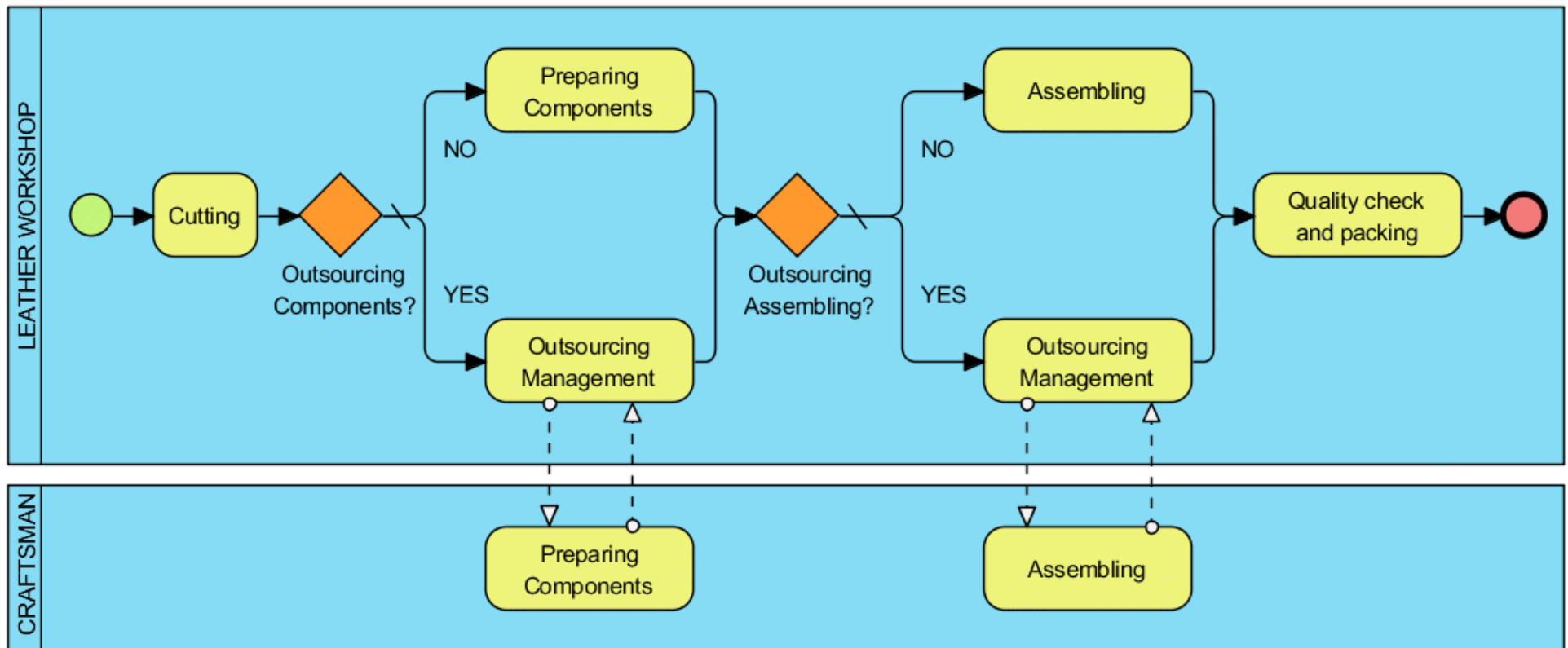


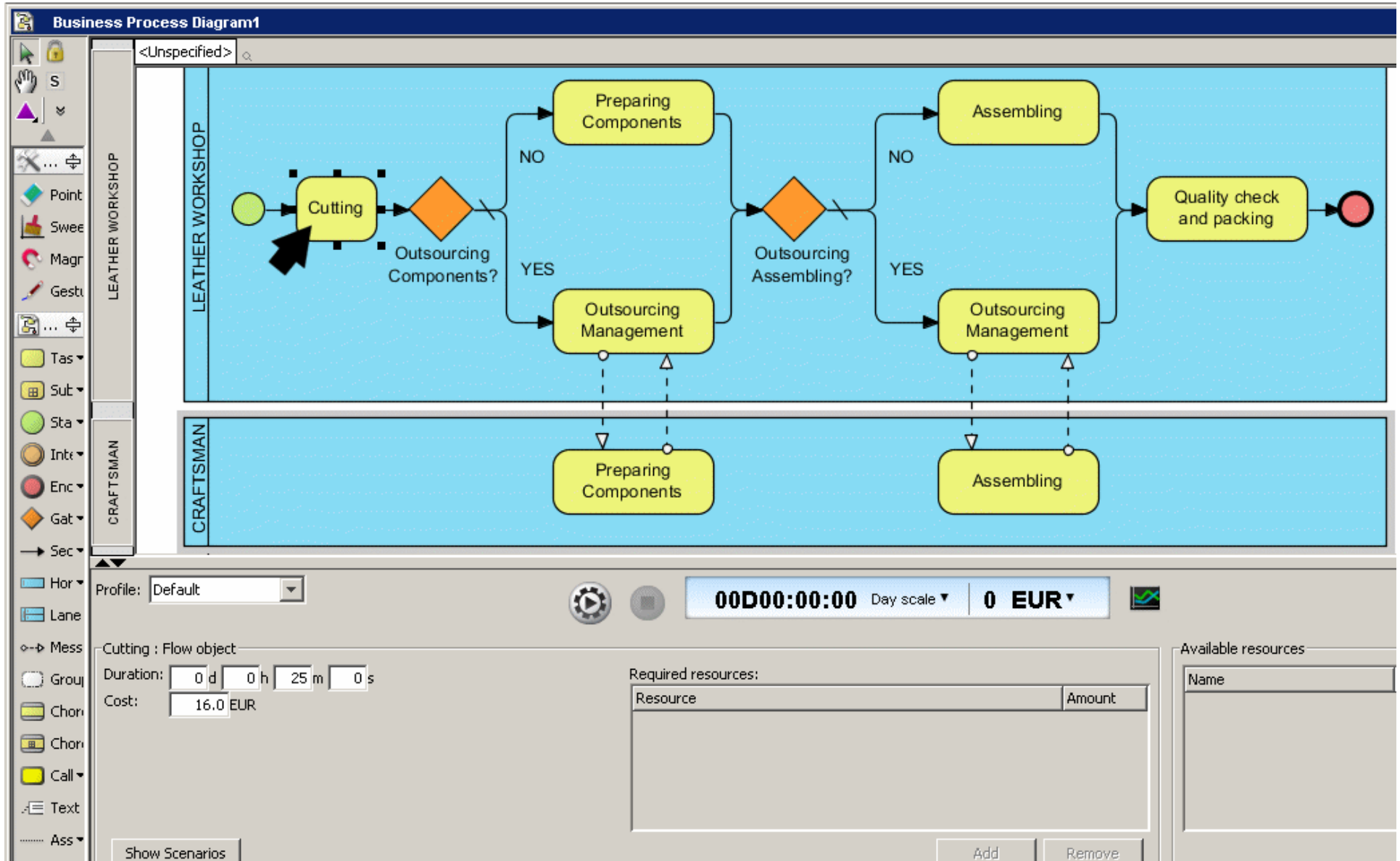
## The process of bag manufacturing

- The figure outlines the macro processes of bag manufacturing in a workshop. First, *cutting* and *preparing* components, where semi-finished products originate; then, *assembling* and *checking* against quality. If products are good, they are *packed* and shipped out. Otherwise corrective actions are triggered to handle error (not modeled).



- In the two exclusive gateways, the *make-or-buy* business decision is made, by comparing the costs and benefits of carrying out internal or external manufacturing of product components, via outsourcing to a third party specialist.

# 1. Select each task, and insert duration and cost per execution.



## 2. Data concerning all the activities of the model.

Activity	Average Duration	Average Cost (EUR)
Cutting	25	16
Preparing Components (internal)	28	31
Preparing Components (external)	24	48
Assembling (internal)	93	67
Assembling (external)	68	93
Quality check and packing	42	26
Outsourcing Management *	5	2

\* Interfacing with the third party

## 3. Define number of available instances (pools)<sup>1</sup>, time scale<sup>2</sup> and currency<sup>3</sup>.

The screenshot displays a BPMN simulation interface. At the top, a light blue pool labeled 'CRAFTSMAN' contains a yellow rounded rectangle activity labeled 'Preparing Components'. A red '1' is placed next to the pool name. Below the pool, a control bar shows 'Profile: Default', a play button, a stop button, a timer set to '00D00:00:00' with a 'Day scale' dropdown, and a currency set to '0 EUR'. A red '2' points to the timer, and a red '3' points to the currency. Below the control bar, a text field shows 'CRAFTSMAN : Pool / Lane' and 'Instance: 1', which is circled in red.

4. Create a scenario: left-click on the diagram background and press *add*;
5. Insert the name (Internal production) and the number of cases;
6. Create the path of the scenario.

