Simulation model of professional service personnel inventory

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Abstract: Supply chains are found in service organisations as well as in manufacturing. A common type of supply chain is personnel. Firms such as accounting, consulting, or legal firms need to develop a chain of trained professionals who hone their skills through training and experience throughout their careers. While such firms have to consider these long-range goals, they also need to manage operations in the short-term to generate adequate profit, both through increasing demand for their services as well as controlling costs of delivering them. This paper applies a simple Monte Carlo simulation model to a legal firm decision of managing short-term capacity. Factors to include covering demand, minimising cost, and maintaining quality are considered. The simulation model deals with the uncertainties involved in demand, to include consideration of risk level. A hypothetical law firm (based loosely on an existing firm) is used as a basis for this analysis. Results emphasise that the tools developed for very different purposes work appropriately in this context.

Keywords: service operations; supply chain; Monte Carlo simulation; legal personnel management.

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1 Introduction

Supply chain studies in academics have emphasised manufacturing applications, as noted by Narasimhan and Jayaram (1998). However, industry has recognised the need to view service supply chains as well (Sparks, 2010). There has been recognition that value chains need to develop operations strategies considering not only traditional cost-based factors, but also competitive priorities (Paiva and Vieira, 2011). This includes the need to consider customer service along with conventional manufacturing considerations (Chirumalla, 2013). Contemporary operations need to consider both the manufacturing and service elements of any product. Retail operations inherently have an important service element. Service relies on supply chains providing efficiently integrated supply chain elements to tap quality sources, in a timely manner, holding all supply chain components responsible for delivering product in sustainable ways and flexible enough to respond to changes in demand.

Southard and Swenseth (2003) demonstrated the need to match order winners and qualifiers experienced in the marketplace with the operational processes of service firms. Professional service organisations face similar needs to match existing order winners and qualifiers with operational processes. However, the parameters that define these order winners and qualifiers can differ substantially from other organisations. The concept of order winner in a service context is generally provision of quality service at a convenient time and location. Service firms qualify by develop quality expertise. Professional service firms often involve providing experts capable of providing clients with quality advice. Developing this capability is accomplished through career management and training of employees.

Thus professional consulting organisations face the need to maintain a supply of qualified and productive people. Human capital management is important in supply chain organisations (Tavakoli et al., 2013). This is a form of supply chain, applying to medical clinics, accounting firms, legal firms, and others (Nakano, 2011). Manning decisions typically are profit driven, although profit itself is not the sole important factor. Maintenance of quality will have a long-term impact on demand that is recognised, but hard to directly include in profit models. Completion of projects and tasks by required deadlines, often forced by governmental regulations is also crucial for ongoing success. Other factors such as social responsibility are being recognised as important (Olugu and Wong, 2011; Thornton et al., 2013). As a result, while these firms and their associated decisions are profit driven, price is rarely identified as an order winner and controlling the marketplace through price fluctuations is rarely an option.

The purpose of this paper is to provide a model to analyse the hiring decision of a small hypothetical service firm. We consider alternative policies to deal with changes in demand, modelling expected impact on both revenue as well as quality. We seek to

demonstrate the impact of the personnel supply chain involved, and provide a prototypical simulation model based on the demand for legal services available to a firm to provide a means to assess expected performance considering variable demand for services.

2 Literature review

Service operations research has identified a number of features important in attaining success (Gimenez et al., 2012). Technology plays a role in improving supply chain profitability (de Souza et al., 2011). Resilience, the ability to and adapt to new circumstances was found important by Mandal (2012). Lee et al. (2008) explored application of agility in service sector operations. Agility is a means to be resilient in the face of shifting demand (Castro et al., 2012). Goldsby et al. (2006) discussed strategies of lean, agile, and what was called leagile (hybrid) supply chain systems, used in part to improve customer service. Human resource factors also play a role (Wickramasinghe, 2010; Kung and Chen, 2011). Employee adaptability has been identified as a factor in delivery of customisable services (Sony and Mekoth, 2012).

Our study applied a simulation model to evaluate a personnel supply chain. Simulation is widely used in general supply chain management studies. The inventory aspects of supply chains have been well studied through simulation models (Christopher and Towill, 2001; Disney and Towill, 2006) expanded to include vendor-managed inventory systems (Disney and Towill, 2002; Southard and Swenseth, 2008). Azadeh et al. (2013) applied fuzzy modelling and simulation in an operational setting.

