Retention Analysis Modeling for the Acquisition Workforce

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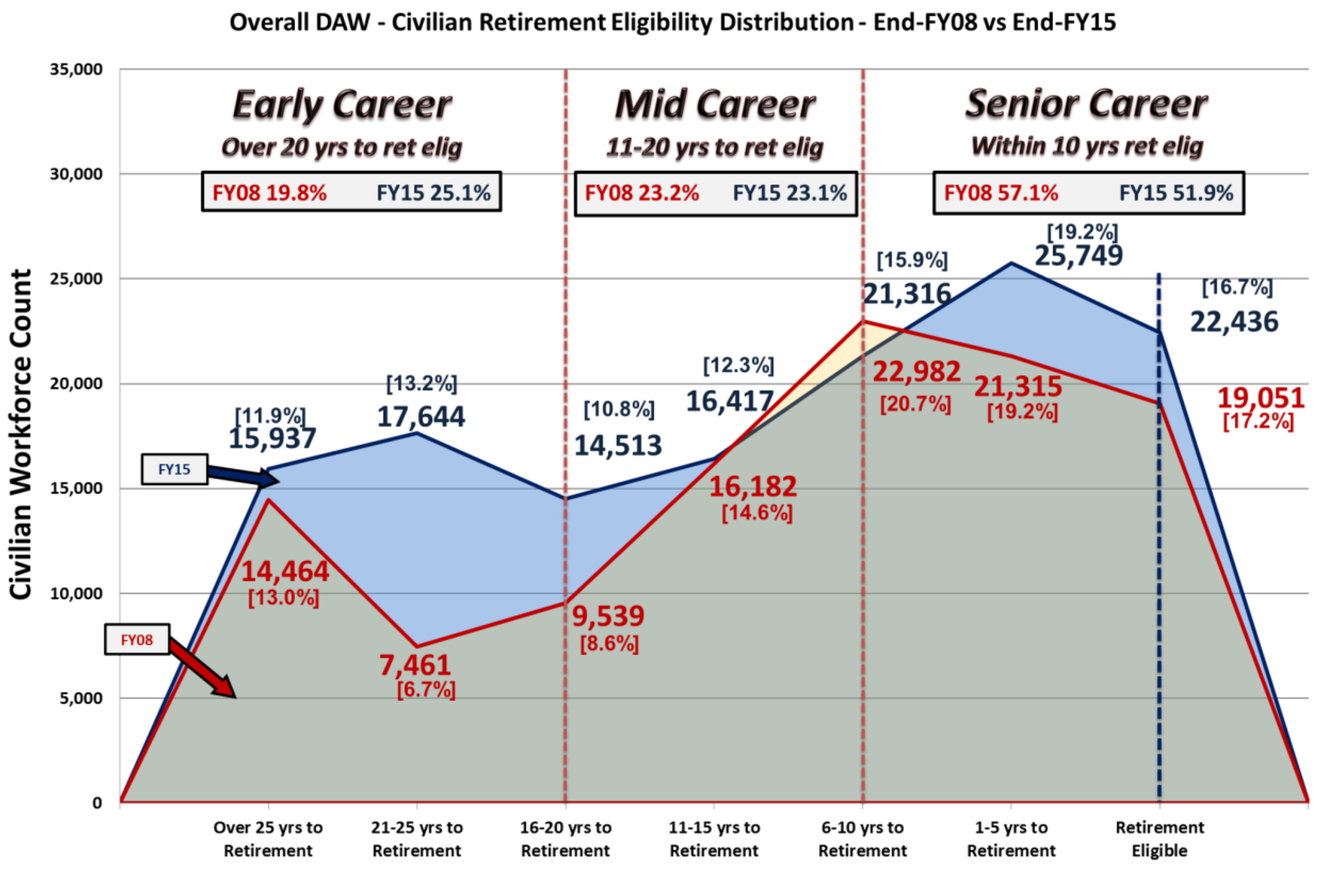
Motivation

- How can we utilize personnel policy to more efficiently reshape AWF?
- How can we prevent the “bathtub” in the first place?



Plan of Attack

1. Look back at attrition patterns using Cox proportional hazard model.
2. Create Dynamic Programming Model based on insights from survivor model.
3. Project forward and simulate AWF evolution in response to optimal hiring/firing/compensation decisions.