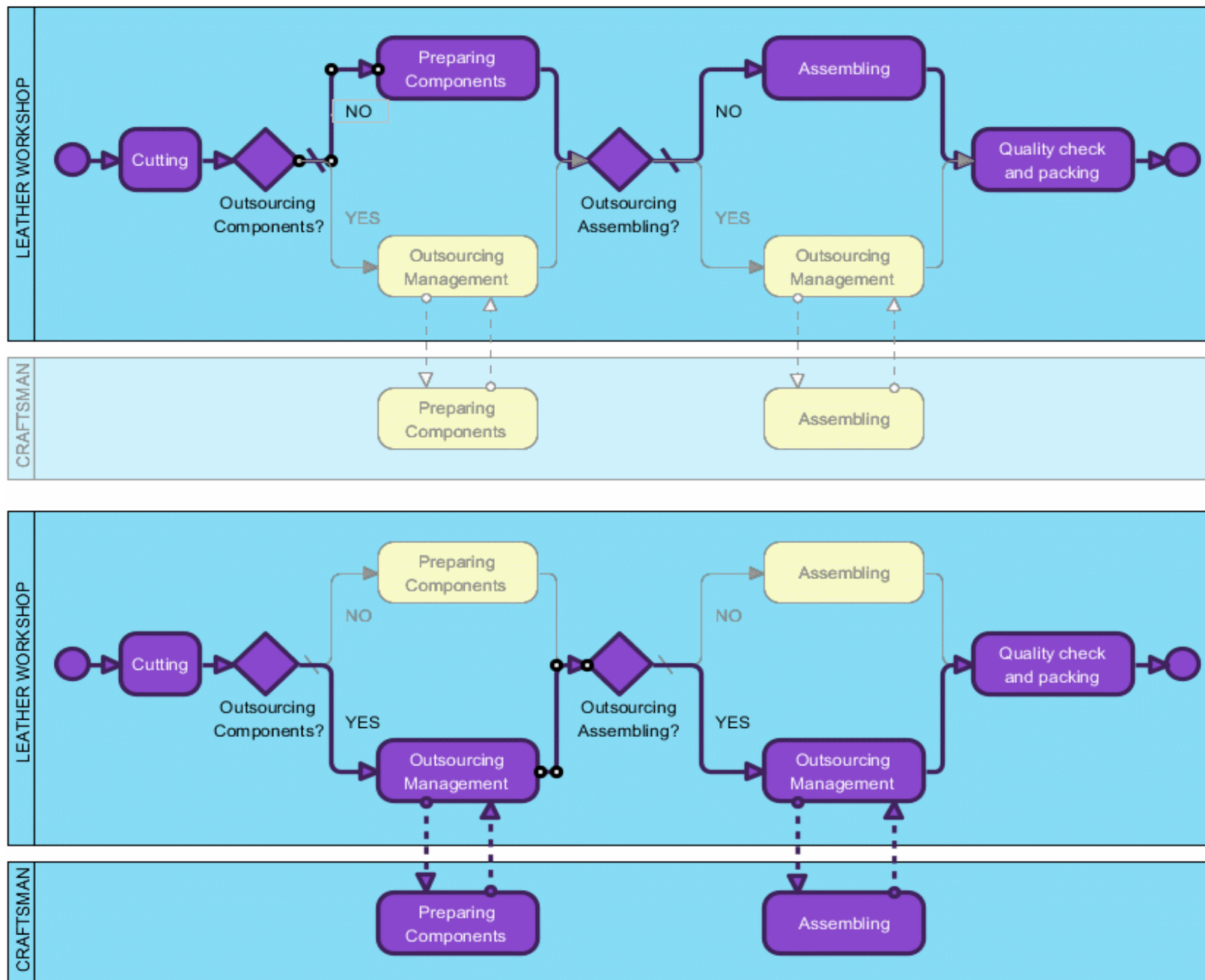
The screenshot displays a BPMN diagram for a leather workshop process. The process starts with a start node leading to a 'Cutting' task, followed by an 'Outsourcing Components?' decision diamond. The 'NO' path leads to 'Preparing Components' (purple task), while the 'YES' path leads to 'Outsourcing Management' (yellow task). From 'Preparing Components', the flow goes to another 'Outsourcing Assembling?' decision diamond. The 'NO' path leads to 'Assembling' (yellow task), and the 'YES' path leads to another 'Outsourcing Management' (yellow task). Both 'Assembling' and 'Outsourcing Management' tasks lead to a final 'Quality check and