

# D

## QIX best first search test results

Here we present our runtime statistics when running our implementation of the algorithm in QIX with best first search heuristic to solve random instances of the warehouse problem with different attributes. Every attribute is either of the value 'Low' or 'High'. The first table displays what high and low for the different attributes represents.

| Attribute \ Value | Low  | High   |
|-------------------|--|--|
| Demands           | Demands on $\frac{1}{4}$ of all products   | Demands on all products  |
| Sparsity          | No warehouses are empty                    | $\frac{1}{2}$ of all warehouses are empty                                    |
| Products          | Warehouses have at least 0 of each product | Warehouses have at least $\frac{1}{5}$ of the maximum demand of each product |

Furthermore a column having the value '\*' means that it did not terminate within a reasonable time frame (>12 hours). A value of '\*\*' means that we did not bother to run the instance at all since the problem is considered harder than a previously unfinished problem.

In our implementation we put the values from the hypercube built by QIX

#### *Appendix D. QIX best first search test results*

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in hashes for easy access, that is we spend some time building the model. This time is represented by Setup time in the tables below, while Algorithm Time is the time spent on the actual algorithm.

*Appendix D. QIX best first search test results*

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| Size  | Type    |          |          | Branches | Setup<br>Time(s) | Algorithm<br>Time (s) | Optimal<br>Value |
|-------|---------|----------|----------|----------|------------------|-----------------------|------------------|
|       | Demands | Sparsity | Products |          |                  |                       |                  |
| 10x10 | Low     | Low      | High     | 2        | 0                | 0                     | 4                |
|       | Low     | Low      | Low      | 3        | 0                | 0                     | 4                |
|       | Low     | High     | High     | 1        | 0                | 0                     | 2                |
|       | Low     | High     | Low      | 1        | 0                | 0                     | 2                |
|       | High    | Low      | High     | 6        | 0                | 0                     | 4                |
|       | High    | Low      | Low      | 10       | 0                | 0                     | 12               |
|       | High    | High     | High     | 79       | 0                | 0                     | 33               |
|       | High    | High     | Low      | 48       | 0                | 0                     | 20               |

| Size   | Type    |          |          | Branches | Setup<br>Time(s) | Algorithm<br>Time (s) | Optimal<br>Value |
|--------|---------|----------|----------|----------|------------------|-----------------------|------------------|
|        | Demands | Sparsity | Products |          |                  |                       |                  |
| 10x100 | Low     | Low      | High     | 10       | 0                | 0                     | 14               |
|        | Low     | Low      | Low      | 12       | 0                | 0                     | 12               |
|        | Low     | High     | High     | 135      | 0                | 0                     | 42               |
|        | Low     | High     | Low      | 677      | 0                | 0                     | 82               |
|        | High    | Low      | High     | 4        | 0                | 0                     | 4                |
|        | High    | Low      | Low      | 45       | 0                | 0                     | 19               |
|        | High    | High     | High     | 430      | 0                | 0                     | 65               |
|        | High    | High     | Low      | 708      | 0                | 0                     | 68               |

*Appendix D. QIX best first search test results*

| Size   | Type    |          |          | Branches | Setup<br>Time(s) | Algorithm<br>Time (s) | Optimal<br>Value |
|--------|---------|----------|----------|----------|------------------|-----------------------|------------------|
|        | Demands | Sparsity | Products |          |                  |                       |                  |
| 20x100 | Low     | Low      | High     | 14       | 0                | 0                     | 6                |
|        | Low     | Low      | Low      | 36       | 0                | 0                     | 12               |
|        | Low     | High     | High     | 142      | 0                | 0                     | 15               |
|        | Low     | High     | Low      | 673      | 0                | 0                     | 24               |
|        | High    | Low      | High     | 19       | 0                | 0                     | 6                |
|        | High    | Low      | Low      | 76       | 0                | 0                     | 15               |
|        | High    | High     | High     | 554      | 0                | 0                     | 18               |
|        | High    | High     | Low      | 12726    | 0                | 6                     | 40               |