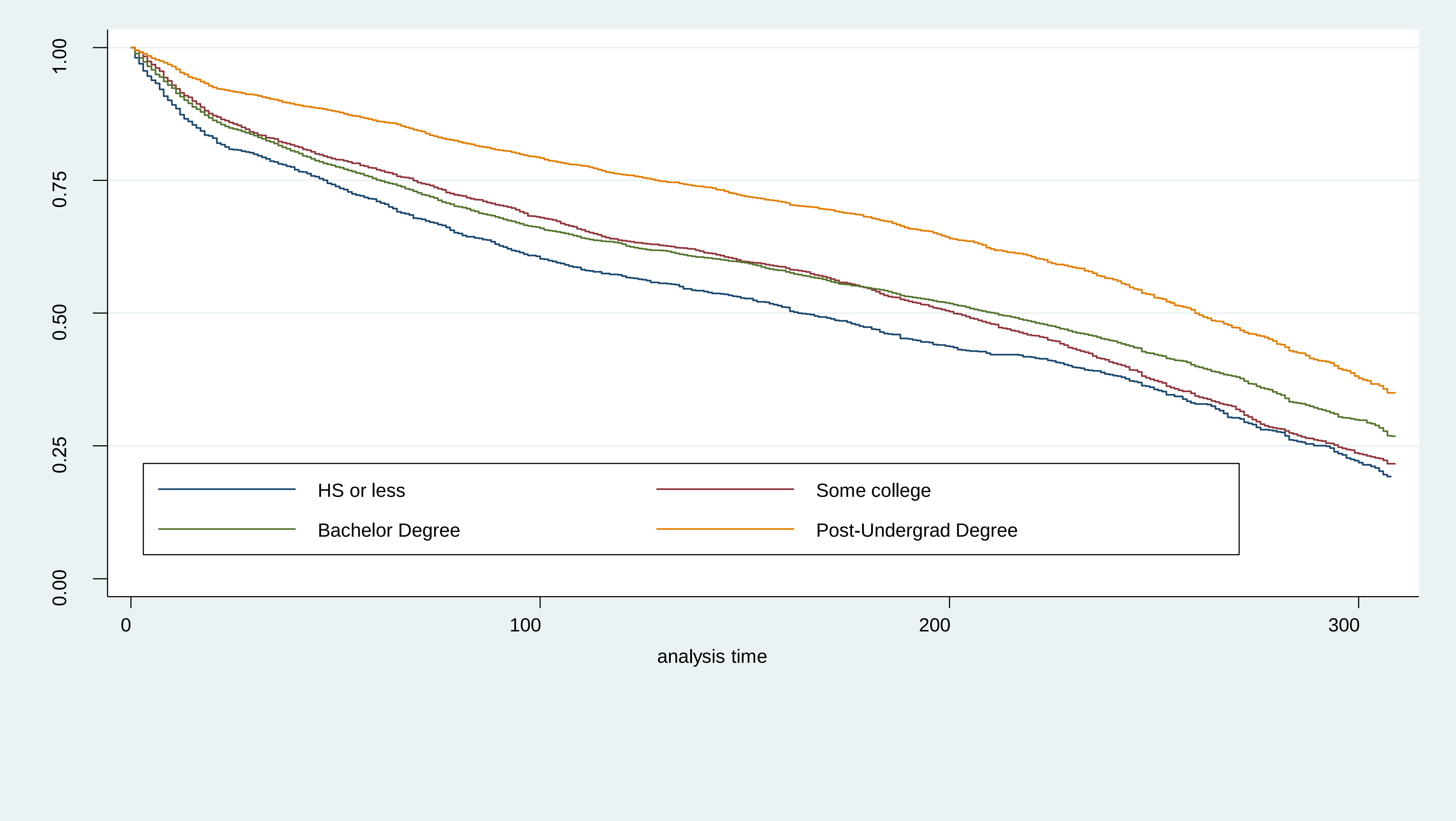
Table 2. Summary Statistics for the DoD Acquisition Workforce. Source: DMDC (2019).

Variables		Mean (Std. Dev) [Min/Max]
Female		0.632
White		0.776
African-American		0.222
Hispanic		0.045
Asian		0.081
Native American / Native Alaskan		0.011
Has Identified Disability		0.202
Prior Military Service		0.619
Has Bachelor's Degree		0.547
Has Post-graduate Degree		0.332
Gained Additional Education in AWF		0.441
Career Length in AWF (in months)		143.6 (103.8) [1 / 309]
Age at Entry		33.0 (8.2) [15 / 65]
Age at Exit		48.2 (10.55) [20 / 68]
Position Type:	Professional	0.657
(Ever Held)	Technical	0.245
	Blue-Collar	0.018
	White-Collar	0.297
Ever Ranked Not Fully Satisfactory		0.575
Highest Salary		95,143.67 (30,410.74) [27,397 / 189,600]
Observations		13,590