Operations management needs to assure that organisations operate at a profit level ensuring survival of the firm. However, supply chain operations involve many risks that need to be considered. Wright and Datskovska (2012) argued that globalisation, introduction of lean manufacturing, and geographical concentration of manufacturing increase supply chain risks. To counter this, reducing supply chain uncertainty tends to increase responsiveness (Childerhouse and Towill, 2004, 2011). Towill and Disney (2008) showed that increased information accuracy coupled with automatic information dissemination [a common form of business process reengineering (BPR)] across the supply chain can reduce risks associated with the Bullwhip effect. That study, as well as Towill (2005) applied a classical inventory simulation model of a supply chain. Various other aspects of supply chain risk have been studied as well. Faisal et al. (2006) mapped supply chains based on customer sensitivity and risk alleviation competency. Gosling et al. (2012) examined engineer-to-order supply chains in construction projects.

The traditional mindset was focused on cost-plus pricing – if it cost \$X to make a product, we must charge \$Y (where Y>X) to make profit. The newer mindset is that we are going to charge \$Y to maintain stable demand, so we must reduce cost to \$X to maintain an acceptable profit level (market-based pricing). Lean impact on inventory turnover has been studied (Demeter and Matyusz, 2011) with many studies of supply chain impact (Potter et al., 2009; Ruiz-Torres and Mahmoodi, 2010; Akcali and Cetinkaya, 2011; Portioli-Staudacher and Tantardini, 2012). One means of implementing lean principles in professional service is through a chase personnel policy.

3 Consulting service model

Operations management encompasses bringing resources into the organisation and adding value to the product or service to create an output that meets the expectations of the customer. Services involve resources with a heavier emphasis on human capital than manufacturing. Services such as a consulting firm focus more on people than on traditional inventories of parts and supplies. Each service organisation is going to have key resources which they need to manage. A key resource for consulting firms is people – trained professionals at various levels. Eljiz et al. (2011) analysed the personnel supply chain for a health services organisation.

Many professional service organisations involve a key resource of professional skills, which they develop through experience, hiring, and training. This is true of accounting firms (Balachandran and Steuer, 1982) as well as legal firms. We will use a hypothetical services firm to demonstrate concepts applied to professional personnel management in a legal context. This law firm's work consists of about 40% general tax practice with seasonal increases in November and December, as well as in March and April. General law work consists of entity formation, drafting of minutes and motions, management of trademarks, revision of operating agreements, liquidation planning, and business succession planning, all of which are more automatable than is tax work. About one third of the firm's work is in estate planning and asset protection service (to include wills and trusts). Legal markets tend to have rate caps which preclude use of pricing as a demand management tool. Work is obtained and clients retained more by personalisation of service, use of technologically advanced legal solutions and the ability to meet required deadlines without creating undue stress.

Yield management has been applied widely in services, to include the electricity market (Chao, 2012) and airline pricing (Weatherford and Belobaba, 2002; Hsu et al., 2013). In the healthcare service industry, pricing itself plays less of a dominant role (Blythe et al., 2008), but price is an obvious demand management tool to consider. The legal services industry is more like healthcare service in that pricing is not as appropriate as a demand management tool. Professionals such as doctors or lawyers usually prefer to have established rates, relying on the quality of their service to maintain demand rather than manipulating price.

In the short run, traditional means of dealing with bubbles in demand include overtime, additional shifts, or cross-training to allow floating workers. Part-time workers is another alternative, or carried to the extreme, subcontracting. Each of course has different cost impacts as well as impacts on quality of service provided clients. Professional responsibility and ethical obligations make subcontracting inappropriate for many legal operations. Part-time workers in professional fields are also problematic. Job sharing may provide a more workable means of obtaining just-in-time features in the legal consulting environment.

The personnel resources in a legal firm might include a small group of attorneys, some of whom are partners, others associates, and yet others counsels. Each attorney bills an average of about 2,000 hours per year, the basic measure of productivity output. This pool of lawyers is supported by an office manager, a receptionist, a law clerk, and paralegals. Short term demand surges are dealt with by hiring additional law clerks, who are typically law students. In the USA, full-time law students are restricted to work no more than 20 hours per week when courses are in session. Part-time students are not common in the legal domain. This makes flexible staffing problematic. A chase strategy

will be modelled. Liao et al. (2011) found a chase strategy to be best when total cost is the sole objective. However, in service operations, other considerations may make the chase approach inappropriate. This is greatly exaggerated in professional services where the production employee (the equivalent of a craftsman or assembly line worker in a manufacturing setting) is a highly paid professional. We will examine the impact of a chase strategy as well as various levels of fixed law clerk levels. While not unheard of, increasing and reducing staff at higher levels in the organisation is downplayed.

