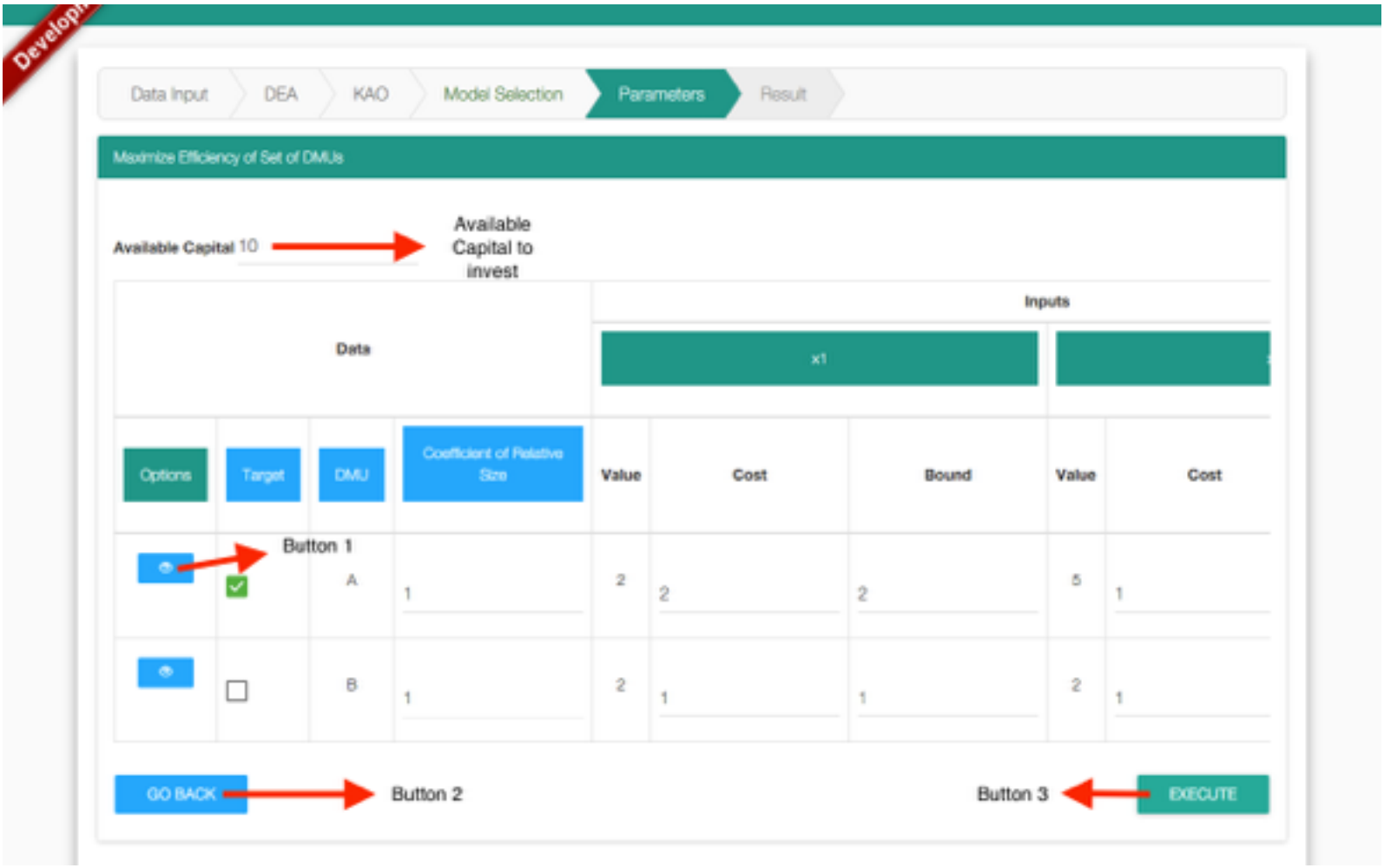


- **Button 1**: The Button 1 shows the DMU details, just as in the previous steps.
- **Button 2**: The Button 2 go back to the previous step, just as in the previous steps.

