A Model for the Cost Analysis of Offset and Digital Printing Processes

Mark Bohan[1], Hal Stratton[2] and Anthony Stanton[3]

Keywords: modelling, analysis, costing, offset, digital

Abstract

Developments in new products over the recent years have resulted in a significant increase in the debate over the cost cross over between offset and digitally produced printed pieces. There are many assumptions that need to be made in the calculation of the cross over and many of the numbers used are heavily influenced by the companies that provide them. When looking at this analysis, it is important to provide the best and most accurate data possible for both offset and digital production.

This paper investigates in detail the different factors that will affect the price structure for both digital and offset printed material. This will combine factors that include the individual cost of each print based on material and consumable use and will also factor in the total cost of ownership of the individual print engines to allow an accurate cost comparison. An electronic calculator will be provided based on the factors outlined.

Introduction

The print industry continues to evolve with innovative technologies that increase the functionality and productivity of modern printing equipment. The cost for producing an individual job will vary depending on the actual press costs at each facility. There have been many "global" statements regarding the cost cross over between different processes by industry experts, and these make many assumptions that are not conveyed to the person reviewing the data. The objective of this model was to provide a simple to use and easy to communicate method to compare the different costs in an objective and unbiased manner.

---

1 Printing Industries of America
2 Komori America Corporation
3 Carnegie Mellon University

In a modern production system there are many factors that will impact the choice of printing process and cost is only one of those factors. There are many other technical or business reasons as to why a job is printed either digitally or using an offset process. When deciding on the production method for the job these factors need to be addressed. The following provides an overview of some of the more common factors that are considered.

- **Delivery date and time:** The delivery may dictate the printing process or press to be used; if it is a short delivery time then digital may be used in many cases.

- **Print quality:** The final print quality that is expected can influence the decision. This would also include the type of imaging screens that were to be used in the image and if the printed material was needed to match the appearance of additional pieces that were being produced.

- **Personalization and variable content:** If either of these features is needed then the product would have to be printed digitally.

- **Design content:** The number and type of solids and tints may lend itself to be produced in one particular press or printing process. In addition, the cross-overs between pages and the color match that is required may necessitate a particular press.

- **Color match:** If there needs to be a spot color match and if this can be achieved by a four color process set or is preferred to be met with a single spot color.

- **Substrate considerations:** The type, weight and surface characteristics of the material can impact the choice of printing process, as in certain cases the substrate would not be able to be printed using one of the presses or processes.

- **Coating (in-line or off-line):** Whether the job has to have a coating for either aesthetic or protection purposes. There can be certain interactions between ink/toner and coating that need to be considered. In addition, if the coating is a special effect or spot coating this will impact the production method.

- **Finishing:** If there is the necessity for in-line or off-line foiling or embossing of the final printed piece. Secondly, if the printed piece is to go into the mailing system, then the survivability of the print to this would have an influence on the printing press or process.

- **Press utilization:** The press utilization in the facility may result in the job being produced in a particular manner to help meet the delivery date and time or to ensure that there is not a bottleneck in production that would impact subsequent jobs in the facility.

As can be seen by the description above, there are many business and production factors other than the actual cost of manufacture that will influence the final decision on the printing press or process. Having accurate information about the actual costs of each combination of press and process will significantly help in analyzing all factors and selecting the appropriate workflow for every production job.

Cost Model Overview

A simple cost model has been developed for both sheetfed and digital (toner based) presses that will calculate the cost per sheet and allow the data to be compared either between the two printing processes or for different configurations of the same printing process. This uses data selected by the user of the model. The model was initially developed as a stand-alone Excel calculation and has since been developed into a executable software package. The model has included many different variables, including factors such as press configuration, machine and material costs, staff costs, times for activities, total impressions / jobs, waste, and financing. The structure has been developed to allow this to be extensible and add additional parameters into these models or add additional processes. Each of the two models will be described in detail, along with the equations used in the calculations. Sheetfed features that will be added in the future include work and turn.

Representative data sets have been created for each of the different configurations. When the model is being used, the user may either enter the data manually or through an CSV data file.