| Size   | Type    |          |          | Branches | Setup<br>Time(s) | Algorithm<br>Time (s) | Optimal<br>Value |
|--------|---------|----------|----------|----------|------------------|-----------------------|------------------|
|        | Demands | Sparsity | Products |          |                  |                       |                  |
| 30x100 | Low     | Low      | High     | 8        | 0                | 0                     | 6                |
|        | Low     | Low      | Low      | 28       | 0                | 0                     | 7                |
|        | Low     | High     | High     | 319      | 0                | 0                     | 10               |
|        | Low     | High     | Low      | 545      | 0                | 0                     | 13               |
|        | High    | Low      | High     | 26       | 0                | 0                     | 8                |
|        | High    | Low      | Low      | 47       | 0                | 0                     | 4                |
|        | High    | High     | High     | 7180     | 0                | 3                     | 35               |
|        | High    | High     | Low      | 18772    | 0                | 8                     | 27               |

*Appendix D. QIX best first search test results*

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| Size   | Type    |          |          | Branches | Setup<br>Time(s) | Algorithm<br>Time (s) | Optimal<br>Value |
|--------|---------|----------|----------|----------|------------------|-----------------------|------------------|
|        | Demands | Sparsity | Products |          |                  |                       |                  |
| 40x100 | Low     | Low      | High     | 18       | 0                | 0                     | 7                |
|        | Low     | Low      | Low      | 69       | 0                | 0                     | 8                |
|        | Low     | High     | High     | 2282     | 0                | 0                     | 21               |
|        | Low     | High     | Low      | 1518     | 0                | 1                     | 14               |
|        | High    | Low      | High     | 17       | 0                | 0                     | 5                |
|        | High    | Low      | Low      | 29       | 0                | 0                     | 5                |
|        | High    | High     | High     | 3977     | 0                | 2                     | 16               |
|        | High    | High     | Low      | 12321    | 0                | 5                     | 22               |

| Size  | Type    |          |          | Branches | Setup<br>Time(s) | Algorithm<br>Time (s) | Optimal<br>Value |
|-------|---------|----------|----------|----------|------------------|-----------------------|------------------|
|       | Demands | Sparsity | Products |          |                  |                       |                  |
| 50x50 | Low     | Low      | High     | 7        | 0                | 0                     | 3                |
|       | Low     | Low      | Low      | 15       | 0                | 0                     | 4                |
|       | Low     | High     | High     | 112      | 0                | 0                     | 8                |
|       | Low     | High     | Low      | 991      | 0                | 0                     | 13               |
|       | High    | Low      | High     | 12       | 0                | 0                     | 4                |
|       | High    | Low      | Low      | 20       | 0                | 0                     | 3                |
|       | High    | High     | High     | 2610     | 0                | 0                     | 12               |
|       | High    | High     | Low      | 15057    | 0                | 4                     | 20               |

*Appendix D. QIX best first search test results*

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| Size   | Type    |          |          | Branches | Setup<br>Time(s) | Algorithm<br>Time (s) | Optimal<br>Value |
|--------|---------|----------|----------|----------|------------------|-----------------------|------------------|
|        | Demands | Sparsity | Products |          |                  |                       |                  |
| 50x100 | Low     | Low      | High     | 14       | 0                | 0                     | 2                |
|        | Low     | Low      | Low      | 38       | 0                | 0                     | 5                |
|        | Low     | High     | High     | 159      | 0                | 0                     | 10               |
|        | Low     | High     | Low      | 3514     | 0                | 1                     | 17               |
|        | High    | Low      | High     | 21       | 0                | 0                     | 6                |
|        | High    | Low      | Low      | 102      | 0                | 0                     | 7                |
|        | High    | High     | High     | 372      | 0                | 0                     | 7                |
|        | High    | High     | Low      | 75331    | 0                | 31                    | 29               |