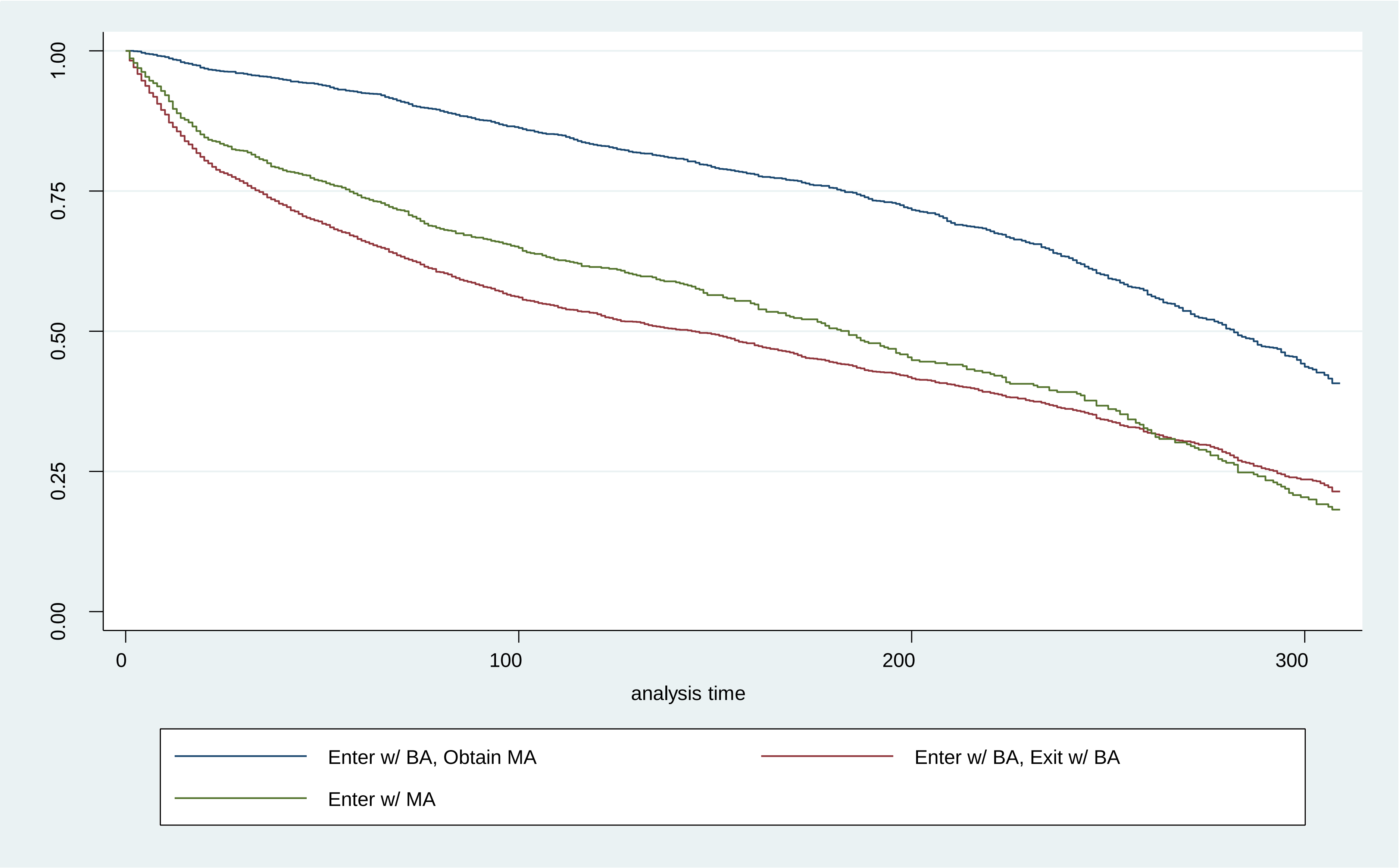
Table 4. Cox Proportional Hazard Model Parameter and Hazard Ratio Estimates

	Model 1		Model 2		Model 3		Model 4	
	Coef.	Hazard	Coef.	Hazard	Coef.	Hazard	Coef.	Hazard
Female	-0.1866*	0.8298	-0.2292*	0.7952	-0.1619*	0.8505	-0.1126*	0.8935
	(0.0252)	(0.000)	(0.0259)	(0.000)	(0.0262)	(0.000)	(0.0261)	(0.000)
African-Am.	-0.0214	0.9789	-0.0250	0.9753	0.0008	1.0008	0.0573	1.0590
	(0.0291)	(0.463)	(0.0292)	(0.391)	(0.0292)	(0.978)	(0.0293)	(0.051)
Hispanic	-0.0492	0.9520	-0.0625	0.9394	-0.0247	0.9756	0.0352	1.0358
	(0.05461)	(0.368)	(0.0546)	(0.252)	(0.0547)	(0.652)	(0.0548)	(0.520)
Native Am.	-0.0414	0.9594	-0.0501	0.9511	0.0306	1.0311	-0.0090	0.9910
	(0.1178)	(0.725)	(0.1178)	(0.671)	(0.1179)	(0.795)	(0.1178)	(0.939)
Disability	-0.1331*	0.8754	-0.1312*	0.8771	-0.1154*	0.8910	-0.0723§	0.9303
	(0.0327)	(0.000)	(0.0327)	(0.000)	(0.0327)	(0.000)	(0.0328)	(0.028)
Prior Military	-3.0036*	0.0496	-2.9681*	0.0508	-2.9652*	0.0516	-3.0574*	0.0470
	(0.0358)	(0.000)	(0.0361)	(0.000)	(0.0364)	(0.000)	(0.0384)	(0.000)
BA degree	-	-	-0.1069*	0.8986	-0.0050	0.9950	0.0319	1.0324
			(0.0242)	(0.000)	(0.0275)	(0.841)	(0.0267)	(0.231)
Post-BA	-	-	-0.1598*	0.8523	-0.0051	0.9949	-0.0626§	0.9393
			(0.0282)	(0.000)	(0.0297)	(0.863)	(0.0314)	(0.046)
Add’n Degree	-	-	-	-	-0.4513*	0.6368	-0.3025*	0.7389
					(0.0272)	(0.000)	(0.0274)	(0.000)
Professional	-	-	-	-	-	-	-1.2607*	0.2835
							(0.0295)	(0.000)
Technical	-	-	-	-	-	-	-1.0919*	0.3356
							(0.0359)	(0.000)
Deficient Rank	-	-	-	-	-	-	-1.2102*	0.2981
							(0.0328)	(0.000)
Observations	1,951,719		1,951,719		1,951,719		1,951,719	
-ln L	63,297.701		58,795.086		58,652.802		57,393.441	

Note: §, * denote statistical significance at the 5% and 1% levels. For coefficient estimates, standard errors are in parentheses. For Hazard ratios, P-values are in parentheses.