Sheetfed Cost Model

The cost model for the sheetfed analysis is split into three sections, namely the fixed costs for the facility, the fixed costs for the job and the variable costs for the job. The fixed costs for the job calculated in this simple model are those for the sheetfed maintenance cost (D_{SMT}), the sheetfed machine financing cost (D_{SMF}) and the sheetfed press cleaning cost (D_{SMC}). These are calculated for a shift basis and then can be allocated either based on the number of impressions for the day or the time available for the day. The sheetfed maintenance cost (D_{SMT}) is defined as

$$D_{SMT} = \frac{T_{SMT} \cdot S_{SMN} \cdot S_{SMAW}}{N_{SD}} \quad \ldots 1$$

Where T_{SMT} represents sheetfed maintenance time, S_{SMN} represents number of sheetfed maintenance staff, S_{SMAW} represents the average salary cost of the sheetfed maintenance staff and N_{SD} represents the number of shifts in a week the sheetfed press is used. The sheetfed machine financing cost (D_{SMF}) is defined as

$$D_{SMF} = \frac{C_{SMF}}{N_{SD}} \quad ...2$$

Where C_{SMF} represents the cost per week of the sheetfed press financing. The sheetfed press cleaning cost (D_{SMC}) is that carried out at the end of the production shift and is defined as

$$D_{SMC} = T_{SCT} \cdot S_{SN} \cdot S_{SAW} \quad ...3$$

Where T_{SCT} represents sheetfed cleaning time, S_{SN} represents number of sheetfed production staff and S_{SAW} represents the average salary cost of the sheetfed production staff. Therefore the total fixed facility costs (D_S) is defined as

$$D_S = D_{SMT} + D_{SMF} + D_{SMC} \quad ...4$$

The sheetfed fixed costs include the sheetfed make-ready time cost (F_{SMRT}), sheetfed make-ready waste cost (F_{SMRW}), plate costs allowing for recycling (F_{SP}) and the sheetfed job clean-up cost (F_{SJC}). These costs are aggregated across the total number of impressions for the job that are to be printed (S_{RL}) or else the total time for the job (T_{STT}). The cost for the sheetfed make-ready time is defined as

$$F_{SMRT} = T_{SMR} \cdot S_{SN} \cdot S_{SAW} \quad ...5$$

Where T_{SMR} is the time take for the sheetfed make-ready. The sheetfed make-ready waste cost is defined as

$$F_{SMRW} = PA_{SC} \cdot W_{SMRW} \quad ...6$$

Where P_{ASC} is the sheetfed paper cost and W_{SMRW} is the number of waste sheets used during the sheetfed make-ready process. The total plate costs are calculated as the difference between the plates cost and the money received back from the recycling and is defined as

$$F_{SP} = N_{SP} \cdot PL_{SC} - N_{SP} \cdot R_{SP} \quad ...7$$

Where N_{SP} represents the number of sheetfed plates for the job, P_{LSC} is the individual sheetfed plate cost and R_{SP} is the recycling value of the sheetfed plate. The sheetfed job clean-up cost is defined as

$$F_{SJC} = T_{SJC} \cdot S_{SN} \cdot S_{SAW} \quad ...8$$

Where T_{SJC} is the time for the final sheetfed clean-up at the end of the day. The total fixed costs for the job (F_S) is therefore defined as

$$F_S = F_{SMRT} + F_{SMRW} + F_{SP} + F_{SJC} \quad ...9$$

The variable costs include sheetfed running paper cost (V_{SP}), sheetfed running waste (V_{SRW}), fixed overrun (V_{SOF}) or percentage overrun (V_{SOP}), ink (V_{SI}), blanket (V_{SB}) and sheetfed staff running cost (V_{SS}). These costs are calculated in the total number of impressions for the job that is to be printed (S_{RL}). Each of the variables are described below with the sheetfed running paper cost defined as

$$V_{SP} = R_{SL} \cdot PA_{SC} \quad ...10$$

Where R_{SL} is the run length for the sheetfed job. The sheetfed running waste is defined as

$$V_{SRW} = R_{SL} \cdot PA_{SC} \cdot R_{SW} \quad ...11$$

Where R_{SW} is the run waste percentage for the sheetfed job. The sheetfed fixed overrun waste is defined as

$$V_{SOF} = PS_{SC} \cdot R_{SOF} \quad ...12$$

Where R_{SOF} is the fixed overrun sheets for the sheetfed job. The sheetfed variable overrun waste is defined as

$$V_{SOP} = R_{SL} \cdot PA_{SC} \cdot R_{SOP} \quad ...13$$

Where R_{SOP} is the percentage overrun sheets for the sheetfed job. In the calculations it is only possible to use either the fixed overrun or a percentage overrun. The ink consumable cost is defined as