- **Maximization of Efficiency**: this model requires two arguments:
  - **Capital**: it's a number, representing the available capital to invest at the target DMU. For example, the number 10, means 10 monetary units available to invest at the target DMU.
  - **Relative Size Coefficient**: it's a number, representing a factor that will be used to determined the new l2 efficiency (KAO's Efficiency) of a target DMU. For example, the number 0.9 means that the efficiency can be decreased in 10%. The number 1 means the efficiency will be the same and the number 2 means it will be doubled. This parameter must be set for each target DMU.

To select a target DMU, just click on the check box on the column "target" of the table that contains all the DMUs. For the target DMU, it's also required the costs of each input, along with the lower bounds of each input and output.

After all parameters are set, you are ready to execute the model. To execute it, just click on the **Button 3 - Execute** on the bottom right of the screen. If there's any missing information or wrong parameters, the application will show an error message, the same goes if the execution leads to an infeasible problem. The following image shows the screen elements as described:



- **Button 1**: The Button 1 shows the DMU details, just as in the previous steps.
- **Button 2**: The Button 2 go back to the previous step, just as in the previous steps.

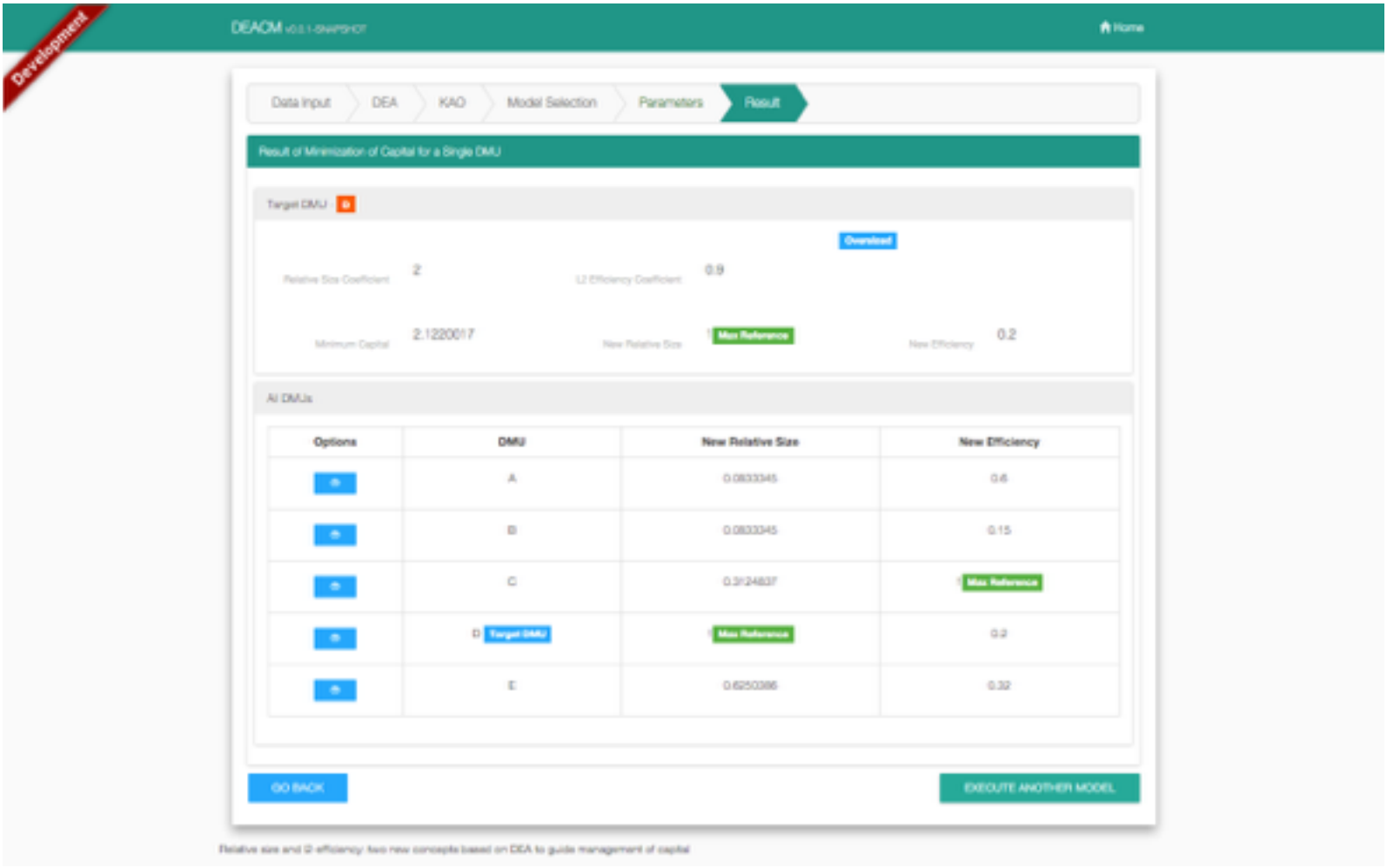
3.4 Result

This is the last step where you can see the model's result. Each model gives a different result and the interpretation of the results are up to you.

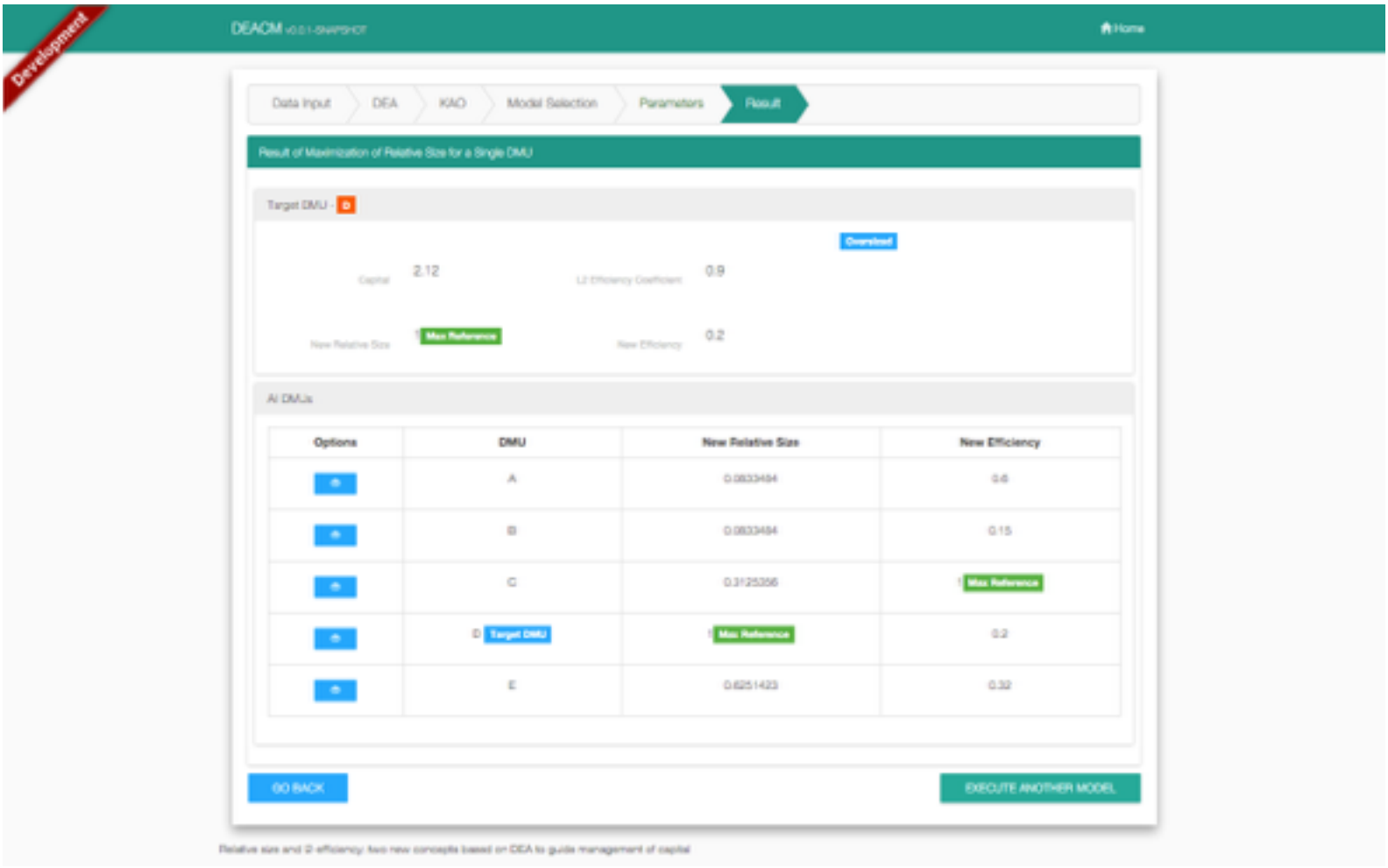
The result screen shows the model executed, it's arguments, the model's result, each DMU details and if two situations occurred during the execution: oversize and super-efficiency. The oversize situation means that one of the DMUs got out of the range area, the same goes to the efficiency.