packing' task, which ends at a final node. Below the main diagram, there are two smaller diagrams for 'Preparing Components' and 'Assembling', each connected to its respective task in the main process by dashed lines.

The interface includes a sidebar with 'LEATHER WORKSHOP' and 'CRAFTSMAN' labels. At the bottom, there is a control panel with a 'Profile: Default' dropdown, a play button, a stop button, a timer showing '00D00:00:00' on 'Day scale', and a cost indicator '0 EUR'. Below this is the 'Scenarios' section with a table and a 'Path' configuration window.

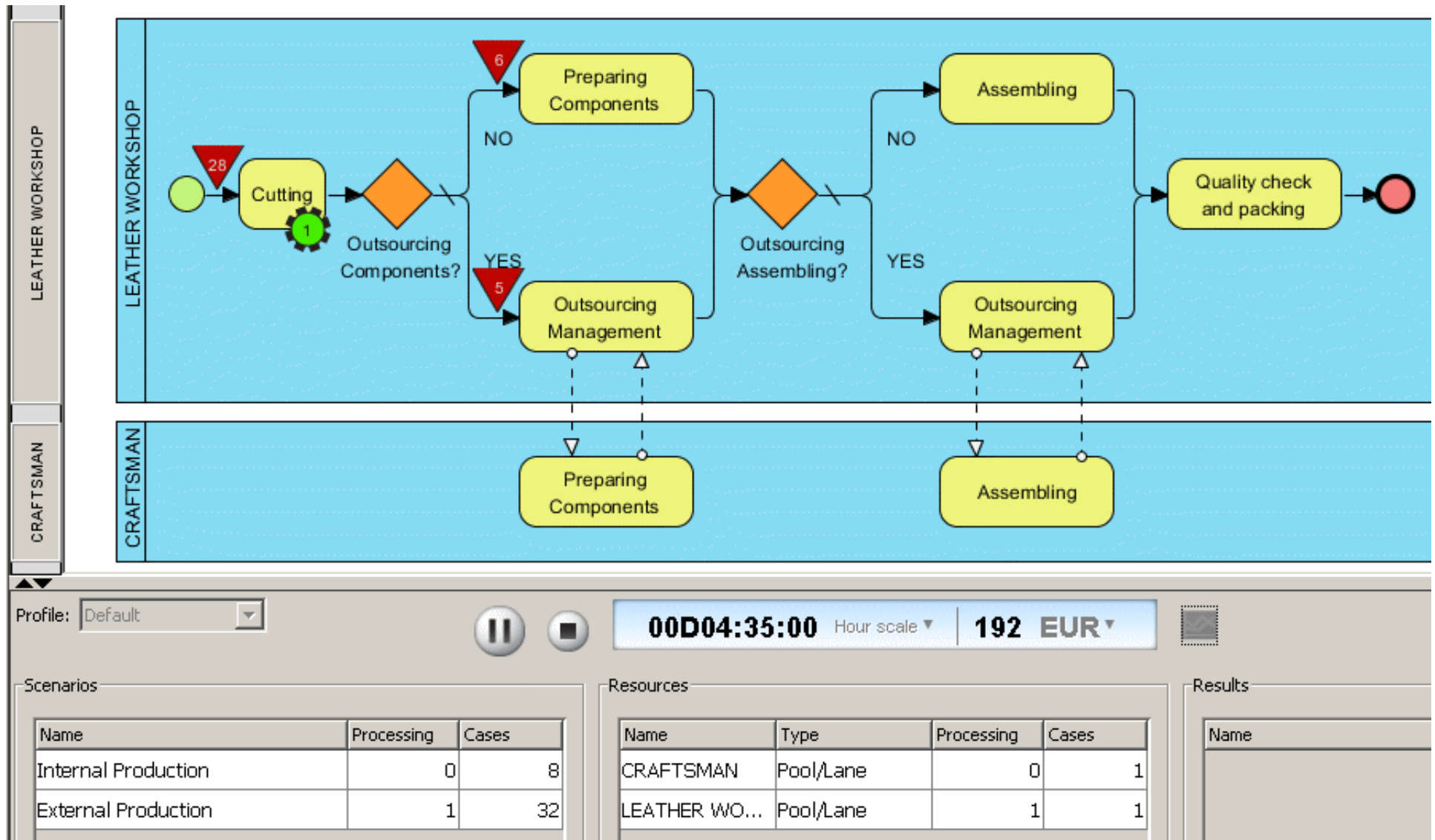
Name	Percent	Cases
Internal Production	20%	8
External Production	80%	32
Total:		40