$$V_{SI} = C_{SI} \cdot P_{SI} \cdot I_{SU} \cdot R_{SL} \quad ...14$$

Where C_{SI} represents the sheetfed image coverage, P_{SI} the sheetfed ink cost per unit volume (lb.), I_{SU} the sheetfed mileage for the unit volume (lb.). The blanket consumable cost is defined as

$$V_{SB} = \frac{P_{SB} \cdot R_{SL} \cdot N_{SB}}{B_{SL}} \quad ...15$$

Where P_{SB} represents the price of the sheetfed blanket, N_{SB} the number of sheetfed blankets, and B_{SL} represents the blanket life. The sheetfed staff cost during the production is then defined as

$$V_{SS} = \frac{(R_{SL} + R_{SOF} + R_{SOP} \cdot R_{SL}) \cdot S_{SN} \cdot S_{SAW}}{P_{SS}} \quad ...16$$

Where P_{SS} is the average running speed of the press. The variable cost for the job (V_S) is defined as

$$V_S = V_{SP} + V_{SRW} + V_{SOF} + V_{SOP} + V_{SI} + V_{SB} + V_{SS} \quad ...17$$

The total time for the job T_{STT} is therefore defined as

$$V_S = V_{SP} + V_{SRW} + V_{SOF} + V_{SOP} + V_{SI} + V_{SB} + V_{SS} \quad ...18$$

Finally for the calculation cost of the sheet is calculated combining the fixed costs for the facility, the fixed costs for the job and the variable costs for the job. Each of these can be assessed either on a time or impression basis, with the final calculation for the cost of a letter page being defined on an impression basis (C_{IS}) as

$$CI_S = \frac{D_S \cdot SR_L}{TN_S} + \frac{F_S}{SR_L} + V_S \quad ...19$$

Where T_{NS} is the total number of impressions that will be printed in the shift. The cost of a letter page being defined on an time basis (C_{TS}) as

$$CT_S = \frac{D_S \cdot T_{STT}}{TT_S} + \frac{F_S}{SR_L} + V_S \quad ...20$$

Where T_{TS} is the total time available in the sheetfed shift.

Digital Cost Model

The cost model for the digital analysis is split into three sections as with the sheetfed model, namely the fixed costs for the facility, the fixed costs for the job and the variable costs for the job. The fixed costs for the job calculated in this simple model are those for the digital press maintenance cost (D_{DMT}), the digital press financing cost (D_{DMF}) and the digital press start-up/shut-down cost (D_{DMC}). These are calculated for a shift basis and then can be allocated either based on the number of impressions for the day or the time available for the shift. The digital press maintenance cost (D_{SMT}) is defined as

$$D_{DMT} = \frac{T_{DMT} \cdot S_{DMN} \cdot S_{DMAW}}{N_{DD}} \quad ...21$$

Where T_{DMT} represents digital press maintenance time, S_{DMN} represents number of digital maintenance staff, S_{DMAW} represents the average salary cost of the digital maintenance staff and N_{DD} represents the number of shifts in a week the digital press is used. The digital press financing cost (D_{DMF}) is defined as

$$D_{DMF} = \frac{C_{DMF}}{N_{DD}} \quad ...22$$

Where C_{DMF} represents the cost per week of the digital press financing. The digital press start-up/shut-down cost (D_{DMC}) is that carried out at the starts and end of the production shift and is defined as

$$D_{DMC} = T_{DCT} \cdot S_{DN} \cdot S_{DAW} \quad ...23$$

Where T_{DCT} represents digital press start-up/shut-down time, S_{DN} represents number of digital production staff and S_{DAW} represents the average salary cost of the digital production staff. Therefore the total fixed facility costs (D_D) is defined as

$$D_D = D_{DMT} + D_{DMF} + D_{DMC} \quad ...24$$

The digital fixed costs are based on the make-ready time cost (F_{DMRT}) and the digital press make-ready waste cost (F_{DMRW}). These costs are then aggregated across the total number of impressions for the job that are to be printed (D_{RL}) or else the total time for the job (T_{DTT}). The cost for the digital make-ready time is defined as

$$F_{DMRT} = T_{DMR} \cdot S_{SD} \cdot S_{DAW} \quad ...25$$

Where T_{DMR} is the time take for the digital press make-ready. The digital press make-ready waste cost is defined as

