USING MARKOV ANALYSIS FOR WORKFORCE PLANNING

Christina Thompson M.A. & Frank Igou Ph.D.

Louisiana Tech University

AGENDA

- Current issues facing the workforce
- Workforce planning
- Markov chains and analyses
- Using Markov in workforce planning
- Questions

CURRENT WORKFORCE ISSUES

AGING WORKFORCE — The number of working adults over the age 55 doubled in last 20 years

DELAYED RETIREMENT — Life expectancy has increased by 9 years since 1970

LOWER BIRTHRATES — Less workers entering workforce, smaller growth for 16 to 24 and 25 and 35

DIVERSITY — Workforce demographics changing

ORGANIZATIONAL IMPACTS OF WORKFORCE ISSUES

MASS EXODUS

Large number of adults leaving the workforce in the next 20 years

LABOR SHORTAGE

More employees leaving the workforce than entering the workforce

LOSS OF KNOWLEDGE

Decades of cumulative knowledge and experience

RESOURCES

Loss of time and capital operating reactively instead of proactively

WORKFORCE PLANNING

- Involves analyzing, forecasting, and planning workforce supply and demand
- Identifying gaps, and deciding on targeted talent management interventions
- Ensure the right people, with the right skills, in the right places, at the right time, to carry out its mission and achieve its strategic goals

ADVANTAGES OF WORKFORCE PLANNING

PLANNING

Meet operating requirements, expansion, growth, downsizing

INFRASTRUCTURE

Recruiting, training, performance management, knowledge sharing

PROACTIVE

Prepare for unforeseen events and forces and develop plans to deal with them

WORKFORCE PLANNING PROCESS

SUPPLY ANALYSIS

Identfying compentiecies, demographics, trends for baseline of existing staff

DEMAND ANALYSIS

Forecasts the demographics, workloads, activities, and competencies that will affect future needs

GAP ANALYSIS

Compare suppy and demand to understand the difference in current and future workforce

SOLUTION ANALYSIS

Development of organizational strategies intended to close the gap

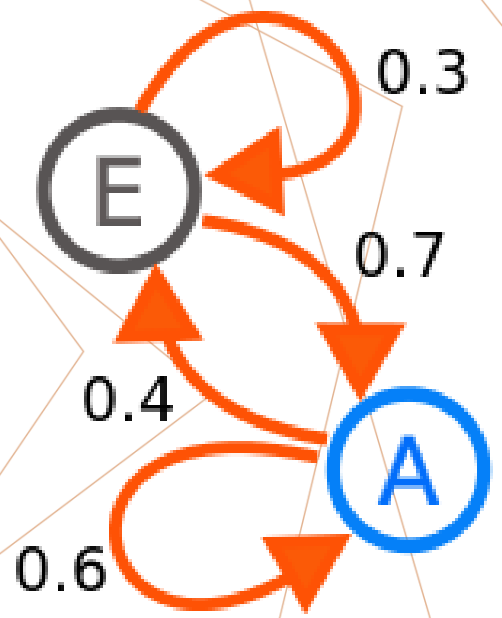
WORKFORCE PLANNING TECHNIQUES

- Ratio and Trend Analyses
- Judgmental Forecasting
- Box Grid
- HR Dashboarding
- Transition Analysis*

MARKOV ANALYSIS

- Uses historical information about the percentage of employees that transition in and out of positions
- Probabilities in conjunction with current labor supply
- Forecast needs and surplus in each position for the next period
- Traditionally not practical for large organizations with complicated hierarchies
- Technological advances and machine learning methods

INTRO TO MARKOV CHAINS



- Based on the theory of finite matrices that have a random probability distribution pattern
- Analyzes the transition probability from one state to any other state,
- Memoryless - based only on the current state
- Can be visualized as a matrix or a process
- Useful for any time-series process

MARKOV TYPES

- Countable (finite) state space
- Measurable state space

- Discrete-time
- Continuous-time

- Homogenous (independent of time)
- Absorption (a state that cannot be transitioned out of)

MARKOV EXAMPLE

(Adapted from Philip & Gully, 2015)

SUPPLY ANALYSIS

in each position

Position	Job Level	Job Level Description	Current number of employees
Full-time Customer Service	1	Entry-level	400
Part-time Customer Service	1	Entry-level	150
Supervisor	2	Mid-level	75
Manager	3	Upper-level	20