The 'Path' configuration window shows a tree structure for the 'OutsourcingComponents?' decision diamond. The 'NO' path is selected, leading to the 'Preparing Components' task. The 'YES' path is also visible, leading to the 'OutsourcingAssembling?' decision diamond. The '<Unspecified>' option is at the bottom.

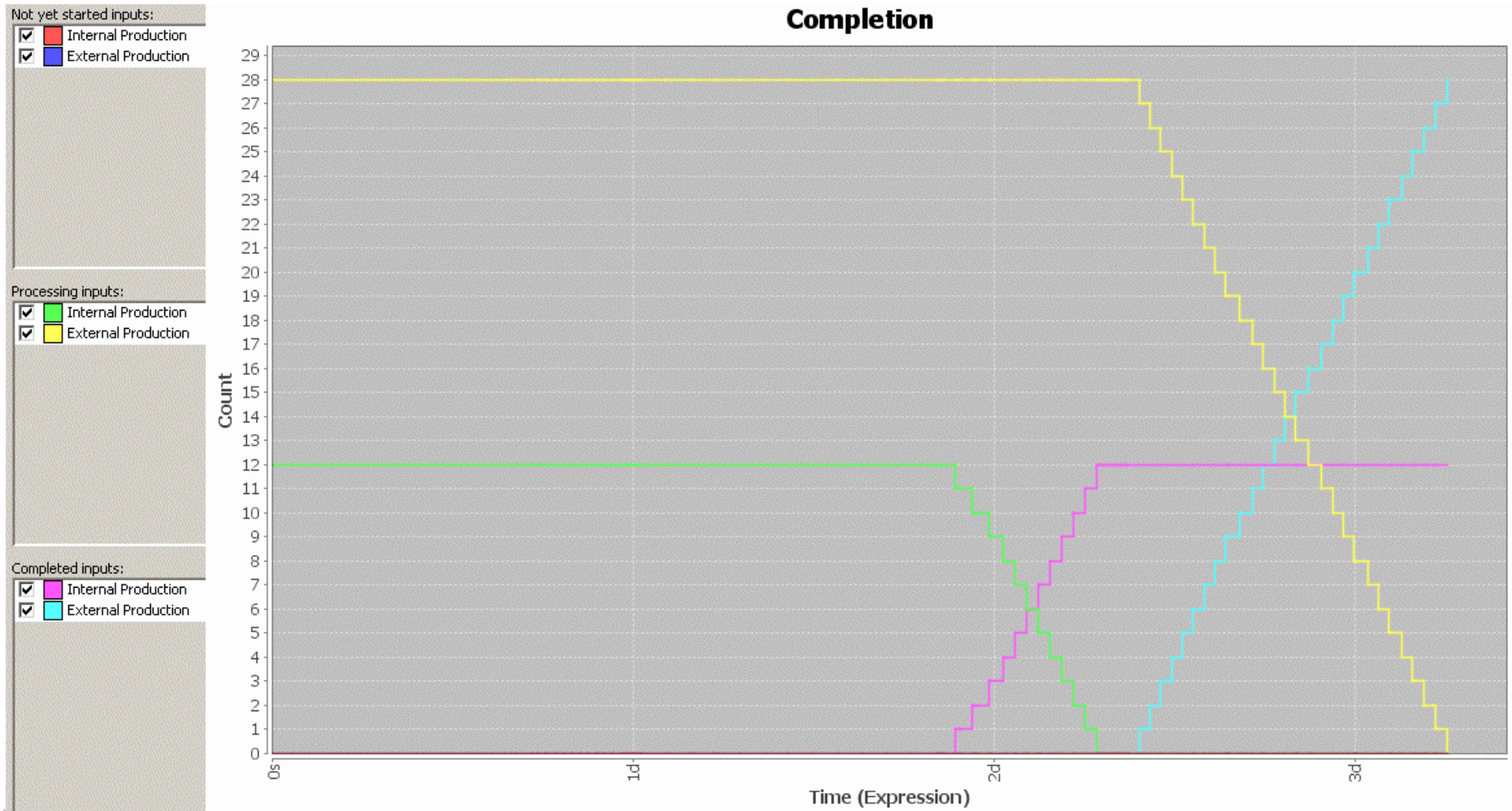
## 7. Two scenarios: internal production and (partially) external production.