1.00
0.75
0.50
0.25
0.00
0
100
200
300
analysis time
HS or less
Some college
Bachelor Degree
Post-Undergrad Degree


1.00
0.75
0.50
0.25
0.00
0
100
200
300
analysis time
Enter w/ BA, Obtain MA
Enter w/ BA, Exit w/ BA
Enter w/ MA

Dynamic Retention Model

$$V_t^L = W_t^c + \omega^c + \beta E_t\left[V_{t+1}^L\right] + \varepsilon_t^c = \sum_{\tau=t}^{T} \beta^{\tau-t}(W_\tau^c + \omega^c) + \varepsilon_t^c, \qquad (1)$$

$$V_t^S = W_t^m + \omega^m + \beta E_t[V_{t+1}] + \varepsilon_t^m, \qquad (2)$$

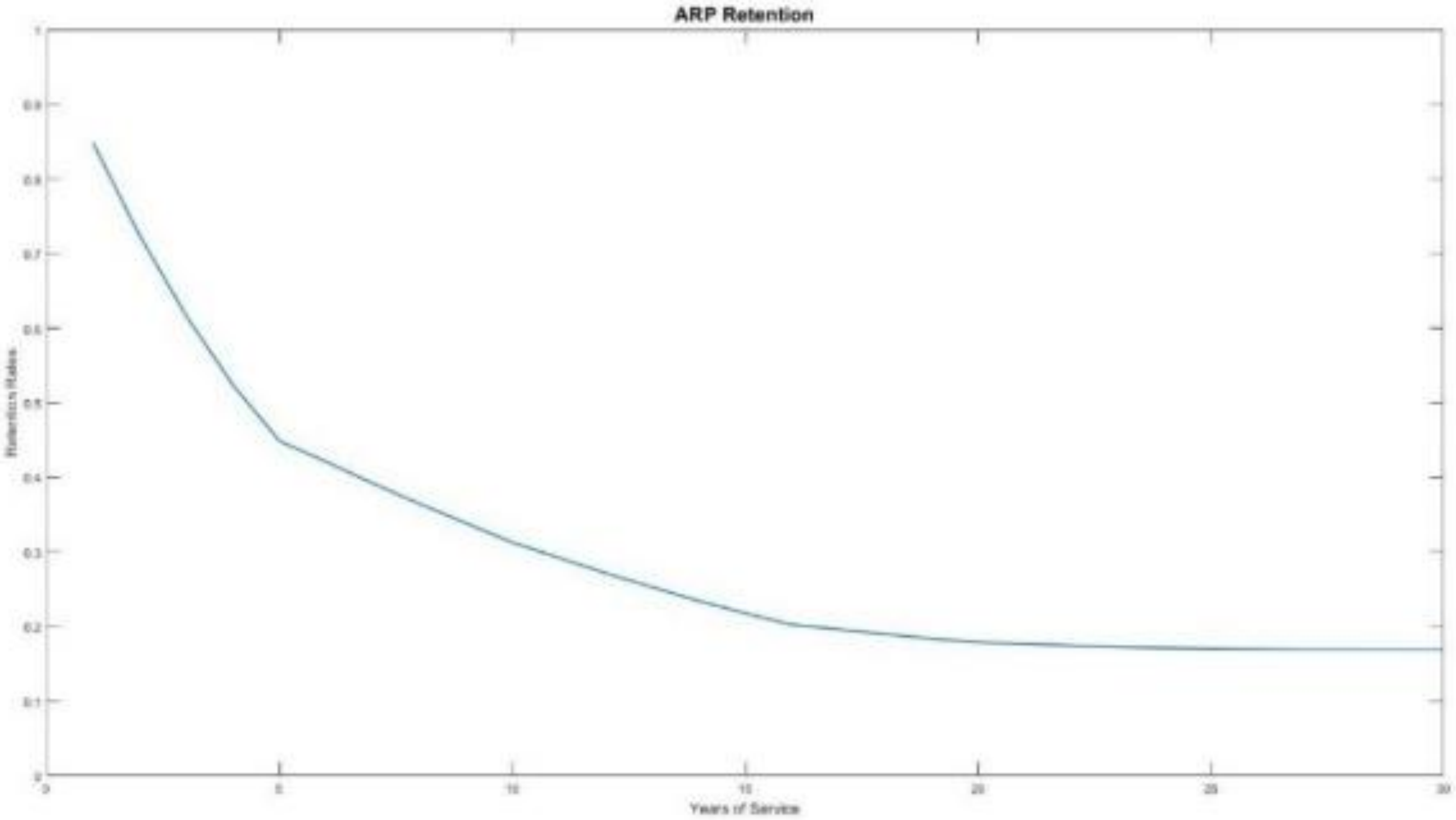
$$V_t = Max\left[V_t^L, V_t^S\right] \qquad (3)$$

- W_t^m : compensation the worker earns in period t
- W_t^c : compensation the worker earns outside the AWF in period t
- T : time horizon of the decision problem
- $\beta = \frac{1}{1+r}$: discount factor. r is the subjective discount rate of worker
- ω^c : taste parameter that captures monetary equivalent of preference for civilian life
- ω^m: taste parameter that captures monetary equivalent of preference for AWF/mil. work
- $E_t[.]$: expectation operator given the information in period t
- ε_t^c and ε_t^m : random shocks with zero mean

