



CA2 Model documentation, analysis and reporting

Sample project S02

Sample summary

Spinks-Northby Auctioneer Work Schedules

Purpose

The overall purpose of this project is to determine the most suitable order of shifts for four auctioneers during a planned sale at Spinks-Northby's auction house on 1 August 2011. The most suitable order is the one which enables all lots to be sold in the shortest time possible during the day.

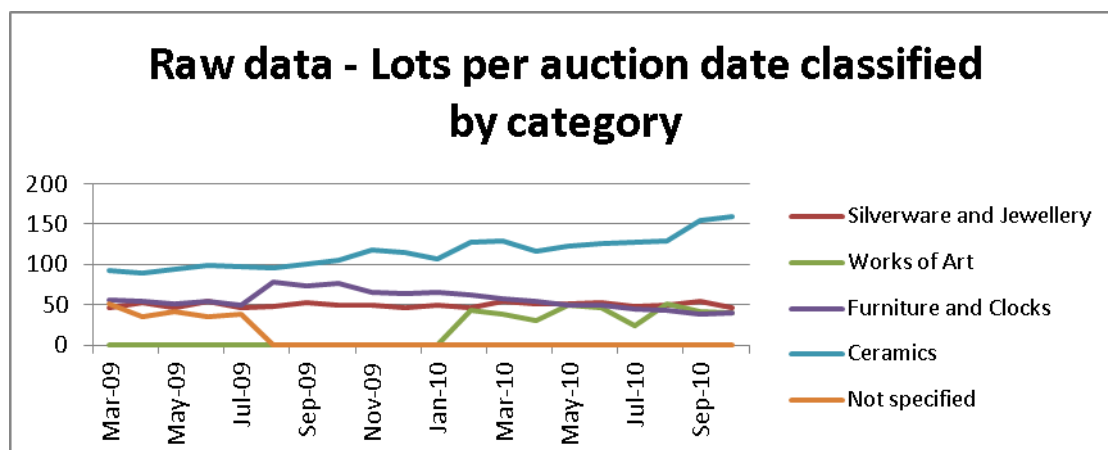
The model projects historic sales data provided to estimate the number of lots expected to be available for sale at the next auction date.

It then tests all possible combinations of work patterns to determine which, if any, will enable all the lots to be sold during an 8-hour day, noting that auctioneers cannot work more than 2 hours in any one day. The most suitable order is defined as the successful work schedule which completes the sales in the shortest time, or, if there is no successful schedule, the one which sells the most lots in the time given.

The combinations are then tested again in the light of information about Gavel-Finger, a disease which is expected to slow down auctioneers and increase the time taken to sell each lot.

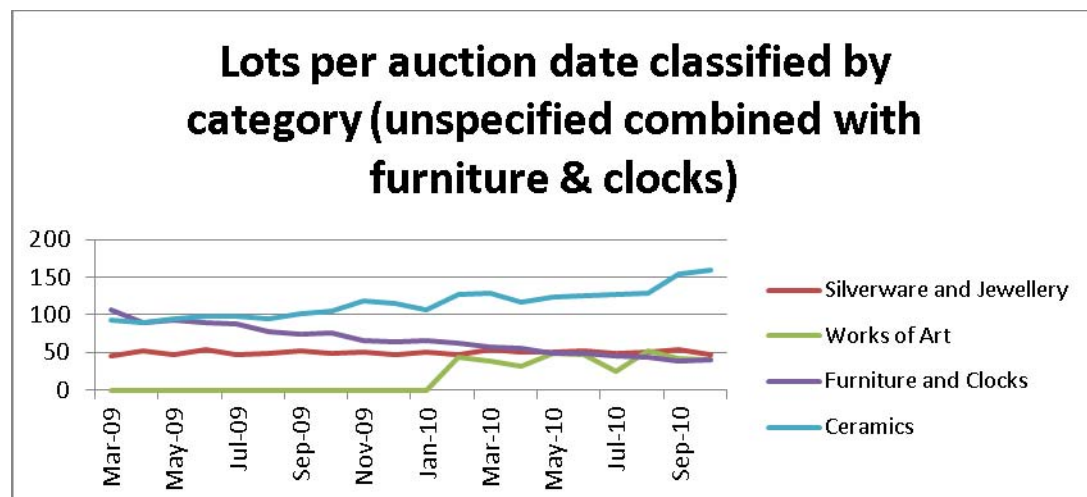
Data

The key data provided is the number of lots sold within each of four classifications (Silverware & Jewellery, Works of Art, Furniture & Clocks and Ceramics) at each of the twenty monthly auctions from 1 March 2009 to 1 October 2010 inclusive. The next auction is due on 1 August 2011. Data for auctions held after 1 October 2010 was not available.