| Size   | Type    |          |          | Branches | Setup<br>Time(s) | Algorithm<br>Time (s) | Optimal<br>Value |
|--------|---------|----------|----------|----------|------------------|-----------------------|------------------|
|        | Demands | Sparsity | Products |          |                  |                       |                  |
| 100x10 | Low     | Low      | High     | 8        | 0                | 0                     | 2                |
|        | Low     | Low      | Low      | 1        | 0                | 0                     | 1                |
|        | Low     | High     | High     | 1        | 0                | 0                     | 1                |
|        | Low     | High     | Low      | 8        | 0                | 0                     | 2                |
|        | High    | Low      | High     | 10       | 0                | 0                     | 2                |
|        | High    | Low      | Low      | 11       | 0                | 0                     | 2                |
|        | High    | High     | High     | 110      | 0                | 0                     | 5                |
|        | High    | High     | Low      | 144      | 0                | 0                     | 5                |

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| Size   | Type    |          |          | Branches | Setup<br>Time(s) | Algorithm<br>Time (s) | Optimal<br>Value |
|--------|---------|----------|----------|----------|------------------|-----------------------|------------------|
|        | Demands | Sparsity | Products |          |                  |                       |                  |
| 100x20 | Low     | Low      | High     | 8        | 0                | 0                     | 2                |
|        | Low     | Low      | Low      | 12       | 0                | 0                     | 3                |
|        | Low     | High     | High     | 21       | 0                | 0                     | 2                |
|        | Low     | High     | Low      | 26       | 0                | 0                     | 3                |
|        | High    | Low      | High     | 16       | 0                | 0                     | 2                |
|        | High    | Low      | Low      | 23       | 0                | 0                     | 3                |
|        | High    | High     | High     | 481      | 0                | 0                     | 7                |
|        | High    | High     | Low      | 4065     | 0                | 1                     | 8                |

| Size   | Type    |          |          | Branches | Setup<br>Time(s) | Algorithm<br>Time (s) | Optimal<br>Value |
|--------|---------|----------|----------|----------|------------------|-----------------------|------------------|
|        | Demands | Sparsity | Products |          |                  |                       |                  |
| 100x30 | Low     | Low      | High     | 11       | 0                | 0                     | 2                |
|        | Low     | Low      | Low      | 10       | 0                | 0                     | 2                |
|        | Low     | High     | High     | 25       | 0                | 0                     | 4                |
|        | Low     | High     | Low      | 919      | 0                | 0                     | 7                |
|        | High    | Low      | High     | 18       | 0                | 0                     | 2                |
|        | High    | Low      | Low      | 66       | 0                | 0                     | 3                |
|        | High    | High     | High     | 1276     | 0                | 0                     | 7                |
|        | High    | High     | Low      | 6805     | 0                | 1                     | 7                |

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| Size   | Type    |          |          | Branches | Setup<br>Time(s) | Algorithm<br>Time (s) | Optimal<br>Value |
|--------|---------|----------|----------|----------|------------------|-----------------------|------------------|
|        | Demands | Sparsity | Products |          |                  |                       |                  |
| 100x40 | Low     | Low      | High     | 3        | 0                | 0                     | 1                |
|        | Low     | Low      | Low      | 14       | 0                | 0                     | 3                |
|        | Low     | High     | High     | 42       | 0                | 0                     | 3                |
|        | Low     | High     | Low      | 386      | 0                | 0                     | 7                |
|        | High    | Low      | High     | 12       | 0                | 0                     | 2                |
|        | High    | Low      | Low      | 148      | 0                | 0                     | 5                |
|        | High    | High     | High     | 1457     | 0                | 0                     | 8                |
|        | High    | High     | Low      | 13541    | 0                | 3                     | 9                |

| Size   | Type    |          |          | Branches | Setup<br>Time(s) | Algorithm<br>Time (s) | Optimal<br>Value |
|--------|---------|----------|----------|----------|------------------|-----------------------|------------------|
|        | Demands | Sparsity | Products |          |                  |                       |                  |
| 100x50 | Low     | Low      | High     | 15       | 0                | 0                     | 3                |
|        | Low     | Low      | Low      | 11       | 0                | 0                     | 2                |
|        | Low     | High     | High     | 298      | 0                | 0                     | 5                |
|        | Low     | High     | Low      | 102      | 0                | 0                     | 4                |
|        | High    | Low      | High     | 9        | 0                | 0                     | 3                |
|        | High    | Low      | Low      | 25       | 0                | 0                     | 3                |
|        | High    | High     | High     | 1568     | 0                | 0                     | 6                |
|        | High    | High     | Low      | 3467     | 0                | 1                     | 7                |