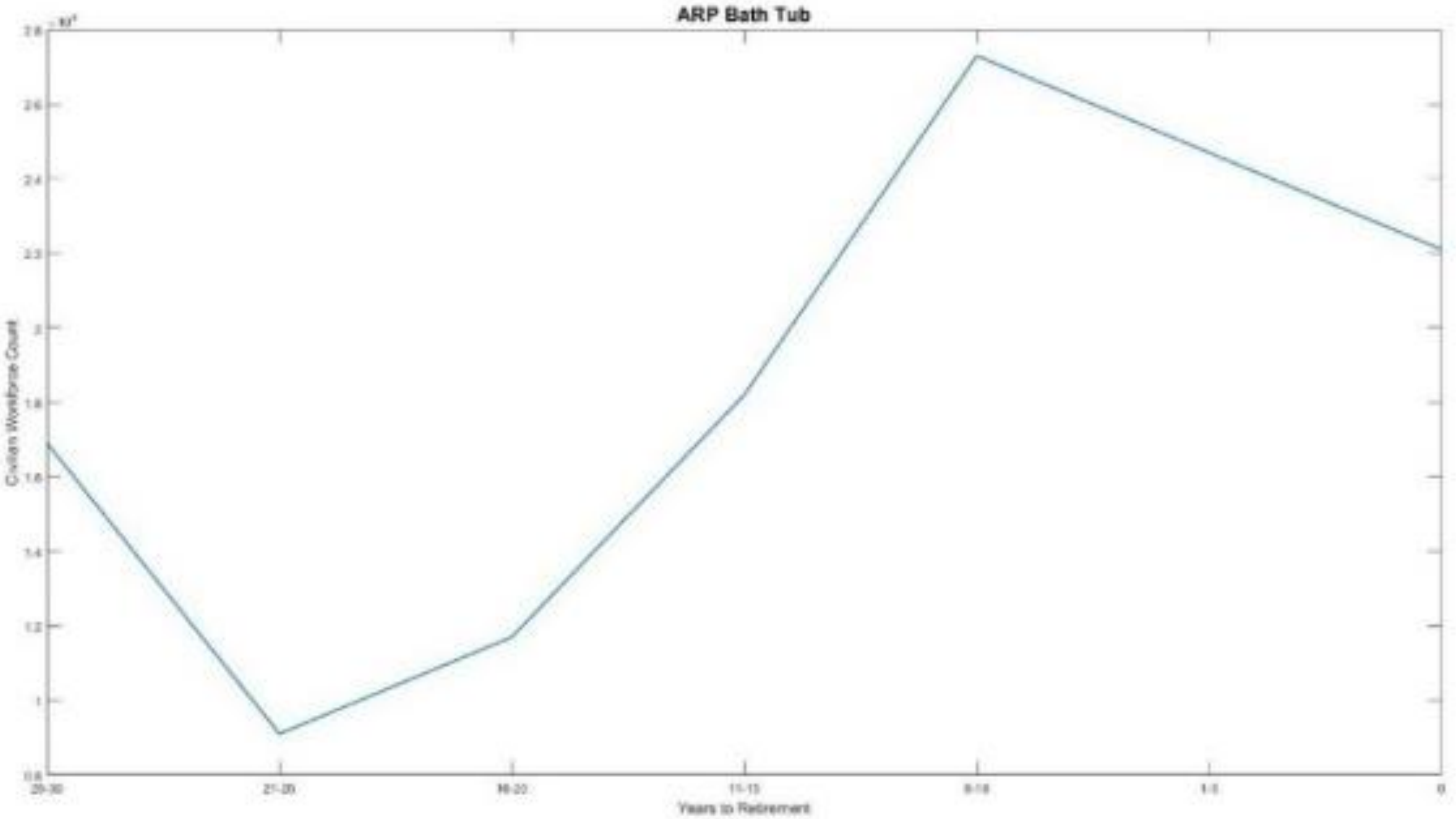
Table 6. Initial Parameter Values

Parameter	*Value*
$W_t^{\ m}$	1
$W_t^{\ c}$	1
T	30
β	0.95
ω^m	0.1
ω^c	0.1
$\mu_{\varepsilon,m}$	0
$\mu_{\varepsilon,c}$	0
$\sigma_{\varepsilon,m}$	0.1
$\sigma_{\varepsilon,c}$	0.1