More promising is how firms use resources. Legal firms can use overlapping or staggering shifts, as well as cross-training and flexible scheduling. BPR is a useful means to obtain a more lean operation in such service consulting (Gunasekaran and Kobu, 2002). Burgess (1998) argued that BPR of supply chains would lead to reduced lead-times and improved customer service, quality, and ultimately lower costs. BPR is often attained through implementation of computer technology (Gunasekaran and Nath, 1997), and is a key component of ERP systems (Subramoniam et al., 2009). A variety of experiences in reengineering State motor vehicle departments have been reported [Clark et al. (1992) in Florida using simulation modelling; Narasimhan and Jayaram (1998) in an unspecified state focusing on BPR; Dhillon and Caldeira (2008) emphasising IT project management issues in Nevada; and McCubbrey and Fukami (2009) reporting ERP implementation issues in Colorado]. Implementation of BPR through information technology provides substitution of automation for personnel. Such an approach would be viable for about one-third of our hypothetical legal firm's work.

4 Model

We use a hypothetical demonstration model based upon a real legal firm in Nebraska. As stated above, this firm focuses on income tax law, with a similar volume of non-tax work. The firm has two partners, three associates, and four counsellors, plus part-time legal clerks hired from law students for limited hours/week. Billable tax work is allocated to the most senior people first, with work given to associates and counsellors prioritised by first accomplishing tax work, then non-tax work. Law clerks are available to work on non-tax work only. Table 1 shows monthly billable availabilities based on 170 work hours per month.

Table 1 Billable hour parameters

Level	*Partner*	*Associate*	*Counsellor*	*Law clerk*
Number	2	3	4	Varies
Billable proportion	0.9	0.8	0.7	0.7
Billable hours/month	306	408	476	Varies

Demands for tax and non-tax work vary by month, following lognormal distribution. This distribution was selected to reflect the skewed nature of demands, which vary by month for each type of legal activity the firm is involved in. In practice, standard statistical distribution tests should be applied to identify the appropriate distribution for each application (Evans and Olson, 2001), but we would expect the lognormal to be a promising candidate for such demand. Table 2 gives the parameters of the lognormal distribution used in our model for monthly demands.

Table 2 Monthly demands

Month	*Tax hours mean*	*Tax st. dev.*	*Tax min*	*Non-tax hours mean*	*Non-tax st. dev.*	*Non-tax min*
January	500	200	200	900	180	300
February	800	300	200	800	160	300
March	1,500	600	500	700	140	300
April	1,400	600	500	700	140	300
May	500	300	200	800	160	300
June	400	200	100	800	160	300
July	300	200	100	900	180	300
August	200	100	100	900	180	300
September	400	200	100	900	180	300
October	600	300	200	900	180	300
November	1,100	400	300	1,000	200	300
December	1,300	500	400	1,100	220	300

The decision to be made is how many law clerks to retain. The current level is 3, but that leaves a lot of available non-tax work undone. The supply chain issue is what hiring strategy to adopt. Alternatives to the current system are to increase the number of law clerks to some constant level, to utilise BPR through software to enable one-law clerk to do the work of 10 without the software, or adopting a chase strategy where the amount of work undone (or idle law clerk time) each month is used to identify the number of law clerks to hire/layoff for the subsequent month.

Figure 1 Excel spreadsheet model

	A	B	C	D	E	F	G	H	I
1				Pay Hours					Bill Hours TAX
2	DEMANDS	Tax	Nontax	PartHr	AssocHr	CounsHr	LCHr	Clerks	PartBill
3	JAN	**LN**	**LN**	306	408	476	=56*H3	3	=MIN(B3,D3)
4	FEB	**LN**	**LN**	306	408	476	=56*H4	=MAX(0,IF(Q3>56,INT(Q3/56)+H3,H3-1))	=MIN(B4,D4)
…	…	…	…	…	…	…	…	…	…

	J	K	L	M	N	O	P	Q
1				Bill Hours OTHER				
2	AssocBill	CounsBill	unTAX	PartOB	AssocOB	CounsOB	LCOB	unOTH
3	=MAX(0,MIN(B3-I3,E3))	=MAX(0,MIN(B3-I3-J3,G3))	=MIN(0,B3-I3-J3-K3)	=MIN(C3,D3-I3)	=MIN(C3-M3,E3-J3)	=MIN(C3-M3-N3,F3-K3)	=MIN(C3-M3-N3-O3,H3*56)	=C3-M3-N3-O3-P3
4	=MAX(0,MIN(B4-I4,E4))	=MAX(0,MIN(B4-I4-J4,G4))	=MIN(0,B4-I4-J4-K4)	=MIN(C4,D4-I4)	=MIN(C4-M4,E4-J4)	=MIN(C4-M4-N4,F4-K4)	=MIN(C4-M4-N4-O4,H4*56)	=C4-M4-N4-O4-P4
…	…	…	…	…	…	…	…	…