$$F_{DMRW} = PA_{DC} \cdot W_{DMRW} \quad ...26$$

Where P_{ADC} is the digital paper cost and W_{DMRW} is the number of waste sheets used during the digital press make-ready process. The total fixed costs for the job (F_D) is therefore defined as

$$F_D = F_{DMRT} + F_{DMRW} \quad ...27$$

The digital variable costs include digital running paper cost (V_{DP}), digital click charges, (V_{DC}), digital running waste (V_{DRW}), fixed overrun (V_{DOF}) or percentage overrun (V_{DOP}), and digital staff running cost (V_{DS}). These costs are calculated in the total number of impressions for the job that is to be printed (D_{RL}). Each of the variables are described below with the digital running paper cost defined as

$$V_{DP} = R_{DL} \cdot PA_{DC} \quad ...28$$

Where R_{DL} is the run length for the digital job. The digital click charge is defined as

$$V_{DC} = R_{DL} \cdot C_{DC} \cdot C_{DK} \quad ...29$$

Where C_{DC} is the click charge for the digital job based on a single side of the press sheet being printed and C_{DK} is a multiplier used for the second side. The digital running waste is defined as

$$V_{DRW} = R_{DL} \cdot PA_{DC} \cdot R_{DW} \quad ...30$$

Where R_{DW} is the run waste percentage for the digital job. The digital fixed overrun waste is defined as

$$V_{DOF} = PS_{DC} \cdot R_{DOF} \quad ...31$$

Where R_{DOF} is the fixed overrun sheets for the digital job. The digital variable overrun waste is defined as

$$V_{DOP} = R_{DL} \cdot PA_{DC} \cdot R_{DOP} \quad ...32$$

Where R_{DOP} is the percentage overrun sheets for the digital job. In the calculations it is only possible to use either the fixed overrun or a percentage overrun. The digital staff cost during the production is then defined as

$$V_{DS} = \frac{(R_{DL} + R_{DOF} + R_{DOP} \cdot R_{DL}) \cdot S_{DN} \cdot S_{DAW}}{P_{DS}} \quad ...33$$

Where P_{DS} is the average running speed of the press. The variable cost for the job (V_D) is defined as

$$V_S = V_{DP} + V_{DC} + V_{DRW} + V_{DOF} + V_{DOP} + V_{DS} \quad ...34$$

The total time for the job T_{DTT} is therefore defined as

$$T_{DTT} = \frac{(R_{DL} + R_{DOF} + R_{DOP})}{P_{DS}} + T_{DMR} \quad ...35$$

Finally for the calculation cost of the sheet is calculated combining the fixed costs for the facility, the fixed costs for the job and the variable costs for the job. Each of these can be assessed either on a time or impression basis, with the final calculation for the cost of a letter page being defined on an impression basis (C_{ID}) as

$$CI_D = \frac{D_D \cdot DR_L}{TN_D} + \frac{F_D}{DR_L} + V_D \quad ...36$$

Where T_{ND} is the total number of impressions that will be printed in the shift. The cost of a letter page being defined on a time basis (C_{TD}) as

$$CT_S = \frac{D_S \cdot T_{STT}}{TT_S} + \frac{F_S}{SR_L} + V_S \quad \text{...37}$$

Where TT_D is the total time available in the shift.

Results and Discussion

The model was compiled in an excel file and the analysis was carried out for a series of representative data, this data is tabulated in Appendix 1. It should be noted that the data used in the model would vary dependent on the actual facility and that any results should not be used as definitive cost comparisons between different processes or configurations. Typical results from the sheetfed analysis are shown in Figure 1 which plots the number of letter pages produced against the cost for each of those pages. In this scenario the sheetfed press is printing eight up letter pages, with two make-readies and sets of plates. The results show a reduction in the cost per print as the run length increases. Reductions in cost continue throughout the 10,000 letter pages assessed as the analysis indicates that the fixed costs for the job are split between each of the individual copies.