MARKOV TRANSITION MATRIX

Top row represents position transitioned to

Transition probabilities

Represents turnover

Start\end	FTCS	PTCS	SUP	MGR	EXIT
FTCS	.40	.10	.10	.0	.40
PTCS	.20	.50	.5	.0	.25
SUP	.5	.0	.85	.5	.5
MGR	.0	.0	.0	.65	.35

Position starting from

This column equals to 100

FORECAST OF EMPLOYEES IN EACH POSITION

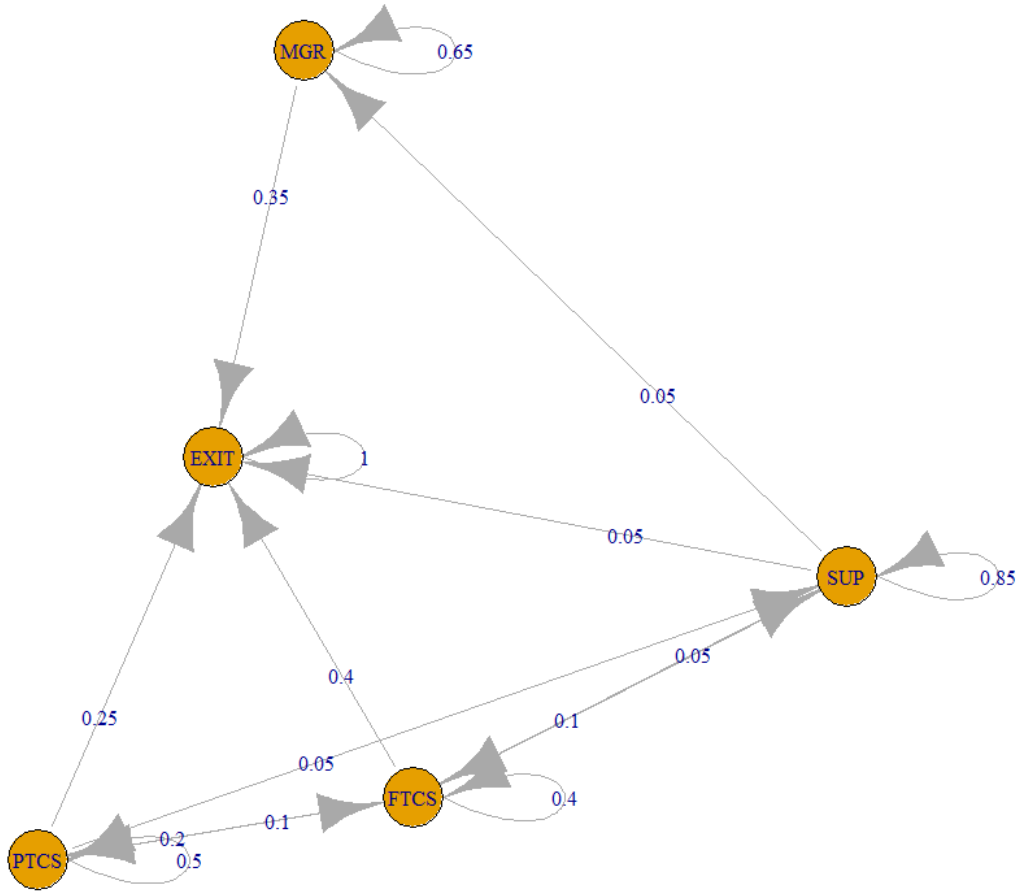
Diagonal values represent number that will remain in position

Position	FTCS	PTCS	SUP	MGR	EXIT
FTCS	**160**	40	40	0	160
PTCS	30	**75**	8	0	37
SUP	4	0	**64**	4	3
MGR	0	0	0	**13**	7
Forecasted Totals	**194**	**115**	**112**	**17**	**207**

FORECAST OF EMPLOYEES OVER 5 YEARS

Position	FTCS	PTCS	SUP	MGR	EXIT
Current - 2021	400	150	75	20	0
Year 1- 2022	194	115	111	17	208
Year 2- 2023	106	79	120	16	326
Year 5 - 2026	28	20	97	16	484

LIMITATIONS



COMPLEX SYSTEMS

Dynamic, constantly changing, adjusting probabilities

RELIABILITY

Accuracy threshold, n > 500, positions with few transitions unstable

DEPENDENCIES

Economy, inflation, labor market

NOTABLE RESEARCH

HENEMAN & SANDVER (1977)