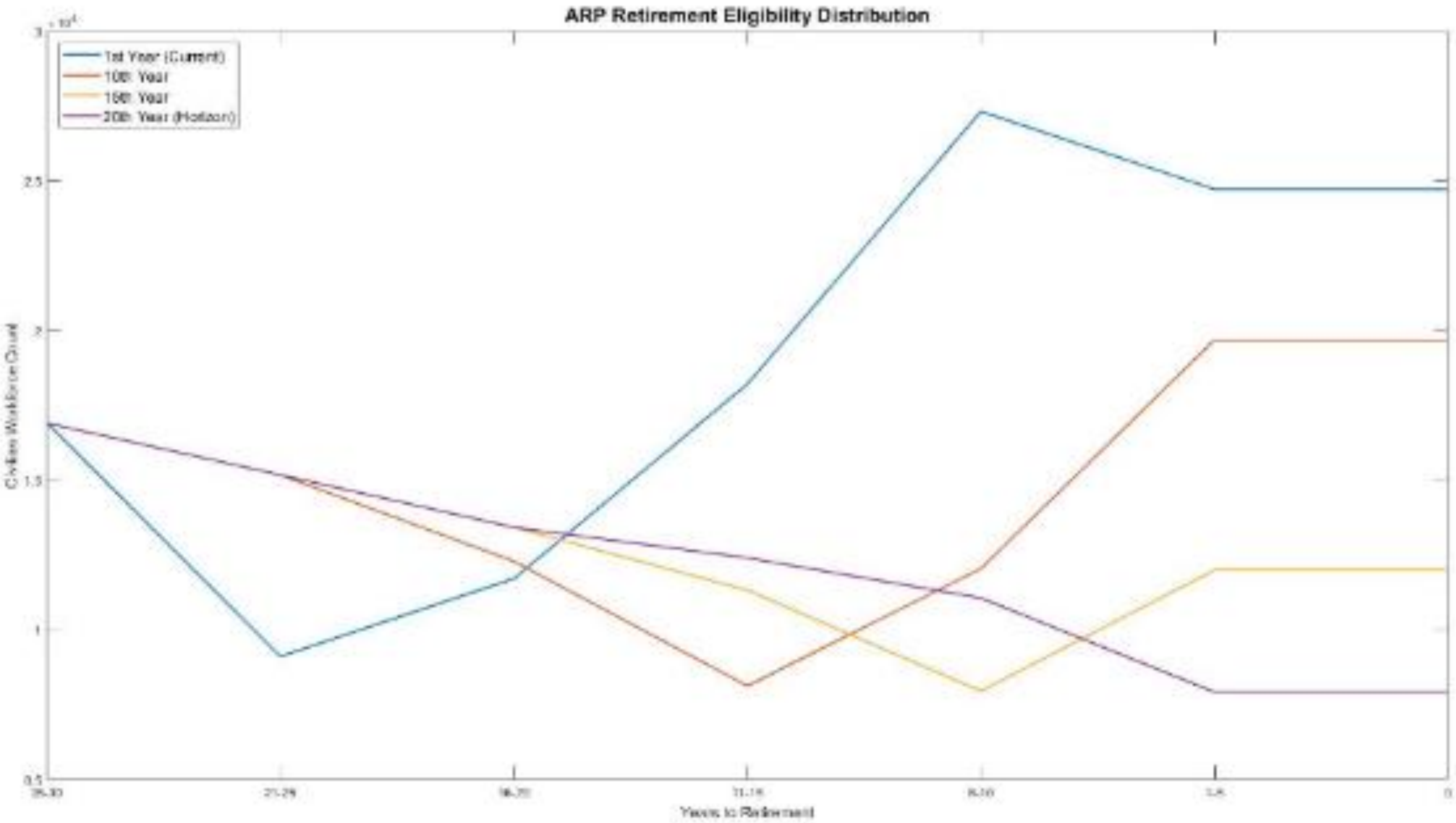
Individual Retention Decision Simulation



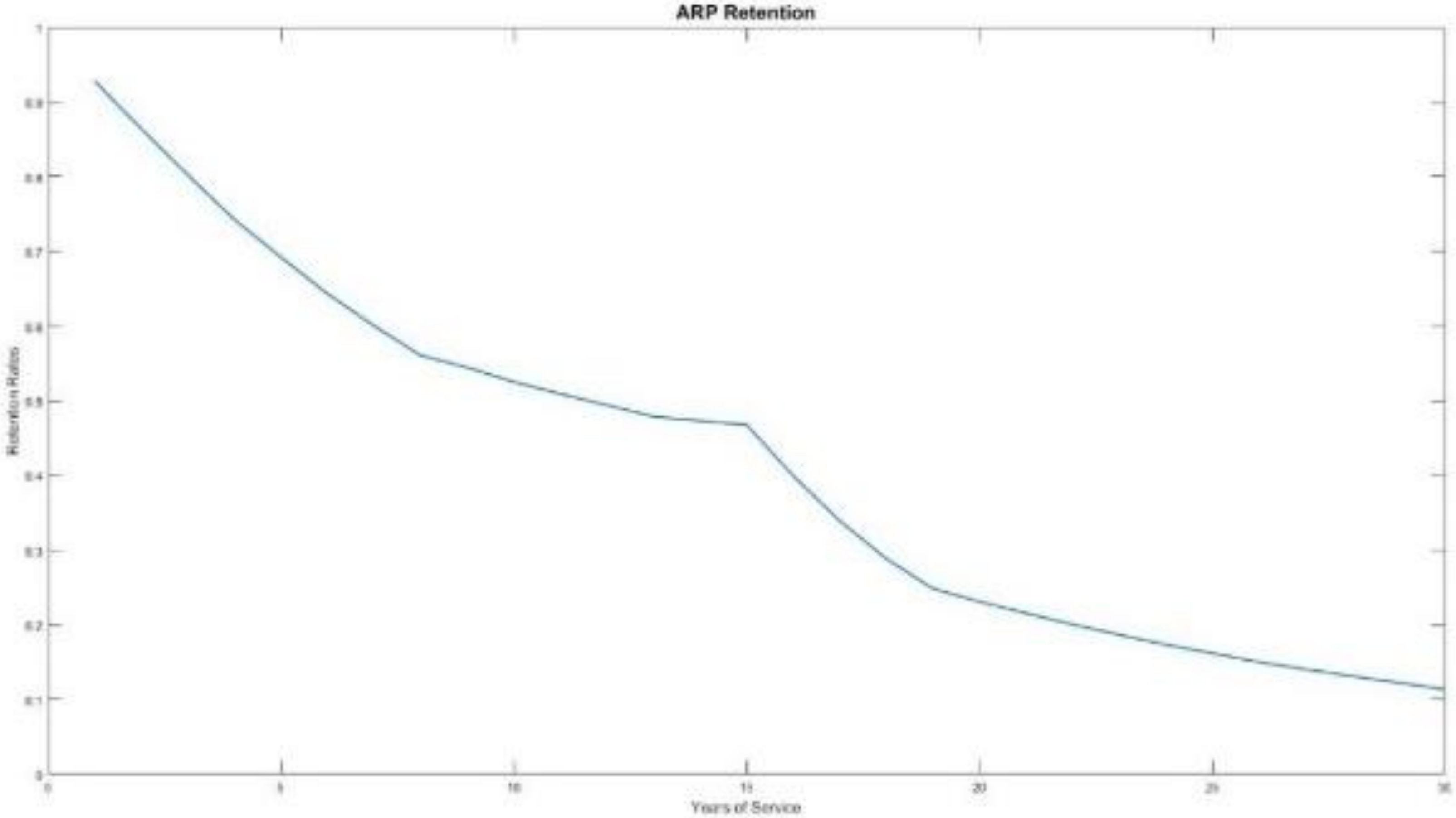
Simulation of “Bathtub” Experience Distribution of AWF