It can be seen that there is some random variation in the data but there is an upward trend in the number of ceramics items sold and a downward trend in the number of furniture & clocks items sold.

Some of the data items were unclassified with evidence provided to indicate that these come from the same one of the four main categories. By visual inspection the unclassified items seem to belong to furniture & clocks and the following chart shows the data with these two combined.



Furniture & clocks now shows a smooth downward trend.

Data was also provided for the length of time it is expected that each lot will take to sell at auction (based on data gathered over the past two years) as follows:

| Classification | Time to sell (mins) |
|------------------------|---------------------|
| Silverware & Jewellery | 2.5 |
| Works of Art | 3 |
| Furniture & Clocks | 4 |
| Ceramics | 1 |

Information was also provided by the Actuarian Auction Association (AAA) on each of the four auctioneers in terms of the adjustments to apply to the times above for classifications where they are specialists and non-specialists in auctioneering as follows:

| Auctioneer | Adjustments to make | | Specialisms |
|------------|---------------------|----------------|-------------------------------------|
| | Specialist | Non-specialist | |
| Sam | 0.6 | 1.4 | Silverware & Jewellery and Ceramics |
| Wally | 0.4 | 0.8 | Works of Art |
| Fred | 0.8 | 1.0 | Furniture & Clocks |
| Clive | 0.9 | 0.9 | none |

Further information was provided by a medical expert who examined each auctioneer about an outbreak of “Gavel-Finger” which is expected to increase the time taken to sell a lot for each auctioneer as follows:

| Auctioneer | Increase |
|-------------------|-----------------|
| Sam | 50% |
| Wally | 25% |
| Fred | 25% |
| Clive | none |

Assumptions

- Past trends in the number of lots sold per classification can be projected into the future
- Where there is no obvious trend in the data, the last available figure is used
- The unclassified lots were part of Furniture & Clocks
- The auctioneers will work their 2 hours in one continuous shift each
- The time taken for one auctioneer to take over from another is negligible
- The average times provided are valid to use for this exercise
- For each lot sold the average time is used (i.e. variation within each class is ignored)
- The adjustments as provided by the AAA are valid for this exercise
- The increases as a result of “Gavel-Finger” are independent of class
- Auctioneers will stop selling within their 2-hour shift if the time remaining is less than the average time taken to sell a lot (i.e., the number of lots sold within the time is rounded down to the lower whole number)
- All lots sell (e.g. for lots with a reserve price, bidding will meet or exceed that price)

Approach

Data Projection

For each class the monthly change in lots sold was identified over a suitable period.

The period was chosen by inspection using a manually chosen starting date and 1 October 2010 as the finish date (ie latest auction date on record). The date had to be chosen manually because there were no works of art sold before the 1 February 2010 auction, so the start date used for works of art was manually adjusted to 1 February 2010.

The data was also inspected by sight for variability. Where there was a definite trend, the monthly change in lots was flagged as suitable for the projection. Where no definite trend existed, the monthly change in lots was ignored. It should be noted that the model is likely to be sensitive to these projections therefore I would recommend performing some sensitivity tests on the results or modelling different trends (see “next steps”).

The trends, where used, were used to project the number of lots to the next auction date, i.e. 1 August 2011, and were rounded up to the next whole number for prudence. Where trends were ignored, the most recent number of sales (as at 1 October 2010) was used.

The projected number of lots in each class was set as the “target” number of lots to sell and used to determine the optimum work schedule for the four auctioneers as follows:

Work schedules

For the four auctioneers, Sam, Wally, Fred and Clive, a table was constructed to show, for each classification, how long each auctioneer was expected to sell a lot in that class. This was done by multiplying the national average times provided by the adjustments per auctioneer, where these adjustments were dependent on whether they were a specialist in that class or not.

It was noted that there are $4! = 1 \times 2 \times 3 \times 4 = 24$ combinations of work schedule, i.e. the order in which the four auctioneers work their 2-hour shifts in turn. For each combination, a work pattern was constructed to show, for each of the four 2-hour shifts, how many lots in each classification were expected to be sold, noting that Silverware & Jewellery would be sold first, then Works of Art, then Furniture & Clocks, then finally Ceramics.

For each period the number of lots sold was determined by dividing the time available by the number of minutes that auctioneer would take to sell a lot in that class, subject to a maximum of the number of remaining available lots. Once the target number of lots in each class was reached, the remaining time available in that time period was used to determine how many lots would be sold in the next class.

At the end of the four shifts, the total number of lots sold was determined (making sure that this did not exceed the “target” for any class).

Each of the 24 combinations was then tested against criteria as follows:

If the combination resulted in the total target number of lots being sold, it was deemed a “success” and a calculation was then done to determine how much time there was left over.

If the combination did not sell the total target number of lots, it was deemed a failure and a further calculation was then done to determine how many lots were sold.