A Monte Carlo simulation model is used to generate work (the Appendix displays work generated for a year both graphically and in tabular form), and then allocate it in the order following the conditions outlined above: Assign tax work first, in the order of partners,

then associates, then counsellors. An Excel spreadsheet was used to model work, using Crystal Ball software to provide Monte Carlo simulation. The current number of lawyers at these levels is expected to be adequate for all tax work (although the Monte Carlo simulation checks and measures any undone tax work). In all simulations, all tax work available was assigned to the top three senior levels of lawyers. Next non-tax work is assigned in the same order – there was always additional non-tax work to be assigned to law clerks. Thus the Monte Carlo simulation generates monthly tax work available and non-tax work available, and allocates it given available billing time by lawyer level. Output measures of interest are law clerk billed hours (monthly numbers are added together for the year), and amount of non-tax work not accomplished. The idle law clerk time can be calculated given a measure of total work generated. The simulation was run with 1,000 repetitions using Crystal Ball software. Figure 1 shows the basic spreadsheet simulation model.

Cells B3 and B4 generate log normally distributed tax work for the month using the appropriate mean, standard deviation, and minimum, while C3 and C4 do the same for non-tax work. Cells G3 and G4 give hours of Law Clerk availability for the appropriate policy. The policy shown in cell H4 is for a chase strategy. All 12 months would show similar rows through row 14 (December). The Crystal Ball system allows summing annual Law Clerk levels in cell H16, the amount of tax work not completed in cell L16 (always 0 in the models we ran), the amount of billable Law Clerk work in cell P16, and non-tax work not completed in cell Q16. Work not completed is called 'left on the table' in the study. Idle Law Clerk activity can be identified by subtracting billable Law Clerk work from Law Clerk pay (generated from cell H16). Crystal Ball output comes in either graphical or tabular form, as shown in Figures 2 and 3 for Billable Law Clerk non-tax work and for uncompleted non-tax work.

Figure 2 Graphical output for billable law clerk non-tax work (see online version for colours)

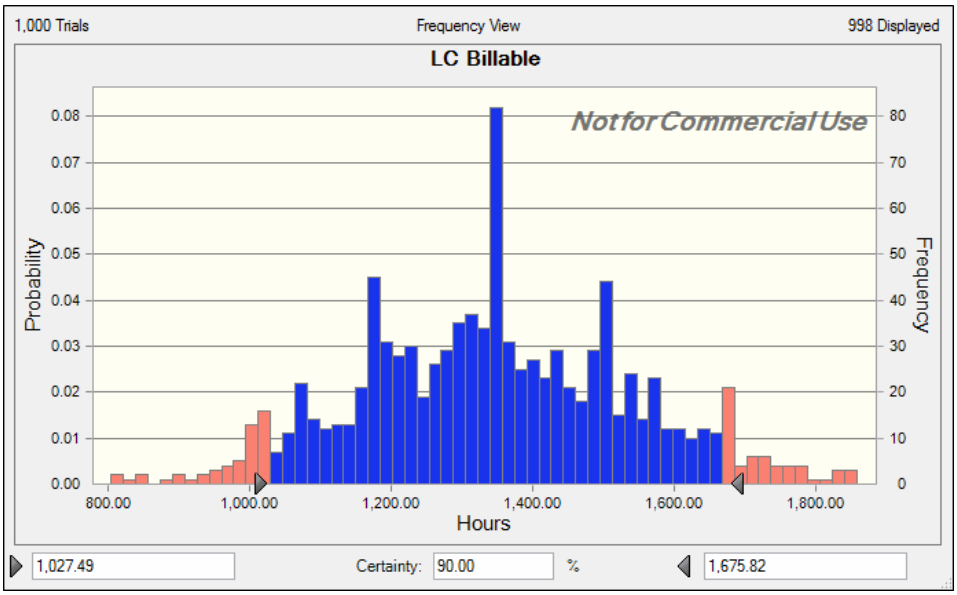
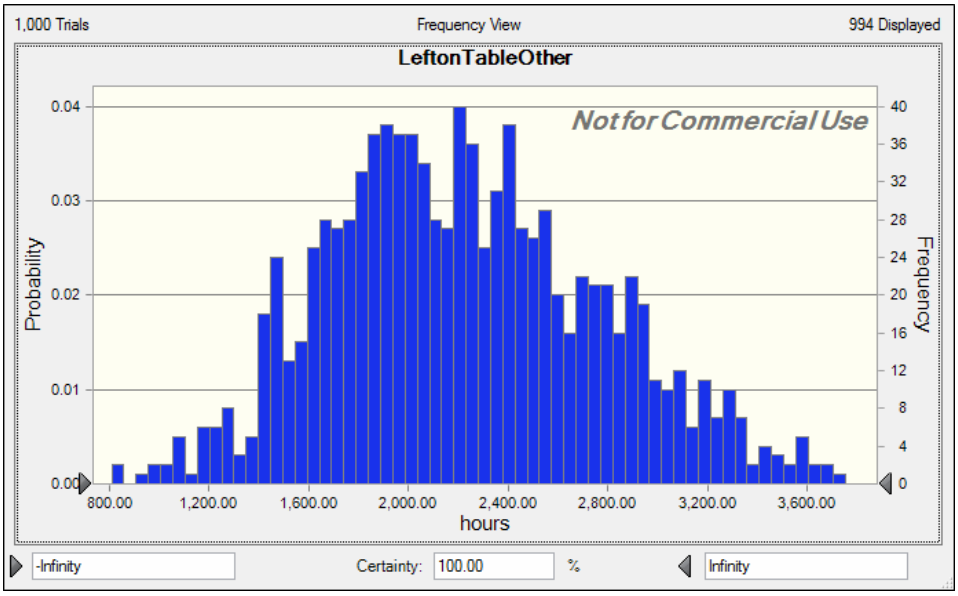


