Here are some general comments and a suggestion for a conventional modeling as a MIP (mixed-integer program).

Model:

Parameters:

I use the same parameters as you with the following exceptions:

– set of SKUs

T – set of “time periods” or sequences. denotes an upper bound on the number of sequences in an optimal solution. A naïve upper bound would be (since we cannot improve a solution by having an empty sequence if there are some SKUs available)

C – maximal capacity of a sequence (=total number of all the conveyor lanes over all the picking locations)

Parameter returns the group of SKU

– set of groups

- set of garments

Parameter returns the garment of SKU

Variables:

– whether SKU i is assigned to sequence t () or not (). Indeed, the only thing that matters in your definitions of the objective function is, to which sequence SKUs are assigned. The exact distribution of the SKUs among the picking locations (provided the capacities of the picking locations are respected) have no impact on the objective function.

- whether group is assigned to sequence t () or not ().

- whether garment is assigned to sequence t () or not ().

Constraints:

(each SKU has to be assigned to some sequence exactly once) (C1)

(the capacity of each sequences cannot be violated) (C2)

(SKUs of max one group can be assigned to the same sequence) (C3)

(C4)

(each all SKUs of the same garment have to be picked within the same sequence, see your p.4. (C5)

(C6)

(C7)

(C8)

(C9)

Improved model (Preprocessing):

Observe that if the SKUs belong to the same garment, they have to be assigned to the same sequence anyway. I.e., all the SKUs of the same garment can be logically treated as “one SKU” with the number of items .

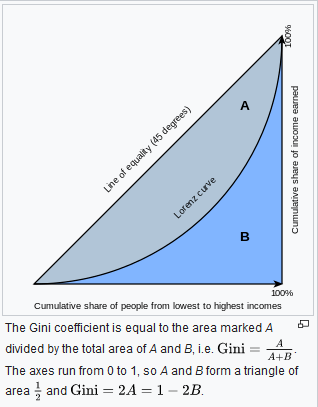
I.e., we rewrite the constraints of the previous model (C1)-(C9) by “replacing” single SKUs with their “garments” as explained above. As a result, we do not need constraints (C5, C6, C9) anymore.

Objective functions:

The objective function of the practitioners, as often, is not clearly defined. Although Mr. Klug underlined the “Gini coefficient”, I doubt that he really prefers it. At least, I would like to discuss it with him on several examples at our meeting (see a). Also, I would be not surprised that he is interested in an additional objective function or constraint (see b). Therefore, in a bachelor’s thesis, I would investigate alternative objective functions as well, which are most suitable for the solution method that you are using (the results of these objective functions can still be plotted as in your writeup on page 6 and analyzed in different ways). In case of using QC, it makes sense to use a quadratic objective function, such as a sum of squared deviations from the mean. In case of the conventional solution procedures of MIP, the suggestions are given in c).

a) Example of the impact of Gini coefficient is **not always as intended, since the number of sequences is not fixed!:**

According to the definition (e.g., see “wiki”: the larger Area (A+B), the smaller is the coefficient. Then, assignment (II), which involves less sequences, will be NOT preferred, although this assignment is probably more attractive for practice



Consider two assignments for 12 SKUs (each belong to one separate garment, each belong to the same group), for all SKUs. Capacity C=4

Assignment (I) with Gini index (adjusted to the discrete data) of :

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Sequence | 1 | 2 | 3 | 4 | 5 | 6 |  |
| NN SKUs | 2 | 3 | 1 | 2 | 2 | 2 |  |

Assignment (II) with Gini index (adjusted to the discrete data) of :

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Sequence | 1 | 2 | 3 |  |  |  |  |
| NN SKUs | 4 | 7 | 12 |  |  |  |  |

b) Discussion on the necessity of an additional objective function or constraint.

The objective, as explained in the write up, aims at smoothing the workload between the periods (sequences). In this case, in the example above, it does not matter whether each sequence contains exactly 1 SKU or if each sequence contains exactly 2 SKUs. The objective function will be the same. Is this indeed the case in practice?

c) Alternative formulations of the “smoothness” objective function:

* MinMax: new variable . New constraint: . Objective:
* Min total abs deviation:
  + New variables [whether a sequence is formed or not]; – deviation in period ; – average [will be found automatically by the model  check]
  + New constraints ; :  
    ; . Objective:

Additional remark:

Overall for me, I have several questions to “understand the case study in depth”. It is very important, since the “real” optimization problem, in which practitioners are interested, often differs from that, which is stated in the very beginning. E.g., the motivation behind constraints (C3) and (C5) is not clear. Also, it is not clear, why no time dimension is considered (no SKU-specific picking times, each sequence seems to start and end simultaneously). Why the sequence of orders cannot be changed? Are we optimizing the problem for one order only? Etc.