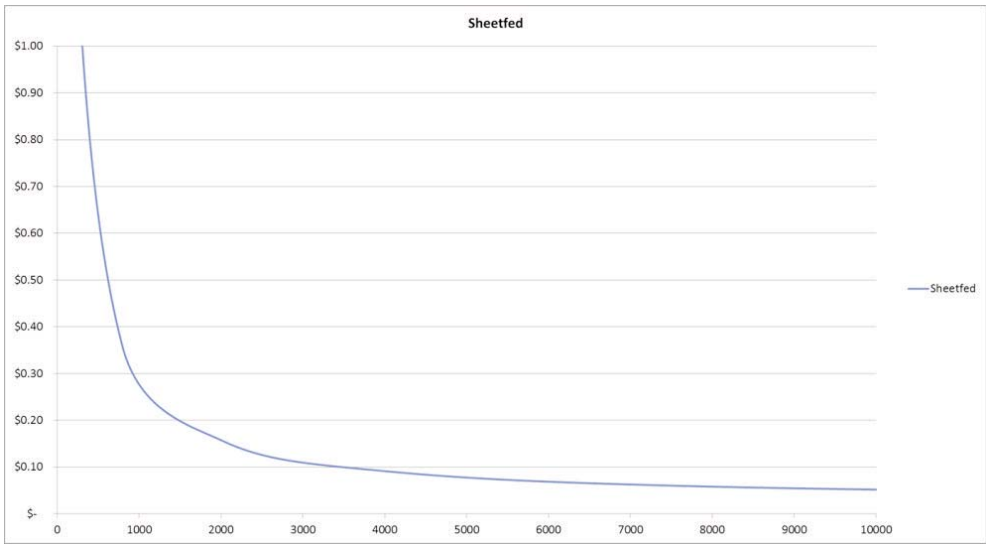

Figure 1: *Cost analysis for sheetfed*

The analysis is then completed to include a digital press that is producing two up on the press and running in a duplexing mode. The results of the calculations are shown in Figure 2. The digital printing has fixed costs, but these are much less than those with the offset production and as such there is a much faster reduction in the cost per sheet, which then levels out to a single fixed charge, related to the variable costs of the job, digital running paper cost, digital click charges, digital running waste, fixed overrun or percentage overrun, and digital staff running cost.

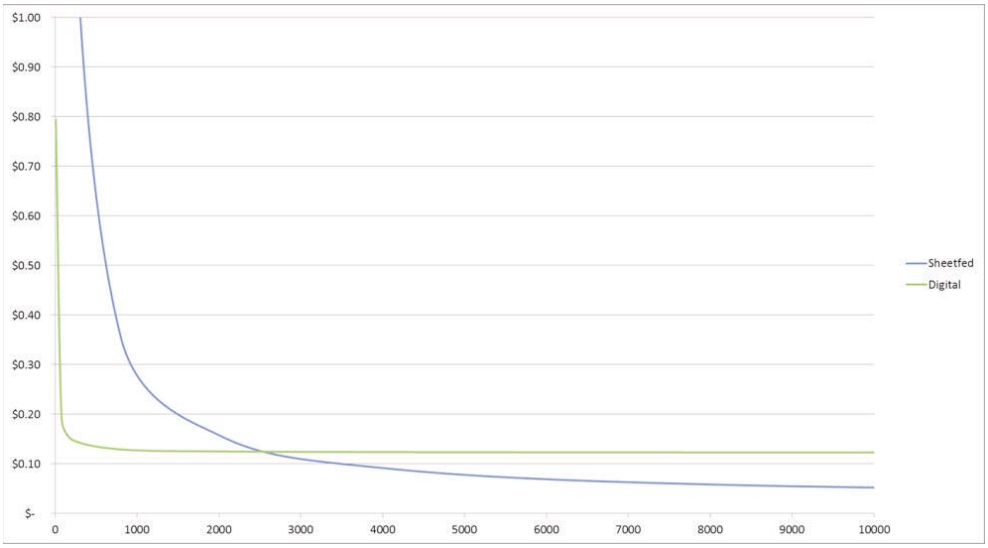

Figure 2: *Cost analysis for sheetfed, and digital*

The savings from ganging multiple jobs on the same sheet for offset is shown in Figure 3. In this analysis, a 40" sheetfed press is used which allows for an 8 up ganging to be created on the print sheet. In this model case, the ganging does not impact either the fixed costs for the facility or the variable costs for the job. However, the fixed costs for the job are impacted with these being divided by the number up used, in this case by eight. As this is a significant cost for the production job it can be seen that the costs per sheet is significantly less expensive than the non-ganged job.