The following images shows the result screen for each model. All the screens share two buttons, the **Go Back Button** and the **Execute Another Model Button**, which takes you to the previous step or execute another model with the same arguments respectively.

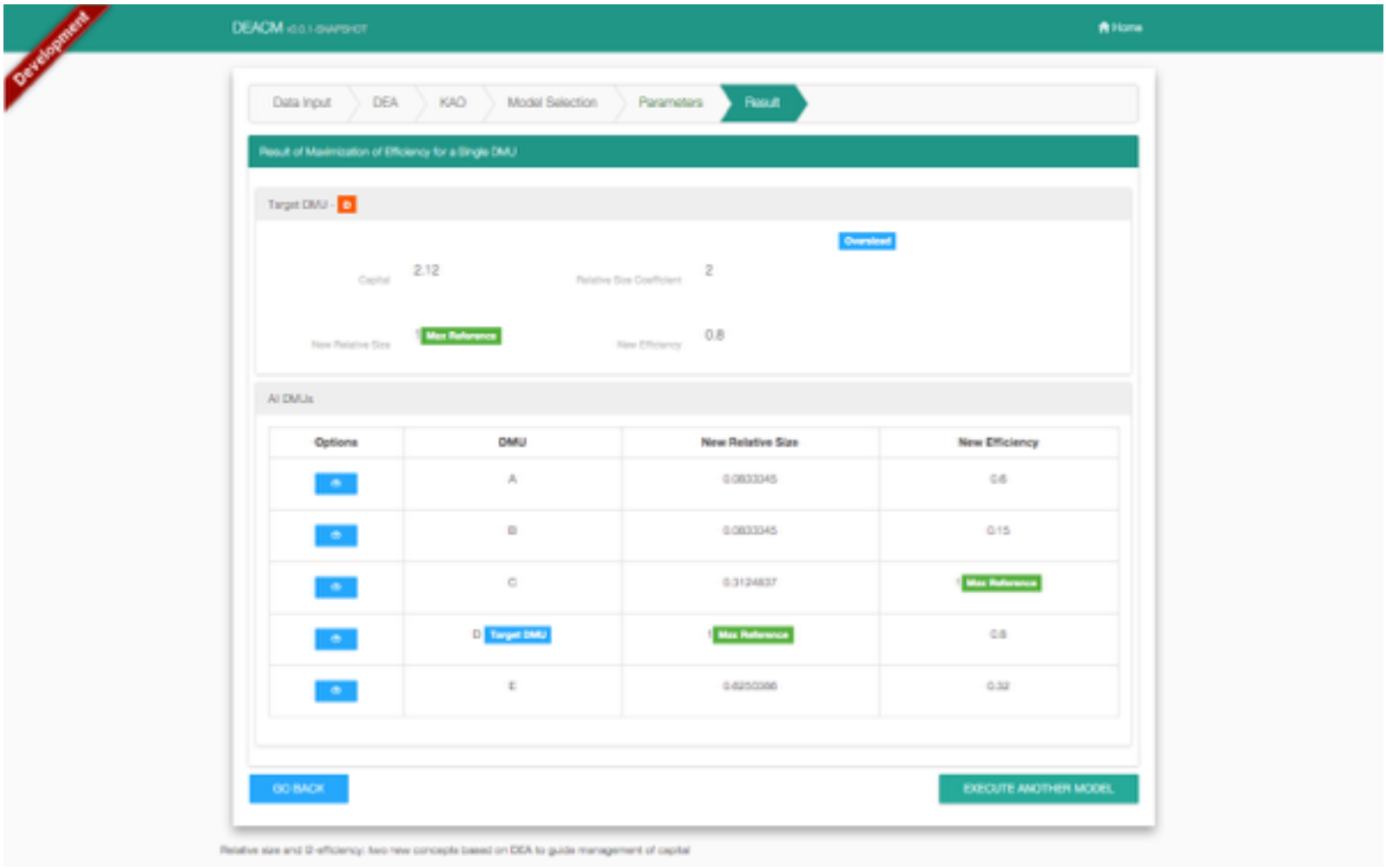
Result of the Minimization of Capital for a single target DMU