Figure 3 Graphical output for non-tax work left on the table (see online version for colours)



Tabular output from crystal ball displays means and other statistics for output cells. In Figure 2, crystal ball's capability to identify probabilistic levels of output is displayed. Here we asked for the 90% coincidence level, which crystal ball implements by showing the lower 5% output and upper 5% output. We use that as a means to evaluate risk for each policy.

Figure 4 Law clerk billable hours – automate with one-law clerk (see online version for colours)

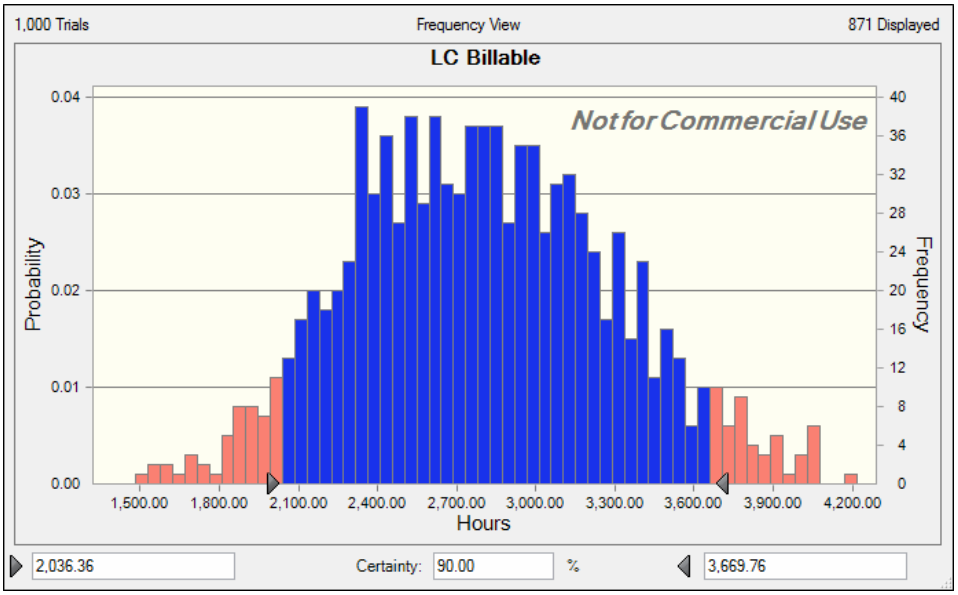


Figure 4 displays the law clerk billable hours for the BPR policy to automate with one-law clerk. It shows that about twice the work is accomplished with one-third the payroll.

Figure 5 shows the graphical display of non-tax work left on the table for this policy. The automated system dramatically changes the distribution of work left-on-the-table.