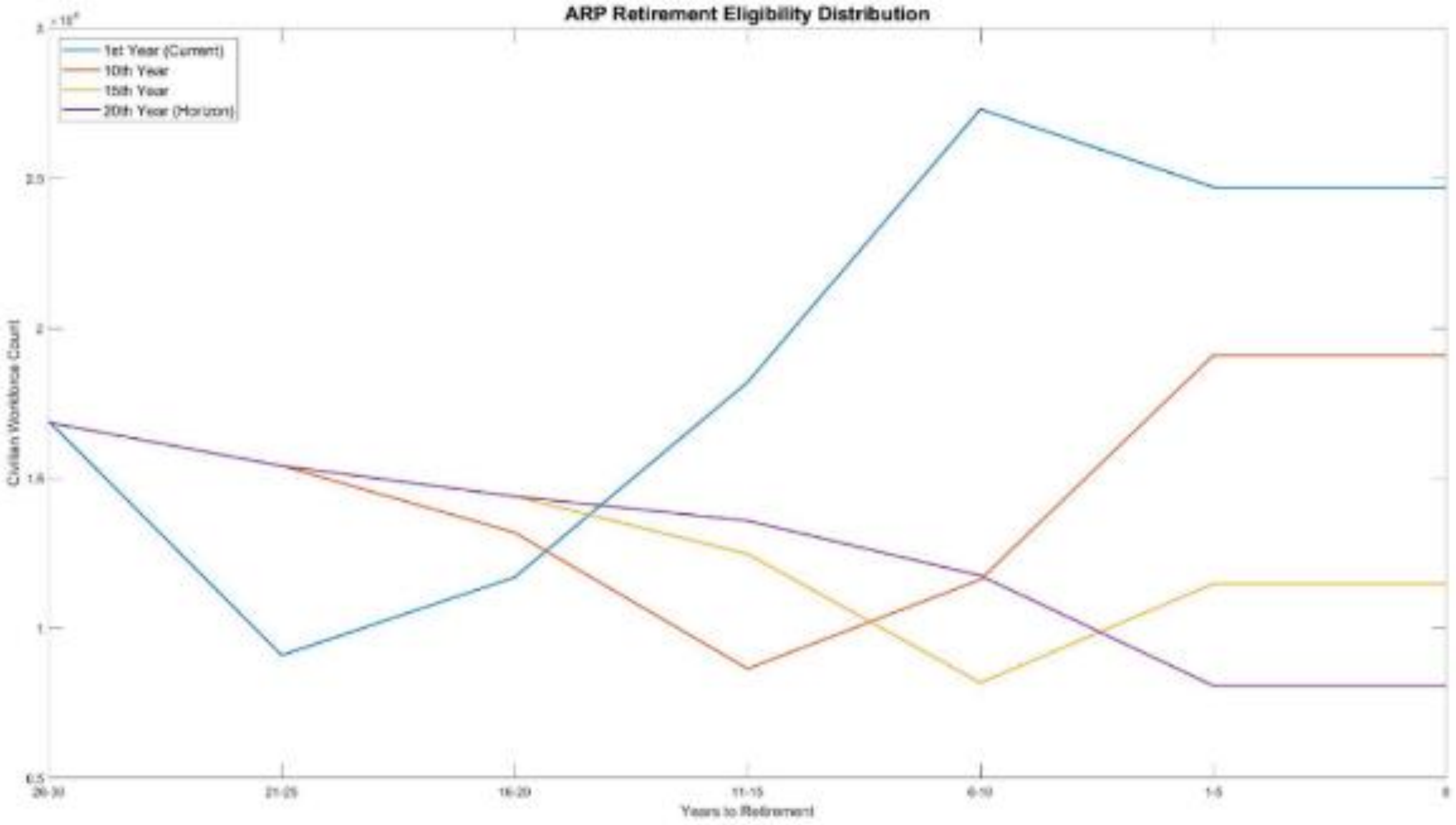
Dynamic Simulation of Evolution of AWF Workforce with Zero Active Intervention