Used a DTMC to analyze the flow of managers and employees through the organization from 1964 to 1965, then estimate the distribution of the internal labor force in 1969, a four-year forecast

GUERRY & DEFEYTER (2012)

Demonstrated the cost-effectiveness and utility of using a Markov model using 9 years of historical data for a multilevel organization in IBM's CPLEX Optimizer software

BANYAI ET AL., (2018)

Demonstrated an absorbing MC simulation as functional to analyze a hierarchical HR promotion system

JEN, ZHEN, & SHEN (2020)

Used a SMC to forecast employee turnover depending on the conditional probability vectors of training, promotions, and education thereby demonstrating MC ability to predict on the job mobility

MARKOV ANALYSIS IN R

```
R 4.0.5 · C:/Users/can2c/Dropbox/PC (2)/Documents/R/RMarkov/
> mcEmployee <- new("markovchain", states = c("FTCS", "PTCS", "SUP", "MGR", "EXIT"),
+                   transitionMatrix = matrix(data = c(0.4, 0.1, 0.1, 0.0, 0.4, 0.2, 0.5, 0.05, 0.0, 0.25,
+                                                      0.05, 0.0, 0.85, 0.05, 0.05, 0.0, 0.0, 0.0, 0.65, 0.35,
+                                                      0.4, 0.25, 0.0, 0.35, 0.0), byrow = TRUE, nrow = 5),name = "Employee")
>
> mcEmployee  ##Print Markov Chain
Employee
 A  5 - dimensional discrete Markov Chain defined by the following states:
 FTCS, PTCS, SUP, MGR, EXIT
 The transition matrix  (by rows)  is defined as follows:
     FTCS PTCS  SUP  MGR EXIT
FTCS 0.40 0.10 0.10 0.00 0.40
PTCS 0.20 0.50 0.05 0.00 0.25
SUP  0.05 0.00 0.85 0.05 0.05
MGR  0.00 0.00 0.00 0.65 0.35
EXIT 0.40 0.25 0.00 0.35 0.00

>
> initialState1 <- c(1, 0, 0, 0, 0)  ##conditional probability if employee is FTCS
> initialState2 <- c(400, 150, 75, 20, 0) ##state values
> after1aPE <- initialState1 * (mcEmployee * mcEmployee)  ##after 1 Performance Evaluation or 1 year/conditional
> after1aPE
      FTCS PTCS  SUP   MGR EXIT
[1,] 0.345 0.19 0.13 0.145 0.19
>
> after1bPE <- initialState1 * mcEmployee  ##after 1 Performance Evaluation or 1 year/conditional
> after1bPE
     FTCS PTCS SUP MGR EXIT
[1,]  0.4  0.1 0.1   0  0.4
>
```

MARKOV ANALYSIS IN R

```
>
> after1bPE <- initialState1 * mcEmployee  ##after 1 Performance Evaluation or 1 year/conditional
> after1bPE
     FTCS PTCS SUP MGR EXIT
[1,]  0.4  0.1 0.1   0  0.4
>
> after1PE <- initialState2 * (mcEmployee * mcEmployee)  ##After 1 Performance Evaluation or 1 year/State
> after1PE
         FTCS     PTCS      SUP     MGR    EXIT
[1,] 189.3625 128.9375 119.6875 89.3375 117.675
>
> after5PE <- initialState2 * (mcEmployee ^ 5)  ##After 5 years/State
> after5PE
         FTCS     PTCS     SUP      MGR     EXIT
[1,] 140.9247 102.2817 130.071 134.7237 136.9989
```

MARKOV MODEL ADVANCES

SEMI MARKOV CHAIN

State dependent and random or dependent time

HIERARCHICAL MARKOV MODEL

Account for multiple levels and division, complex transitions

MARKOV CHAIN MONTE CARLO

Simulation of probabilities and expectations by averaging over the simulations

HIGHLIGHTS OF ADVANCES

- Integrated machine learning and Monte Carlo algorithms
- Forecast beyond one transition
- Consider posterior probabilities in addition to current state
- Increase accuracy and forecasting of labor needs and trends

SUMMARY

- Issues affecting the workforce and organizations
- Workforce planning as one strategy to overcome these issues
- Markov analysis and a brief review
- Advances in technology increases the flexibility and relevance of Markov tools in workforce planning

QUESTIONS

THANK YOU

Send inquiries to:

Christina Thompson

830-237-6601

can2c33@gmail.com

www.can2c33.com