Figure 5 Non-tax work left on the table for the automated policy (BPR) with one-law clerk (see online version for colours)

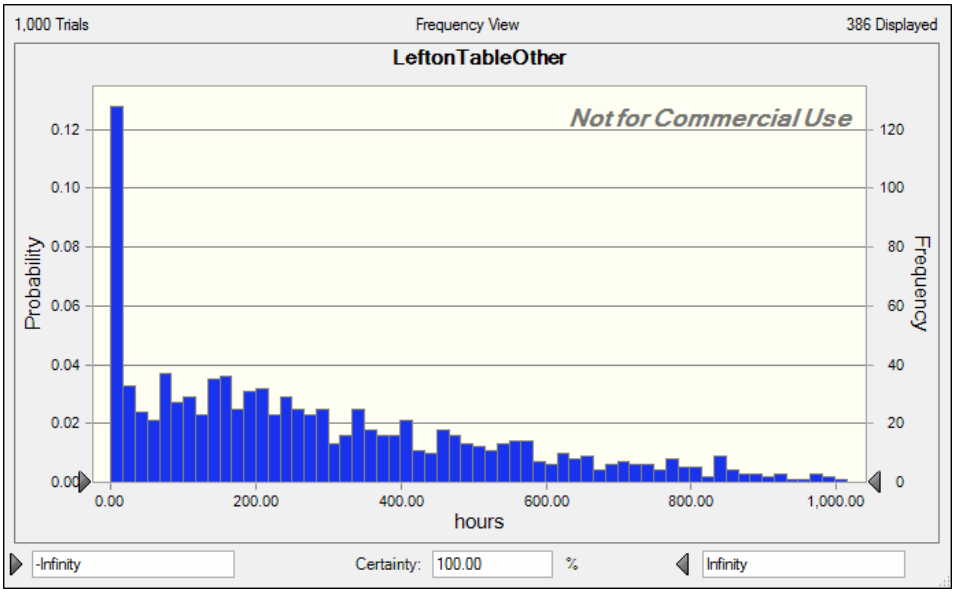


Table 3 displays the output for the models run.

Table 3 Output

Policy	*Law clerk months*	*Law clerk billed hours*	*Undone work*	*Law clerk pay + BPR*	*Law clerk revenue*	*Wasted law clerk time*	*0.95 level LC billed hours*
Three-law clerks	36	1,345.17	2,235.29	90,000	150,659.04	670.83	1,027.49
Four-law clerks	48	1,728.49	2,064.37	120,000	193,590.88	959.51	1,341.95
Five-law clerks	60	2,082.84	1,902.89	150,000	233,278.08	1,277.16	1,596.14
Automate one clerk	12	2,803.22	291.97	30,000*	313,960.64	3,916.78	2,036.36
Automate two clerks	24	3,337.33	11.05	60,000*	373,780.96	10,102.67	2,360.09
Chase	102.88	2,944.37	1,478.55	257,200	329,769.00	2,816.91	1,568.00

In Table 3, Law Clerk revenue is simply Law Clerk Billed hours times 112. Wasted Law Clerk time is Law Clerk Months times 56 minus Law Clerk Billable hours. For the automated systems, available Law Clerk time is Law Clerk Months times 560, as the effect of automation (through BPR) is to enable a law clerk to do ten times the work. This has a dramatic effect on Undone work, reducing it to nearly nothing.

5 Results

The results involve tradeoffs. Extra law clerks always generate more revenue. They also increased wasted law clerk time, but for the initial models with a specific number of clerks, adding clerks always generated more revenue than the assumed pay rate of $30,000 per year. But the models do not consider the added complications from hiring and firing. The chase model is the extreme case in this regard. There are far more law clerk months involved, but the added revenue generated would not pay for the extra clerk time. The chase strategy cannot be considered appropriate in this environment, as Law Clerks cannot be scheduled so cavalierly. Long-term employment considerations mean that they should be viewed as future employees at more senior levels.

Table 4 shows revenue compared with expense, using both the mean billable hours as well as the much more conservative 0.95 level of billed hours.

Table 4 Trade-off results

Policy	*Revenue*	*Payroll*	*Net*	*Conservative revenue*	*Conservative net*
Three-law clerks	150,659	90,000	60,659	115,024	25,024
Four-law clerks	193,590	120,000	73,590	150,298	30,298
Five-law clerks	233,278	150,000	83,278	178,767	28,767
Auto one clerk	313,960	30,000*	283,960	228,072	198,072
Auto two clerks	373,780	60,000*	313,780	264,330	204,330
Chase	329,769	257,200	72,569	175,616	–81,584

The three steady hiring policy results indicate that adding law clerks pays up through at least five clerks. But looking at the conservative figures, the fifth law clerk would not pay for him/herself. The automated systems clearly are much better performing than the non-automated systems. However, this does not consider the cost of BPR and automation. Such costs could easily reach a one-time $500,000, and involve smaller maintenance fees (in ERP systems, maintenance costs are roughly 10% of installation fees). Using just the $500,000, the payback for the automated system with one-law clerk relative to the base three-law clerk system would be $500,000 / ($283,960 – $60,659) or 2.24 years. The same calculation for the automated system with two law clerks yields $500,000 / ($313,780 – $60,659) or 1.98 years. Using the conservative figures yields $500,000 / ($198,072 – $25,024) or 2.89 years for one-law clerk system and $500/000 / ($204,330 – $25,024) or 2.79 years for the two-law clerk system. As with most opportunities to automate, there are promising gains but commensurate risks.