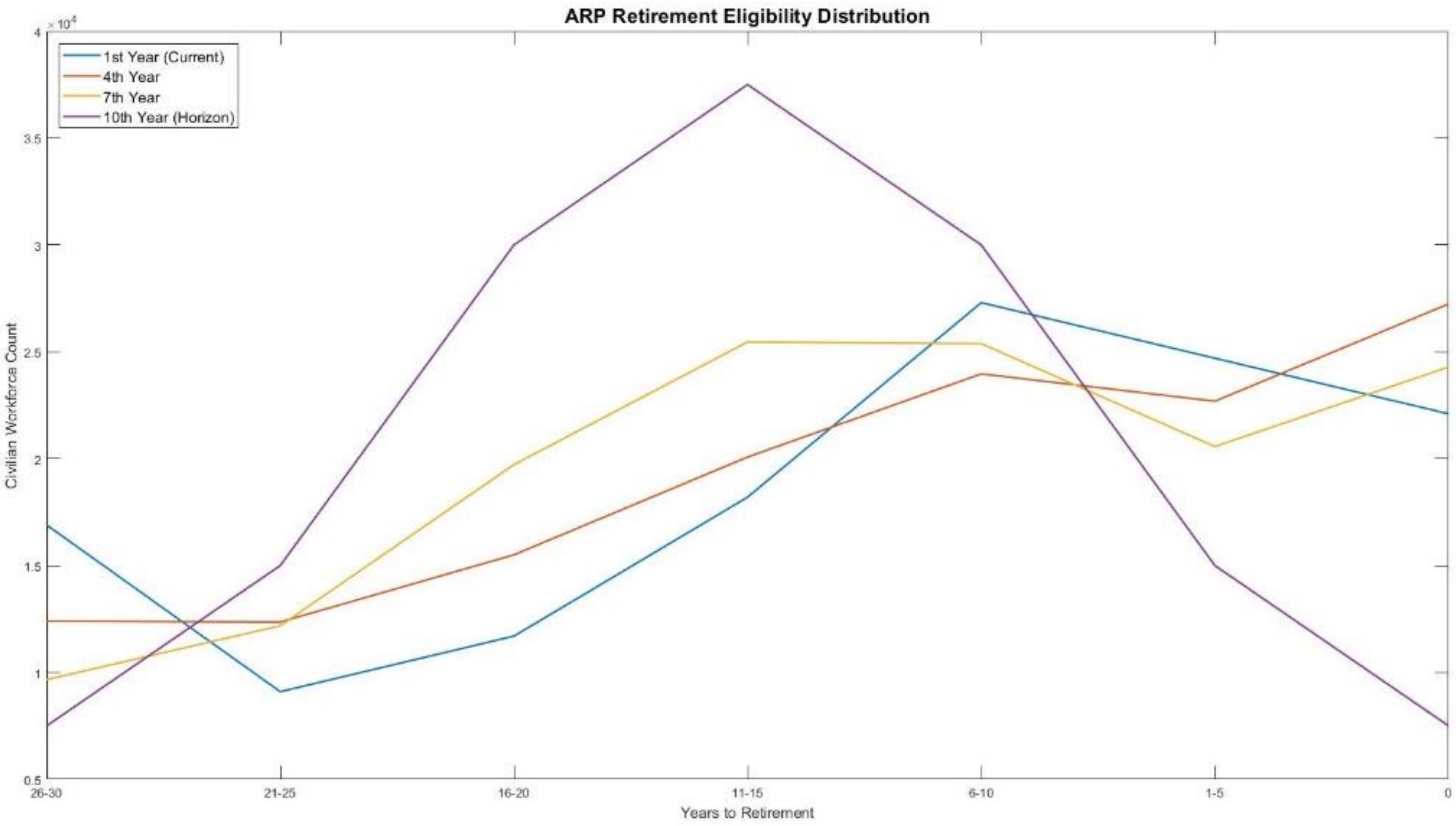
Individual Retention Decision with one-time 15% bonus at Yr. 15



Dynamic Simulation of Evolution of AWF Workforce with One-time Bonus Intervention



Dynamic Simulation of Evolution of AWF Workforce with Active Intervention



Conclusions (1)

- From Cox Proportional Hazard Model :
  - Prior military experience impacts career longevity.
  - Higher education level is positively correlated with career longevity.
  - Workers who acquired additional education while working are likely to stay even longer.
  - Implies leadership can upgrade productivity *and* retain its best people by encouraging and perhaps even subsidizing continuing education.

Conclusions (2)

- From DRM (Dynamic Programming):
  - Models a worker who makes rational, time-consistent decisions about whether to stay in the workforce or leave at each point in time.
  - Forecasts what workforce would look like as it matured through time.
  - Demonstrates that one-time interventions cannot substantively change the shape of AWF.
  - Provides step-by-step “recipe” of number of workers with how much experience to hire/terminate each year to achieve desired shape.

Next Steps

- Empirically estimate model using Rust-Nested-Fixed-Point and data from AWF to estimate model parameters.
- Run new simulations with other incentive policies.
- Incorporate “outside option” that change with strength of economy.
- Include additional decisions besides stay/leave – ex. Investment in education.