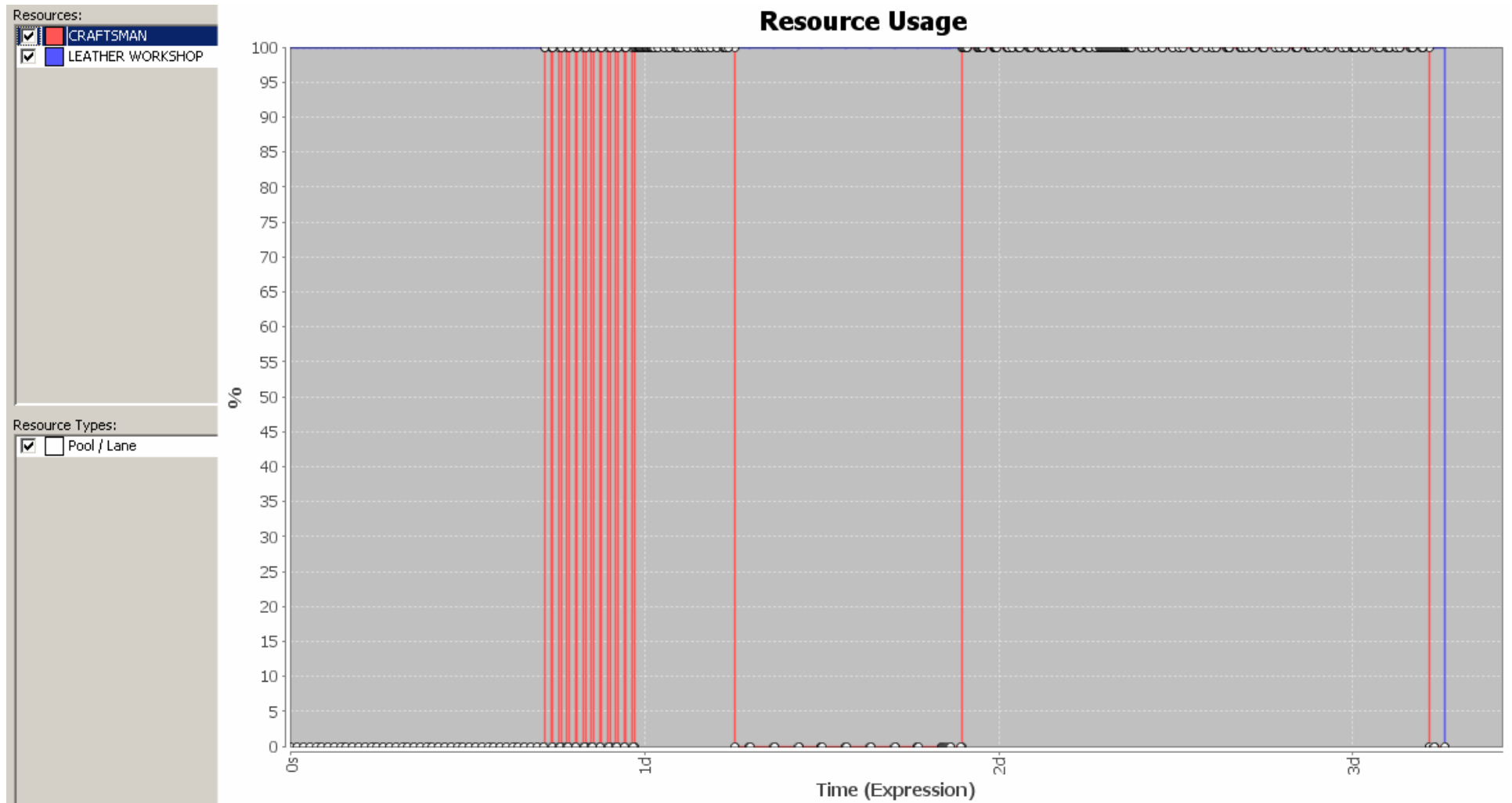
8. Click the *Play/Stop/Pause* buttons to simulate;
9. Look at the red inverted triangles (tokens queues) and at the the green gears (processing tokens);
10. Look at the final duration and cost;



11. The two scenarios are executed considering the related number of tokens, e.g., 30% and 70%;
12. Click on the logo  for plotting important duration and cost parameters;
13. **Completion** against time: to be processed, processing, and processed tokens:



## 14. Resource usage against time:

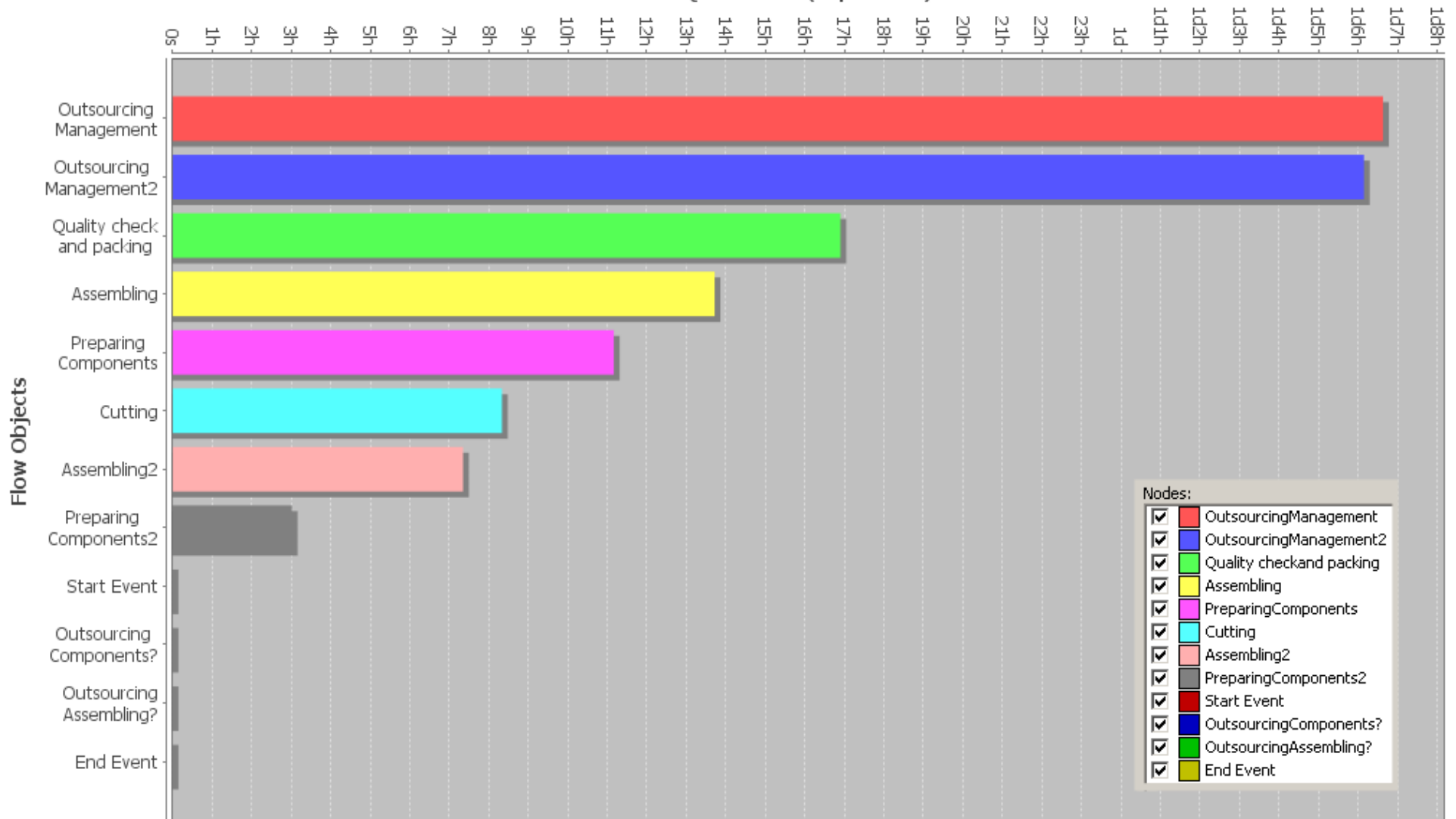




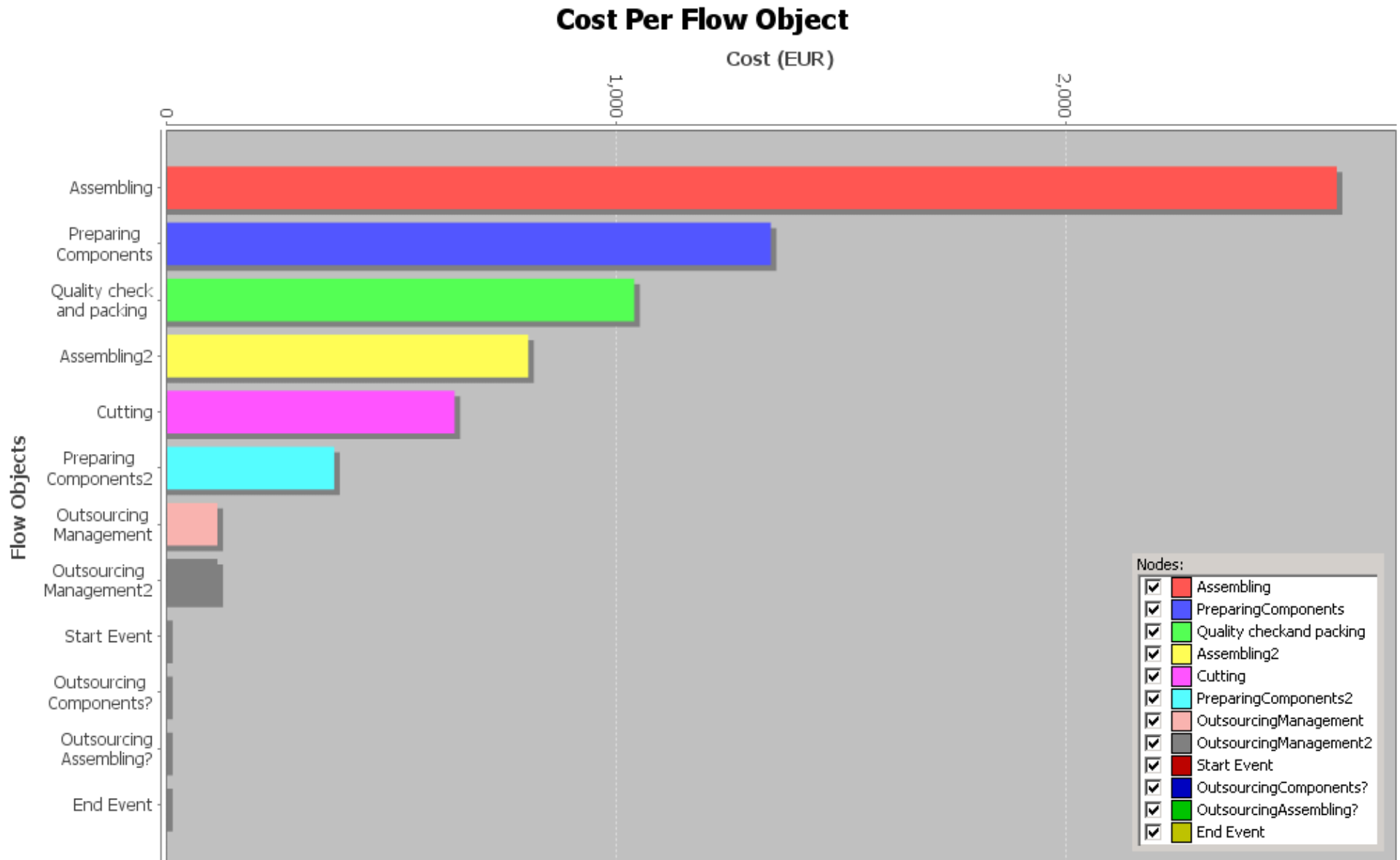
# 15. Queue time

## Queue Time

Queue Time (Expression)



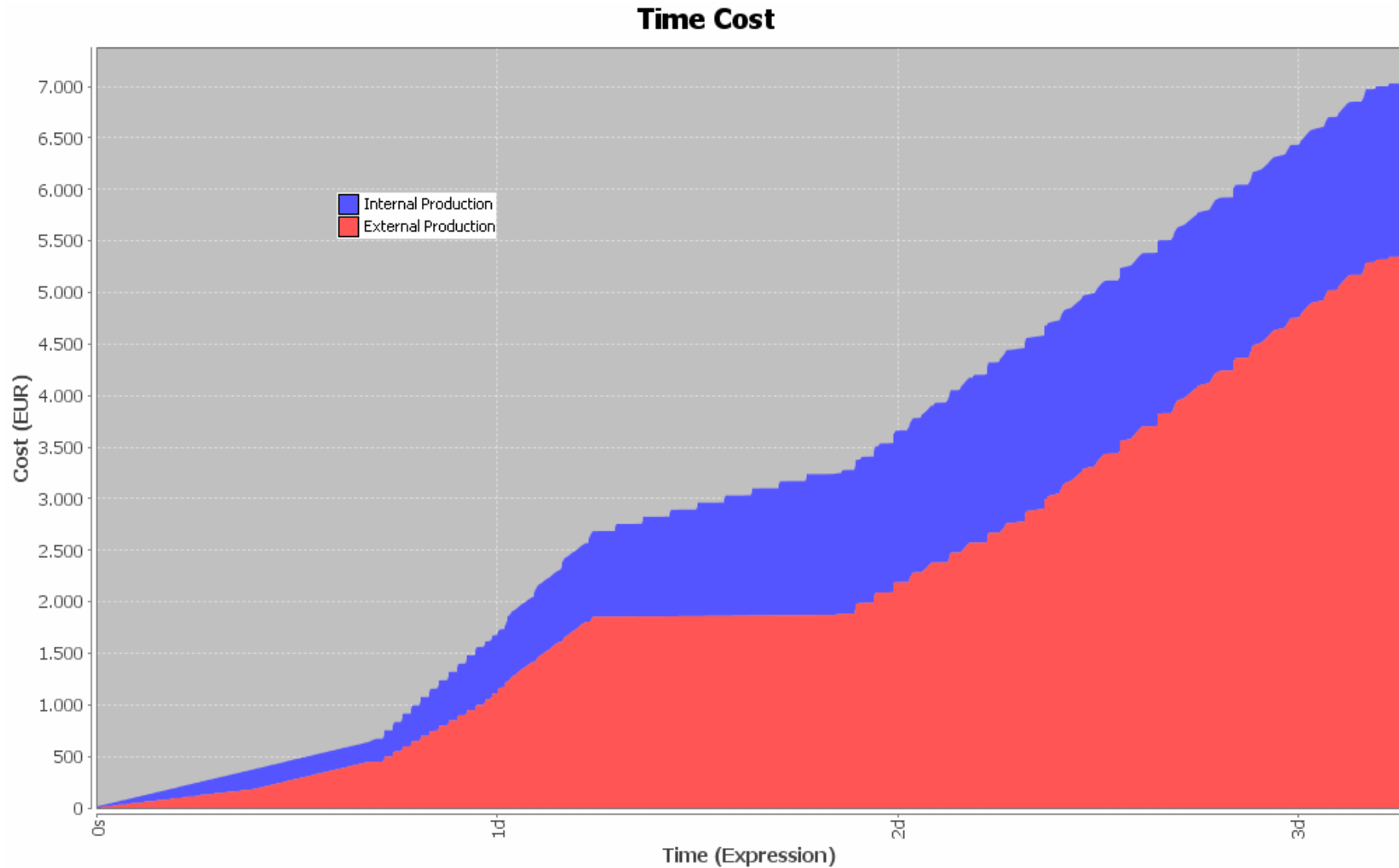
## 16. Cost per flow object (cost per use)



## 17. Other costs

	Input Name	Number Of Instance	Cost Per Instance (EUR)	Total (EUR)
1	External Production	28	191	5,348
2	Internal Production	12	140	1,680

## 18. Time Cost



## 19. Exercise

Suppose to aim at producing 40 bags, by combining internal and external production scenarios, with a single bag workshop and a single third party specialist.