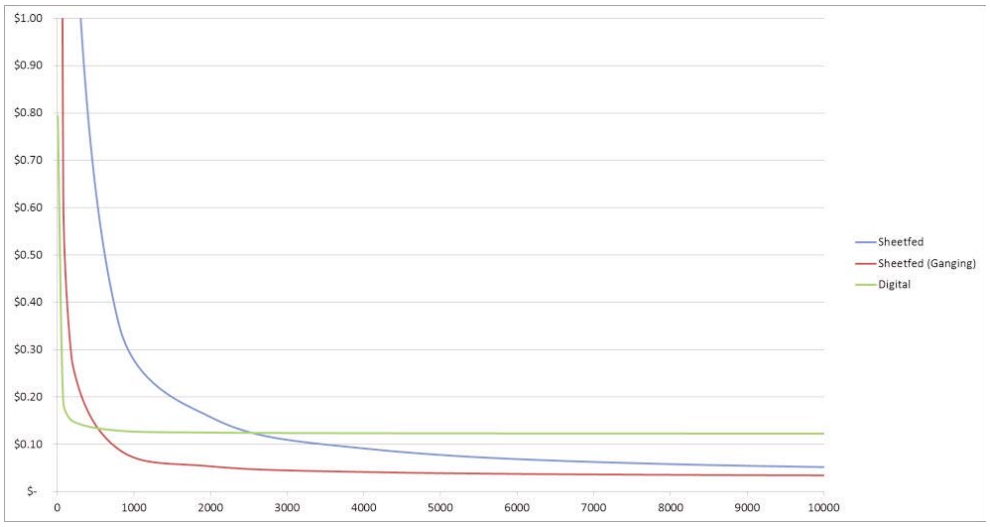

Figure 3: *Cost analysis for sheetfed, sheetfed (ganging) and digital*

Additional analysis was completed assessing the impact of comparing an old and new sheetfed press, Figure 4. The numbers used are all shown in Appendix 1, with the significant differences being;

- The old press having no financing
- The new press having a faster operating speed
- The new press having a faster make-ready and less waste sheets
- The new press having a shorter maintenance period

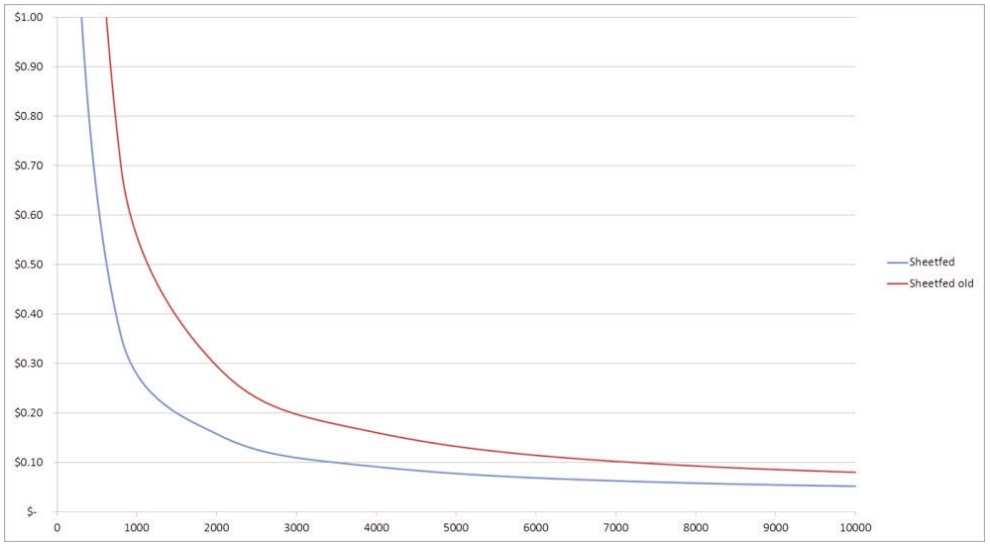

Figure 4: *Cost analysis for new and old sheetfed*

Finally, the calculations were made assessing the impact of multiple shifts during the day, Figure 5. In this case it will only affect the allocation for the fixed costs for the facility, and it can be seen that while there is a cost saving it is not significant.