The “best” combination was then identified as the one which succeeded in the shortest time, or, if there were no successes, the one which sold the highest number of lots.

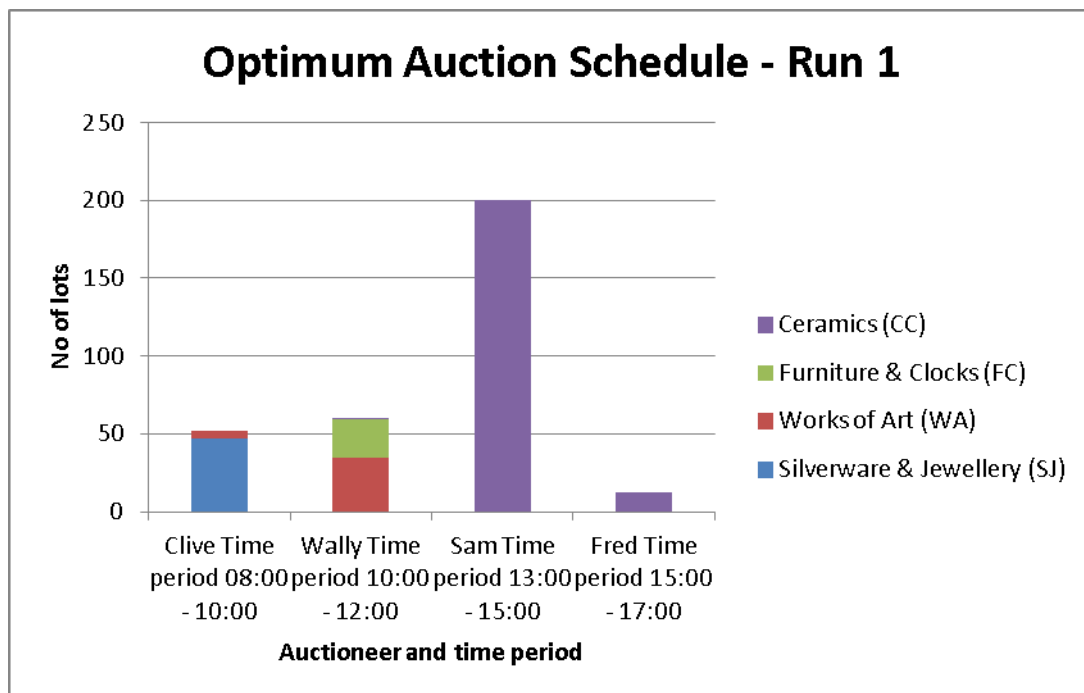
The client expected there to be a number of successful combinations and the results below show this to be the case.

The combinations were re-tested in the light of the information about the outbreak of “Gavel-Finger”, using the same criteria for the original test. The information was applied by increasing the number of minutes per lot for each auctioneer by the appropriate loading.

For all tests, the combination identified as the “best” was plotted on a chart.

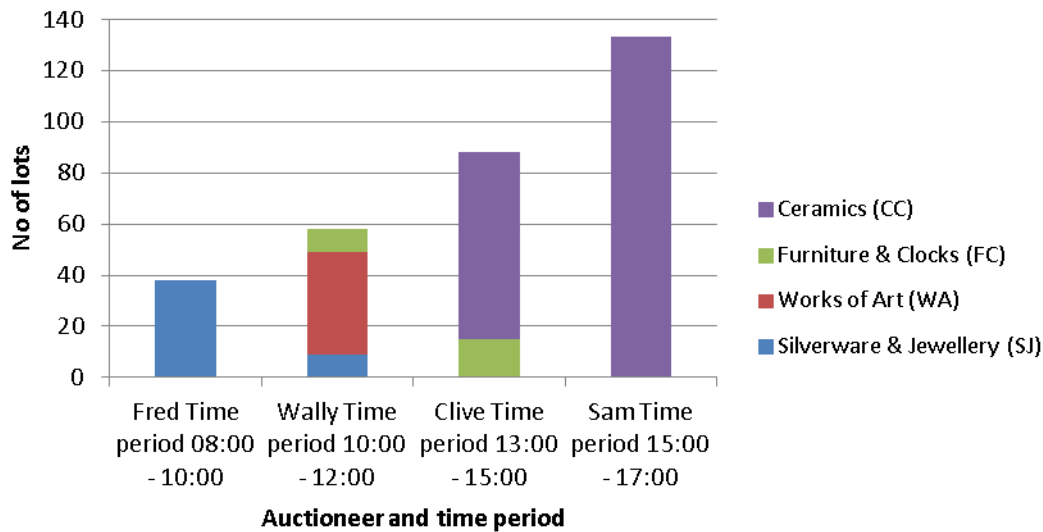
Results

The following two charts show the work schedules for the optimum combination of auctioneers in each case as follows:



- 16 out of the 24 possible combinations resulted in the target number of sales being met. The combination identified as the “best” was Clive, Wally, Sam then Fred. This leaves 108 minutes to spare, i.e. the auction would end just before 3:15pm, with 1¾ hours to spare.
- This combination seems reasonable because Sam is the fastest in CC and SJ, but CC is the bigger category. Wally is fastest in WA and FC. Clive is quite fast, and Fred quite slow, over all categories.