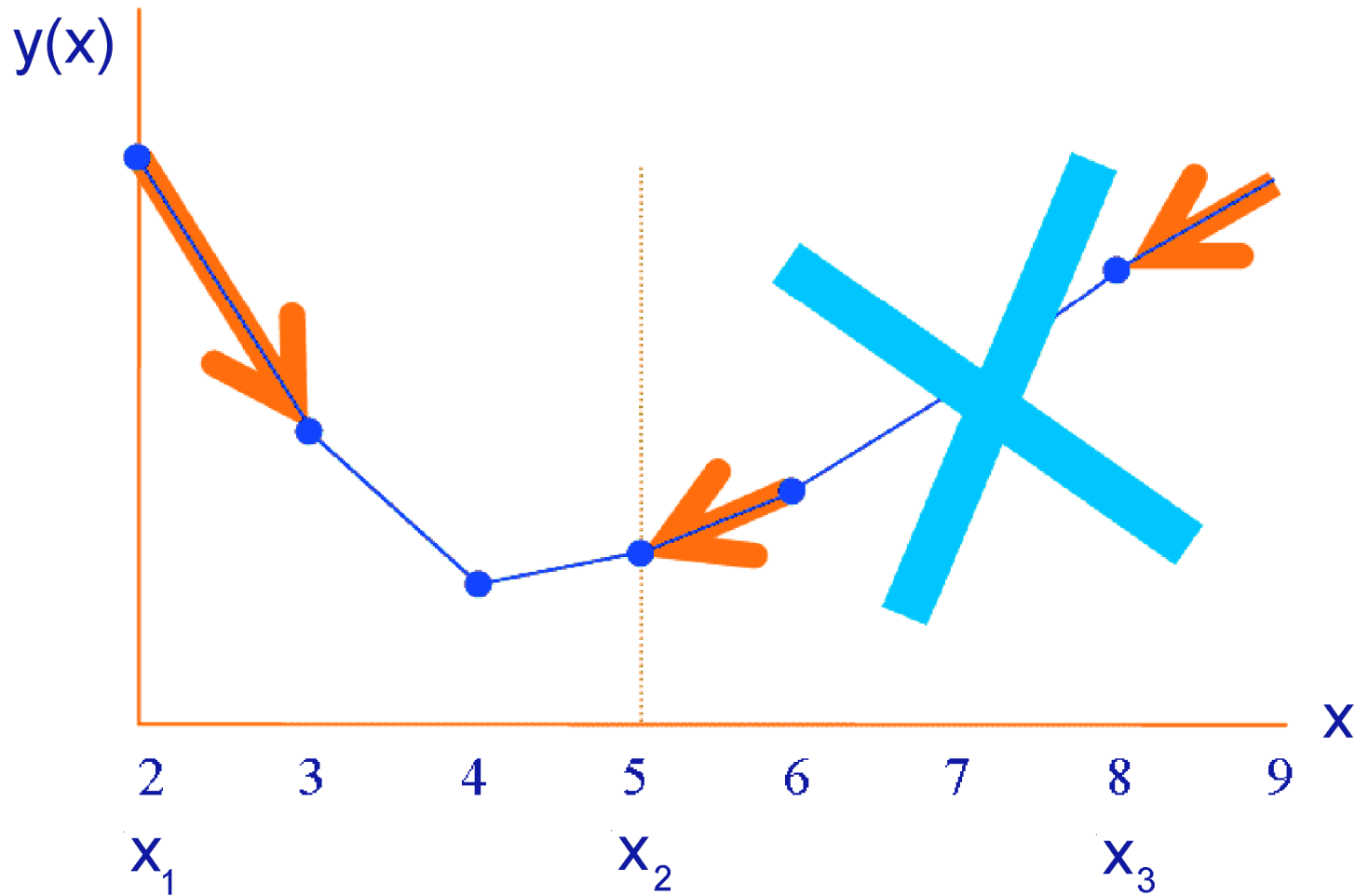
Simulate:

- a) a scenario of totally internal production; analyze results/plots;
- b) a scenario of partially external production; analyze results/plots;
- c) find a combination of the two scenarios so as to carry out the process in both less time and cost, with respect to (a) and (b).

## Solution

Let  $x_1$  be the percentage of bags that are produced internally, and  $y(x)$  the total duration of the production process of 40 bags.

- a)  $x_1=100\% \rightarrow 5g\ 5h\ 20'\ 5600\text{€}$ , with maximum queues on the last phases, due to the sequential character of the workflow;
- b)  $x_1=0\% \rightarrow 3g\ 6h\ 52'\ 7640\text{€}$ , with maximum queues on the assembling stage, which is a process with larger duration, with respect to the other processes;
- c) by carrying out internally some units, the assembling is parallelized, thus reducing queuing effects, and then saving total time and cost; e.g..  $x_1=20\% \rightarrow 3g\ 2h\ 38'\ 7232\text{€}$ ;
- d) In the context of luxury handbags production, for a given quality level that is guaranteed by the control quality process, the **total duration** of the process is the main Key Performance Indicator (KPI), rather than the total production cost;
- e) Is 20% the best solution in terms of total duration? Assuming that there is a unique minimum, it can be efficiently found by using a **binary search**;
- f) Given  $x_1$  and  $x_3$ , calculate the total duration of the process for  $x_1$ ,  $x_3$ , and for the center  $x_2=(x_1+x_3)/2$ , as well as for a value very close ( $dx$ ) to each of these points. On the basis of the **descent direction** we can establish the position of the optimum with respect to the center.



- g) e.g. if the total duration goes down on the right side of  $x_1$ , and on the left sides of  $x_2$  and  $x_3$ , then the minimum is between  $x_1$  and  $x_2$ .
- h) By carrying out **8** simulations, it can be determined that the optimum is located at  $x=12-13\%$ , i.e., 5 bags produced internally and 35 externally, with a total duration of 3d 16m, and a total cost of 7385€.