The chase strategy has little attraction. Besides high risk of alienating a future talent pool, there is little to gain. In fact, using the conservative revenue figures, there would be a loss without considering costs of hiring and laying off.

Table 5 provides a comparison table for these policies considering the criteria of resilience, agility, and risk.

Table 5 Table of comparison

Policy	*Resilience*	*Agility*	*Risk*
Steady manning	Stable environment allows for better growth	A fixed system, with high likelihood of supply/demand mismatch	High probability of not covering demand
BPR	If the software vendor is quick to update, can be an advantage; But at the mercy of the vendor	Vast increase in supply makes it highly likely to cover demand	Very good in providing means to deal with growing demand; Involves heavy investment with risk of loss should long-range demand fall
Chase	While hours are quickly responsive to demand change, not appropriate for professional services	While at first glance to most agile, impractical considering the need to develop future resources	The reacting nature of the policy risks losses when faced with fluctuating demand

Resilience involves the ability to adapt to new circumstances. In the legal field, tax laws change, but they always have, and that generates demand for expert services provided by legal specialists. The non-tax business dealt with by law clerks also involves the possibility of change in regulations or legal codes. A steady manning policy allows these newer members of the legal system to learn in a less turbulent hiring environment (they do not have to worry about pink slips each payday). Automation reduces the number of law clerks, but also allows the remaining ones to focus more on change. While software may need to be updated, the vendors should provide such revisions as part of their service. Automation may even provide an advantage during times of change if the vendor is on top of new legal requirements and quickly provides updates. The chase policy implies a turbulent environment not conducive to employee growth nor employee loyalty.

With respect to agility, automation would be expected to have a strong advantage in terms of the ability to respond to increases in demand. It also provides a great improvement in cost efficiency (although the heavy investment required makes it necessary to analyse on a case-by-case basis). The steady hiring policy is unlikely to do well if demand is variable. The chase policy again appears agile, but is impractical in a professional environment.

The risks of a steady manning policy are primarily in not being able to meet demand, as demonstrated in our simulation model output. A great deal of opportunity would be lost. Automation through BPR would provide a means to meet such demand growth, but there clearly is a risk from the investment required. In our study, the risk of demand growth can be examined much as banks examine value-at-risk through assuming a 5% level of demand in addition to considering mean output. In this study, even at that low level, the automation alternative was clearly superior. However, this is just an example – a firm needs to enter its own data. The chase strategy turns out to be the riskiest in our view. Using mean results, while it had a slight net profit advantage relative to a stable policy of three-law clerks, it was inferior to steady policies of four or five-law clerks. Using the 5% level of demand, the chase policy lost money. However, that does

not capture the primary risk of the chase policy – it provides a bad environment for professional growth and development.

6 Conclusions

The planning process for manufacturing firms blends inventory management, capacity management and people management together with intents to maximise profits, minimise cost or to balance these with other objectives in a complex multi-objective framework. While no less complex in service firms, the process places more emphasis on people management. In many situations, inventory is non-existent or of limited consequence and capacity is flexible or easily expandible. People planning, on the other hand, can become even more complex because the 'labourer' is a highly paid professional, like a doctor, lawyer or engineer.

The model presented here captures the essence of a professional service organisation's personnel supply chain. The model provides a simple analysis that demonstrates how trade-offs can be built into a decision situation of this nature and studied using Monte-Carlo simulation. The point is not to provide generalisable results, but rather to demonstrate how a relatively simple decision tool can be used to improve information available for staffing decisions that may have a long term impact. By adjusting parameters relative to the specific needs of the organisation, the decision maker can incorporate different trade-offs in order winners and qualifiers that are appropriate for the decision at hand. The model can be expanded to incorporate many additional complexities that may be appropriate for a given situation, like the economies accrued by simultaneously training multiple law clerks rather than bring them along one at a time, or bring in automated processes that may affect the rate of learning for new hires. Thus it offers a unique model to assess personnel management in a professional setting.

Given the results presented here, it is conceivable that this model could be extended to other professional service organisations. Medical facilities, for example, can look to balance the workload between doctors, physician's assistants, nurse practitioners, etc., while emergency rooms may look to balance in-house staffing with on-call physicians. The method itself is dependent on the application such that no one solution fits all organisations, but rather emphasis is placed on the flexibility of the method such that it can easily be adjusted to the application at hand and the best result can be identified.