Optimum Auction Schedule - Run 2 Allowing for "Gavel-Finger" outbreak



- The outbreak of "Gavel-Finger" means that all combinations will fail to meet the target. The "best" combination, shown above, results in 317 lots being sold compared to the target of 324 therefore it only just fails to meet it.
- This combination seems reasonable because Wally is now fastest in WA but no one else is particularly fast in any category. Clive and Sam are equally fast in the largest category, CC.

Conclusions

General observations

Under the first scenario, the optimum work schedule concentrates some of the auctioneers in their specialist areas which is to be expected. Sam and Wally are predominantly auctioning lots within their specialist classes with Sam selling wholly Ceramics and Wally mainly Works of Art. The data provided shows that specialism has a very significant effect on the time they take to sell lots. For both Sam and Wally, specialising has the approximate effect of halving the time taken to sell a lot.

For Fred, there is less of a specialism effect on his auction times and for Clive, as an "all-rounder" there is no effect at all. Therefore, it is to be expected that the success of a work schedule depends less on the positions of Clive and Fred compared to Sam and Wally. Of these remaining two, it is optimal for Fred to work in the last period because there are very few lots left to sell by this time and Fred has the slowest rate of the two for the final category of lots.

The outbreak of "Gavel-Finger" means that there is no combination expected to meet the target. However, the "best" combination results in 317 lots being sold compared to the target of 324, i.e. only 7 ceramics short out of 213 (3.2%). This difference is negligible compared to the margins of error in the projections to which the model is sensitive. Therefore, no definite conclusion can be drawn as to whether this combination would fail to meet the target.

Potential next steps

- Gather more information on the number of lots sold within each class to refine the projections of the number of lots at auction, particularly for the missing period since February 2010 – e.g. contact members of the Northby's family to see if they have any other records or information.
- Attempt to obtain further evidence regarding the nature of the unclassified lots in the historic sales data.
- Investigate whether unsold lots have been included in the data provided (i.e. lots which attract bids but are not sold due to not meeting the reserve price). If not, these may need to be added and the model re-run using a higher target figure.
- Re-run the model nearer the auction date by which time the number of lots available to sell should be known with greater certainty.
- Consider splitting classifications further (e.g. split out silverware, jewellery, split ceramics into different types, e.g. figurines, tableware, split out furniture from clocks).
- Investigate the data provided on general auction times – this was published in "That's My Lot" magazine. Consider other sources of data, e.g. any information provided by the AAA on auction houses – consider auction houses similar to Spinks-Northby (e.g. in size, clientele, location) – consider different time period.
- Test sensitivity of model to different auction times per lot for each class.
- Model auction times per lot as random variables and project stochastically.
- Refine model to allow for different times for different values of lot (i.e. more expensive lots are likely to take longer to sell in an auction as they will reach a higher hammer price). Note that this may not be a simple relationship as higher value items are likely to start off with a higher opening bid.
- Investigate whether there might be other factors that influence auctioneer performance and thus the time per lot, e.g. a large number of collectors in a specific specialism area might be planning to attend due to heavy internet publicity, which could lengthen auction times for those pieces.
- Consider splitting auctioneers' shifts into periods of less than 2 hours, say, two x 1-hour periods to optimise further.
- Consider whether two sets of auctions can be run at the same time in different parts of the auction house.
- Verify the AAA's data on adjustments for each individual auctioneer:
 - sensitivity of model to these figures provided test
 - model to be specific to class, not just specialist vs non-specialist refine
- Do further adjustments need to be made to reflect the fact that these auctioneers are new to the company and they may need time to adjust to any different procedures.

- Investigate whether there are any other auctioneers employed by Spinks-Northby who could be used on the day....
- ...in particular after the outbreak of Gavel-Finger, are there reserve auctioneers or freelancers who could be used instead and modelled?
- Consider varying the order in which classes are sold and/or split up classes so not all of one class is sold at once.
- Consider, where lots are similar and from the same seller, whether sale items can be combined into one lot reduce the number of lots to sell – consider what effect this might have on the time taken to sell each lot.
- Investigate further the effects of “Gavel-Finger”, e.g. will the auctioneers be recovered in time for the auction and/or will the increases in auction time be accurate. Re-run the model using different impacts.