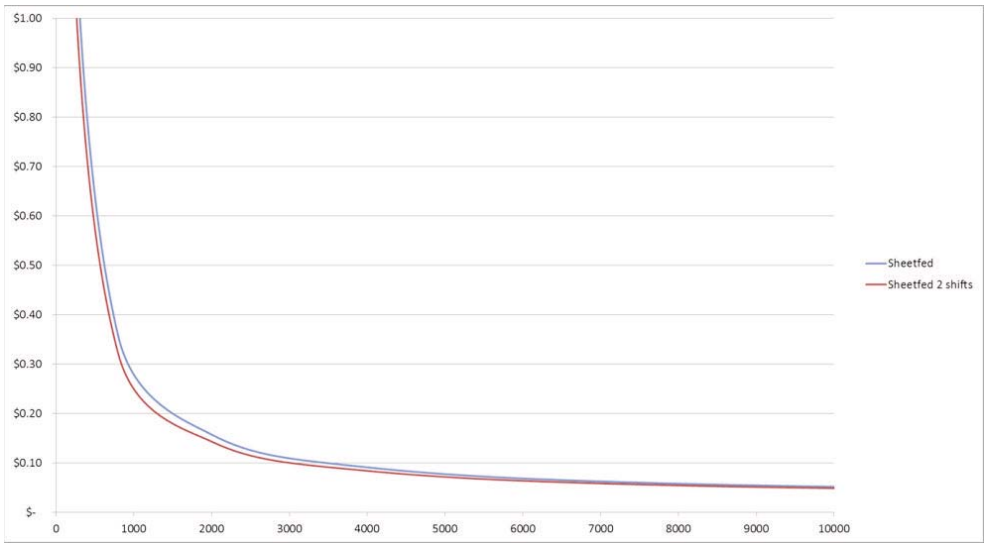

Figure 5: *Cost analysis for one or two shifts*

Conclusions

A model for cost analysis for sheetfed offset and digital printing has successfully been developed. This model is extensible for additional variables and also for different production processes including wide-format, inkjet, web offset, flexography and screen printing. The model allows the user to input their own data to obtain cost per letter page at their facility. The model is available for use at the TAGA website.

Typical analysis was completed for both offset and digital printing scenarios. The results can best be summarized as

- The model shows a reduction in cost per page as the run length is increased, this is evident for both the offset and digital models.
- The digital model does have fixed costs and as such there is a reduction in cost from the first print onwards
- Ganging shows a significant reduction in price per print.
- The model can be used for evaluation of different press configurations and age, as highlighted by the sheetfed analysis.
- There is only a small difference when multiple shifts are introduced.

Each of the conclusions on the model outcome is based on the data that was input and will change dependent on the final data included.

Nomenclature

B_{SL}	sheetfed blanket life
C_{DC}	click charge for the digital job based on a single side of the press sheet being printed
C_{DK}	click charge multiplier used for the second digital side
C_{SI}	sheetfed image coverage
C_{DMF}	cost per week of the digital press financing
C_{SMF}	cost per week of the sheetfed press financing
C_{ID}	cost of a letter page being calculated on a per impression basis
C_{IS}	cost of a sheetfed letter page calculated on a per impression basis
C_{TD}	cost of a letter page being defined on a time basis
C_{TS}	cost of a sheetfed letter page calculated on a time basis
D_D	total fixed digital facility costs
D_{DMT}	digital press maintenance cost
D_{DMF}	digital press financing cost
D_{DMC}	digital press start-up/shut-down cost (shift)
D_{SMT}	digital press maintenance cost
D_S	total fixed sheetfed facility costs
D_{SMC}	sheetfed press cleaning cost (shift)
D_{SMF}	sheetfed machine financing cost
D_{SMT}	sheetfed maintenance cost
D_{RL}	total number of digital impressions for the job
F_D	total fixed costs for the digital job
F_{DMRT}	digital press make-ready time cost
F_{DMRW}	digital press make-ready waste cost
F_S	total fixed costs for the sheetfed job
F_{SMRT}	sheetfed make-ready time cost
F_{SMRW}	sheetfed make-ready waste cost
F_{SJC}	sheetfed job clean-up cost
F_{SP}	sheetfed plate costs allowing for recycling
I_{SU}	sheetfed mileage for the unit volume (lb.)
N_{DD}	number of shifts in a week the digital press is used
N_{SB}	number of sheetfed blankets for job
N_{SD}	number of shifts in a week the sheetfed press is used
N_{SP}	number of plates for the sheetfed job

P_{DS} average running speed of the digital press
P_{SB} cost of the sheetfed blanket
P_{SI} sheetfed ink cost per unit volume (lb.)
P_{SS} average running speed of the sheetfed press
P_{ADC} digital paper cost
P_{ASC} sheetfed paper cost
P_{LSC} sheetfed plate cost