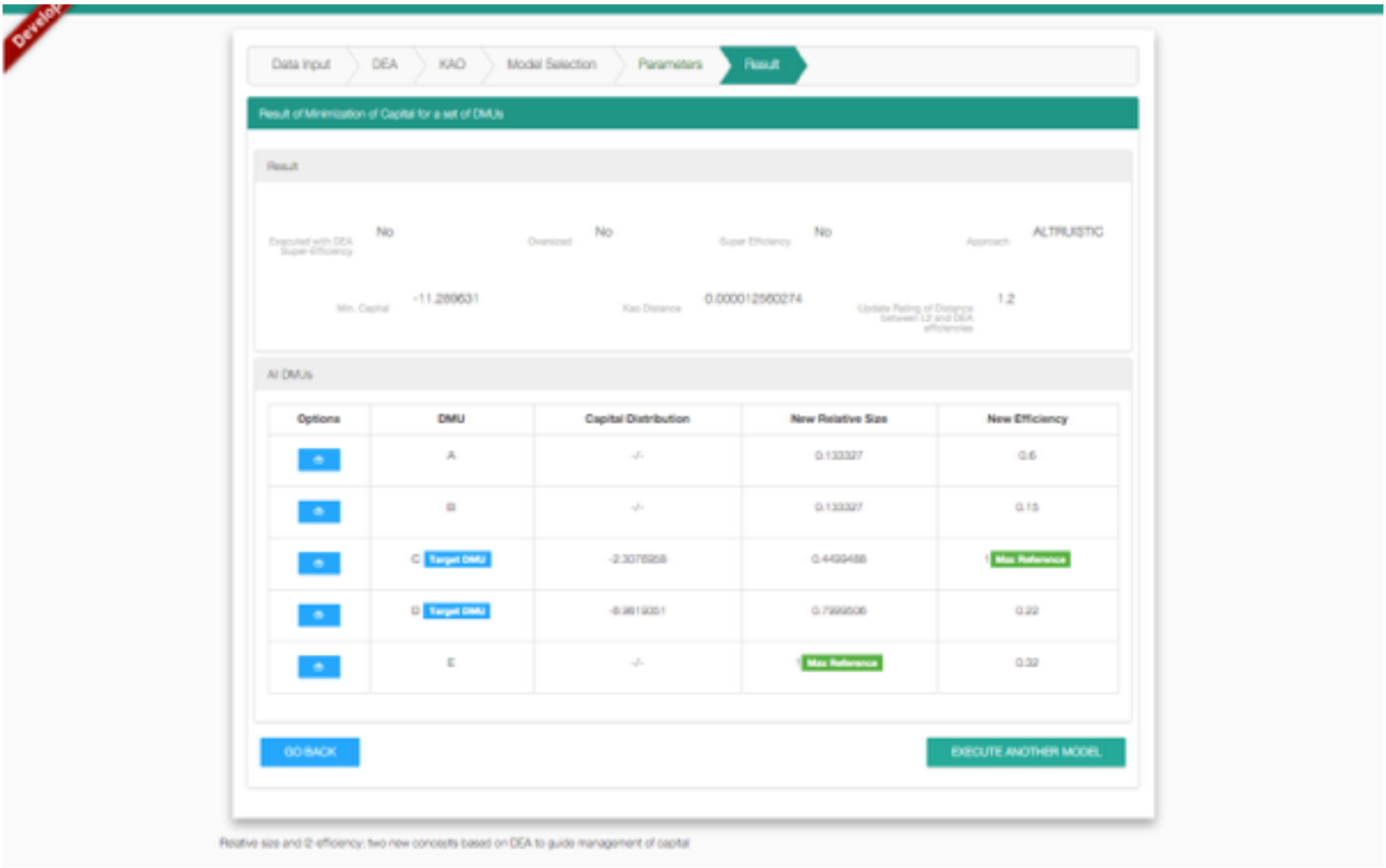
Result of the Maximization of Relative Size for a single target DMU