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| Size    | Type    |          |          | Branches | Setup<br>Time(s) | Algorithm<br>Time (s) | Optimal<br>Value |
|---------|---------|----------|----------|----------|------------------|-----------------------|------------------|
|         | Demands | Sparsity | Products |          |                  |                       |                  |
| 100x100 | Low     | Low      | High     | 16       | 0                | 0                     | 2                |
|         | Low     | Low      | Low      | 47       | 0                | 0                     | 4                |
|         | Low     | High     | High     | 774      | 0                | 0                     | 5                |
|         | Low     | High     | Low      | 991      | 0                | 0                     | 8                |
|         | High    | Low      | High     | 29       | 0                | 0                     | 3                |
|         | High    | Low      | Low      | 265      | 0                | 0                     | 6                |
|         | High    | High     | High     | 6907     | 0                | 3                     | 10               |
|         | High    | High     | Low      | 208739   | 0                | 93                    | 15               |

| Size    | Type    |          |          | Branches | Setup<br>Time(s) | Algorithm<br>Time (s) | Optimal<br>Value |
|---------|---------|----------|----------|----------|------------------|-----------------------|------------------|
|         | Demands | Sparsity | Products |          |                  |                       |                  |
| 200x200 | Low     | Low      | High     | 20       | 0                | 0                     | 2                |
|         | Low     | Low      | Low      | 99       | 0                | 0                     | 3                |
|         | Low     | High     | High     | 4293     | 0                | 1                     | 6                |
|         | Low     | High     | Low      | 169891   | 0                | 51                    | 10               |
|         | High    | Low      | High     | 56       | 0                | 0                     | 3                |
|         | High    | Low      | Low      | 413      | 0                | 1                     | 4                |
|         | High    | High     | High     | 54999    | 0                | 34                    | 9                |
|         | High    | High     | Low      | 1397726  | 0                | 1081                  | 11               |

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| Size    | Type    |          |          | Branches | Setup<br>Time(s) | Algorithm<br>Time (s) | Optimal<br>Value |
|---------|---------|----------|----------|----------|------------------|-----------------------|------------------|
|         | Demands | Sparsity | Products |          |                  |                       |                  |
| 500x500 | Low     | Low      | High     | 155      | 0                | 0                     | 2                |
|         | Low     | Low      | Low      | 380      | 1                | 0                     | 3                |
|         | Low     | High     | High     | 228993   | 1                | 103                   | 6                |
|         | Low     | High     | Low      | 4180226  | 1                | 2226                  | 9                |
|         | High    | Low      | High     | 717      | 2                | 1                     | 3                |
|         | High    | Low      | Low      | 11699    | 2                | 21                    | 4                |
|         | High    | High     | High     | 4817265  | 2                | 7721                  | 8                |
|         | High    | High     | Low      | *        | *                | *                     | -                |

| Size      | Type    |          |          | Branches | Setup<br>Time(s) | Algorithm<br>Time (s) | Optimal<br>Value |
|-----------|---------|----------|----------|----------|------------------|-----------------------|------------------|
|           | Demands | Sparsity | Products |          |                  |                       |                  |
| 1000x1000 | Low     | Low      | High     | 1110     | 2                | 1                     | 3                |
|           | Low     | Low      | Low      | 17502    | 3                | 15                    | 4                |
|           | Low     | High     | High     | 18818268 | 2                | 16410                 | 6                |
|           | Low     | High     | Low      | *        | *                | *                     | -                |
|           | High    | Low      | High     | 1209     | 9                | 3                     | 3                |
|           | High    | Low      | Low      | 53122    | 9                | 180                   | 4                |
|           | High    | High     | High     | *        | *                | *                     | -                |
|           | High    | High     | Low      | **       | **               | **                    | -                |