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Appendix

Tax and non-tax hours

Figure 6 Tax hours (see online version for colours)

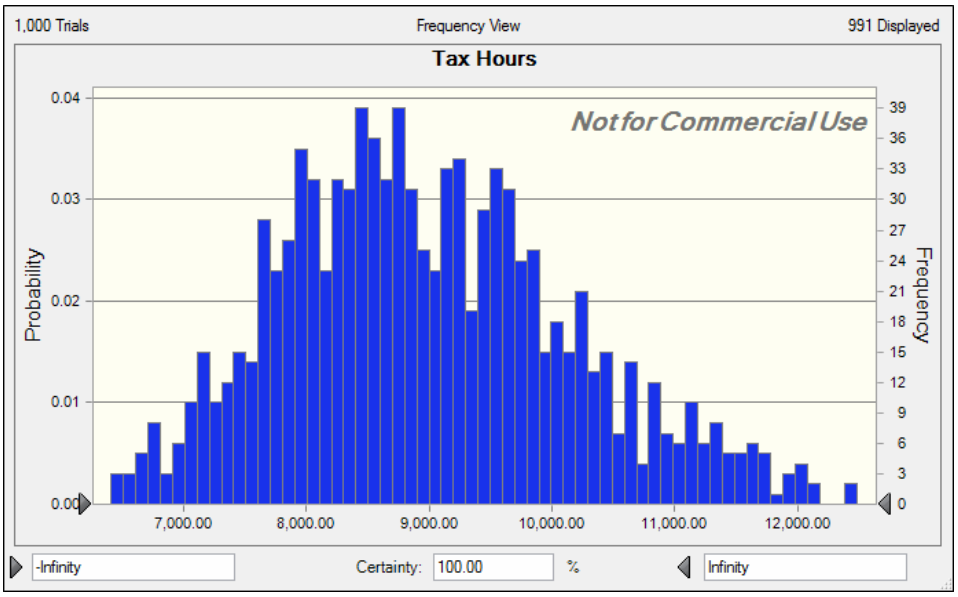

Figure 7 Non-tax hours (see online version for colours)

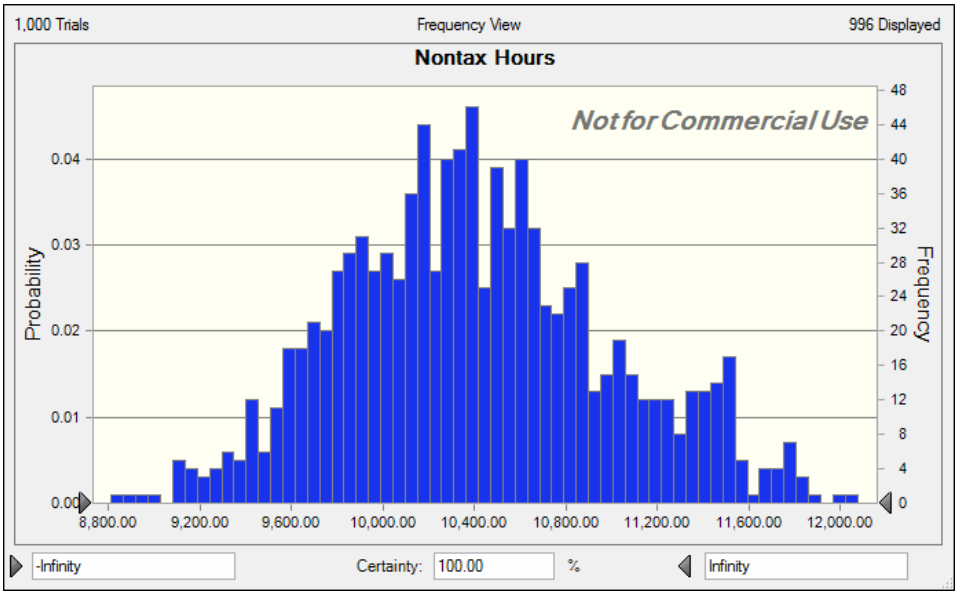

Table 6 Comparative statistics for output

Forecast	*Tax hours*	*Non-tax hours*	*Law clerk billable hours*
Statistic			
Trials	1000		
Mean	9,016.23	10,411.47	1,345.17
Median	8,859.76	10,374.28	1,344.00
StD	1,237.24	594.20	192.99
Skewness	0.6496	0.3093	0.0293
Kurtosis	3.76	2.93	2.79
Coeff. of variability	0.1372	0.0571	0.1435
Minimum	6,411.70	8,813.26	701.43
Maximum	15,134.02	12,639.51	1,858.15
Mean std. error	39.13	18.79	6.10