R_{DL} run length for the digital job
R_{DOF} fixed overrun sheets for the digital job
R_{DOP} percentage overrun sheets for the digital job
R_{DW} run waste percentage for the digital job
R_{SL} run length for the sheetfed job
R_{SOF} fixed overrun sheets for the sheetfed job
R_{SOP} percentage overrun sheets for the sheetfed job
R_{SP} recycling value of the sheetfed plate
R_{SW} run waste percentage for the sheetfed job

S_{DAW} average salary cost of the digital production staff
S_{DMAW} average salary cost of the digital maintenance staff
S_{DMN} number of digital maintenance staff
S_{DN} number of digital production staff
S_{SAW} average salary cost of the sheetfed production staff
S_{SMAW} average salary cost of the sheetfed maintenance staff
S_{SMN} number of sheetfed maintenance staff
S_{SN} number of sheetfed production staff
S_{RL} total number of sheetfed impressions for the job

T_{DCT} digital press start-up/shut-down time
T_{DMR} time take for the digital press make-ready
T_{DMT} digital press maintenance time
T_{DTT} total time for the digital job
T_{SCT} sheetfed cleaning time
T_{SJC} time for the final sheetfed clean-up at the end of the day
T_{SMR} time take for the sheetfed make-ready
T_{SMT} sheetfed maintenance time
T_{STT} total time for the sheetfed job
T_{NS} total number of sheetfed impressions that will be printed in the shift
T_{ND} total number of digital impressions that will be printed in the shift
T_{TS} total time available in the sheetfed shift
T_{TD} total time available in the digital shift

V_D	variable cost for the digital job
V_{DC}	digital click charges
V_{DOF}	digital fixed overrun cost
V_{DOP}	digital percentage overrun cost
V_{DP}	digital running paper cost
V_{DRW}	digital running waste cost
V_{DS}	digital staff running cost
V_S	variable cost for the sheetfed job
V_{SB}	sheetfed blanket cost
V_{SI}	sheetfed ink cost
V_{SOF}	sheetfed fixed overrun cost
V_{SOP}	sheetfed percentage overrun cost
V_{SP}	sheetfed running paper cost
V_{SRW}	sheetfed running waste cost
V_{SS}	sheetfed staff running cost

W_{SMRW}	number of sheetfed waste sheets used during the make-ready process
W_{DMRW}	number of digital waste sheets used during the press make-ready

Appendix 1: Sheetfed costs used in calculations

Item	Sheetfed New	Sheetfed Old
Paper cost (1000)	$150.00	$150.00
Cost per sheet	$0.15	$0.15
Sheet width	41	41
Prints per sheet	8	8
Run speed	12,500	7,500
Ink usage 5% per 1000	0.20	0.20
Ink usage 15% per 1000	0.40	0.40
Ink usage 30% per 1000	0.60	0.60
Ink cost - C	$20.00	$20.00
Ink cost - M	$20.00	$20.00
Ink cost - Y	$20.00	$20.00
Ink cost - K	$15.00	$15.00
Blanket cost	$120.00	$120.00
Blanket life (imp)	500,000	500,000
Plate cost	$12.00	$12.00
Make-ready time	20	45
Make-ready staff used	2	2
Staff cost (avg)	$30.00	$30.00
Make-ready waste	600	2500
Overrun waste sheets	50	50
Overrun waste percent	10	10
Run waste	0.3	0.3
Job cleanup time	10	25
Jobs per day	7	7
Extra time for final wash up	20	20
Maintenance time per week	120	240
Maintenance staff	2	2
Maintenance staff cost	$30.00	$30.00
Press financing costs	$40,000.00	
Recycling plates	$1.13	$1.13

Appendix Table 1: *Sheetfed costs used in calculations*

Item	Digital
Paper cost (1000)	$75
Cost per sheet	$0.075
Prints per sheet	2
Run speed	2,200
Day start up	15
Day close	15
Make-ready time	5
Proofing	3
Staff used	1
Staff cost	$20.00
Make-ready waste	5
Overrun waste sheets	50
Overrun waste percent	10
Run waste	0.2
Hours per day	8
Impressions per day	11000
Maintenance time per week	120
Maintenance staff	1
Maintenance staff cost	$20.00
Leasing costs	$3,000.00
Purchase costs	$5,000.00
Click charge per print	$0.06

Appendix Table 2: *Digital costs used in calculations*