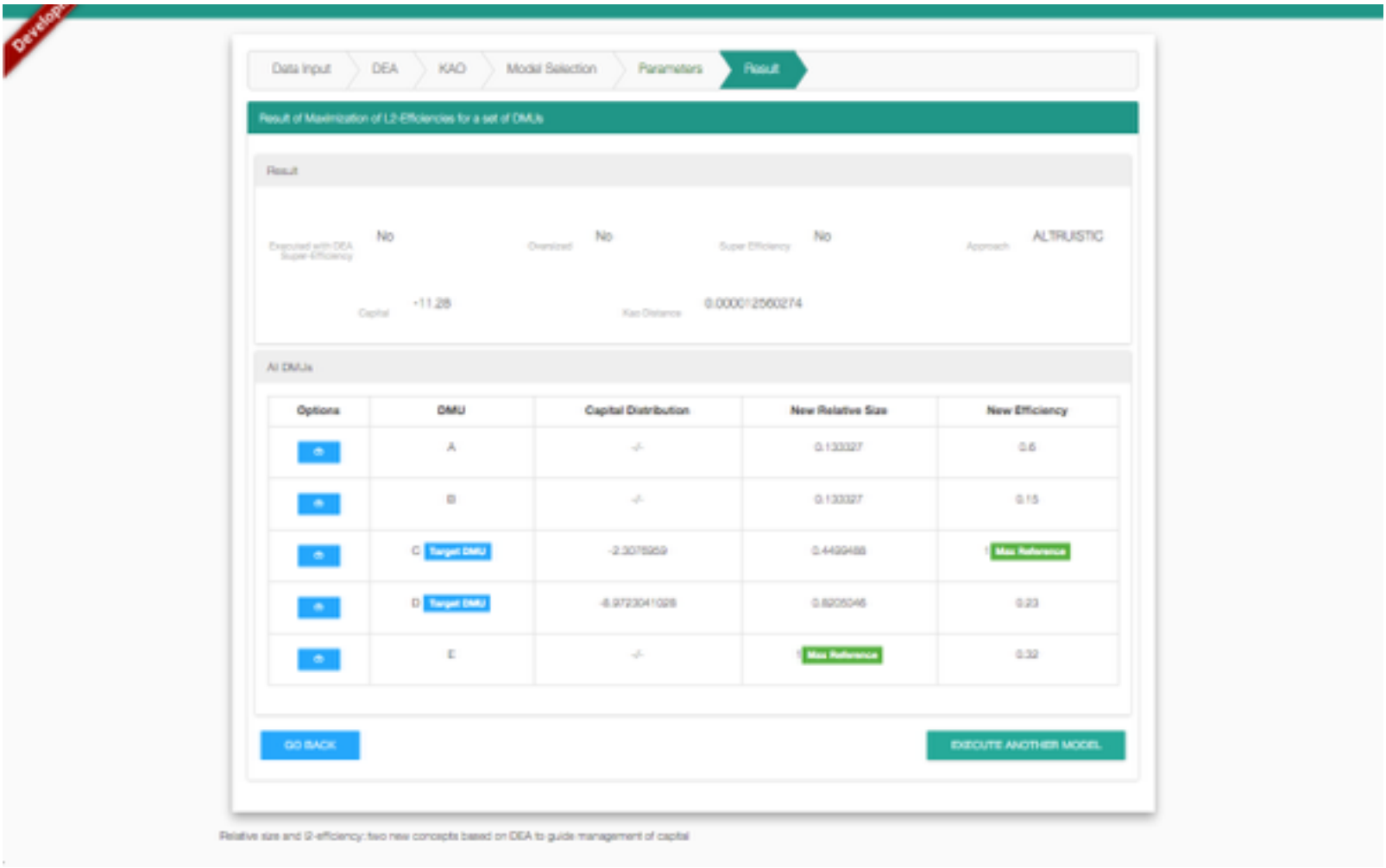
Result of the Maximization of Relative Efficiency for a single target DMU



Result of the Minimization of Capital for a target subset of DMUs



Result of the Maximization of L2-Efficiencies for a target subset of DMUs



4. APPENDIX

4.1 CSV Format Specification

This section explains the CSV file specification for each available model used to import data at the first step of the application.

The CSV file format is the same for all models, what changes are the expected parameters. The following is the general format:

The first line of the file must have 3 numbers separated by comma. The first number is the model code, which can go from 1 to 5. The second number is the number of inputs that the data contains and the third is the number of outputs.

The second line of the file must have 2 numbers separated by comma. These numbers are specific for each model, it can be the available capital, the size or efficiency coefficient or the update factor for distance between the DEA and KAO's efficiencies.

The third line of the file must start with the name DMU followed by the name of each input separated by comma and the name of each output separated by comma.

From the fourth line until the end of the file, it's expected that the first element is the DMU name, followed by a boolean value (true or false) indicating if that DMU is a target or not, followed by the size coefficient for that specific DMU. The following three numbers are, for each input, the value, cost and lower bound, respectively. The following two numbers are, for each output, the value and lower bound, respectively.

The following sections give the model's code, specific parameters and an example of a CSV file.

- **Minimization of Capital for a single target DMU**
  Model's Code: 3
  Expected Parameters: Size and Efficiency Coefficients

  Example:

```
3,2,1
2,0.9
DMU,x1,x2,y1
A,false,,2,2,,5,1,,2,
B,false,,2,4,,2,5,,1,
C,false,,3,2,,4,1,,5,
D,true,,4,4,3,6,3,4,3,2
E,false,,5,3,,5,5,,4,
```

- **Maximization of Relative Size for a single target DMU**
  Model's Code: 2
  Expected Parameters: Capital and Efficiency Coefficient

  Example:

```
2,2,1
2.12,0.9
DMU,x1,x2,y1
A,false,,2,2,,5,1,,2,
```

```
B,false,,2,4,,2,5,,1,
C,false,,3,2,,4,1,,5,
D,true,,4,4,3,6,3,4,3,2
E,false,,5,3,,5,5,,4,
```

- **Maximization of L2-Efficiency for a single target DMU**
  Model's Code: 1
  Expected Parameters: Capital and Efficiency Coefficient

  Example:

```
1,2,1
2.12,2
DMU,x1,x2,y1
A,false,,2,2,,5,1,,2,
B,false,,2,4,,2,5,,1,
C,false,,3,2,,4,1,,5,
D,true,,4,4,3,6,3,4,3,2
E,false,,5,3,,5,5,,4,
```

- **Minimization of Capital for a target subset of DMUs**
  Model's Code: 4
  Expected Parameters: Coefficient of distance between efficiencies

  Example:

```
4,2,1
1.2
DMU,x1,x2,y1
A,false,,2,2,,5,1,,2,
B,false,,2,4,,2,5,,1,
C,true,0.9,3,2,1,4,1,2,5,1
D,true,1,4,4,2,6,3,3,3,2
E,false,,5,3,,5,5,,4,
```

- **Maximization of L2-Efficiencies for a target subset of DMUs**
  Model's Code: 5
  Expected Parameters: Capital

  Example:

```
5,2,1
-11.28
DMU,x1,x2,y1
A,false,,2,2,,5,1,,2,
B,false,,2,4,,2,5,,1,
C,true,0.9,3,2,1,4,1,2,5,1
```

```
D,true,1,4,4,2,6,3,3,3,2
E,false,,5,3,,5,5,,4,
```