Worklife and Unemployment: A New Consideration

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Abstract

Do traditional two-state worklife estimates need adjustment for unemployment? To answer, an augmented three-state model classifies individuals as either 1) employed; 2) unemployed; or 3) inactive but not marginally attached. Periods of unemployment may reduce worklives; however, removal of those marginally attached or discouraged from the inactive state raises worklives. The three-state model results are compared to worklife estimates from the same initial data using the traditional two-state model. Results show that in many cases, the two-state model results are a good proxy for the three-state results that control for unemployment.

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I. Introduction

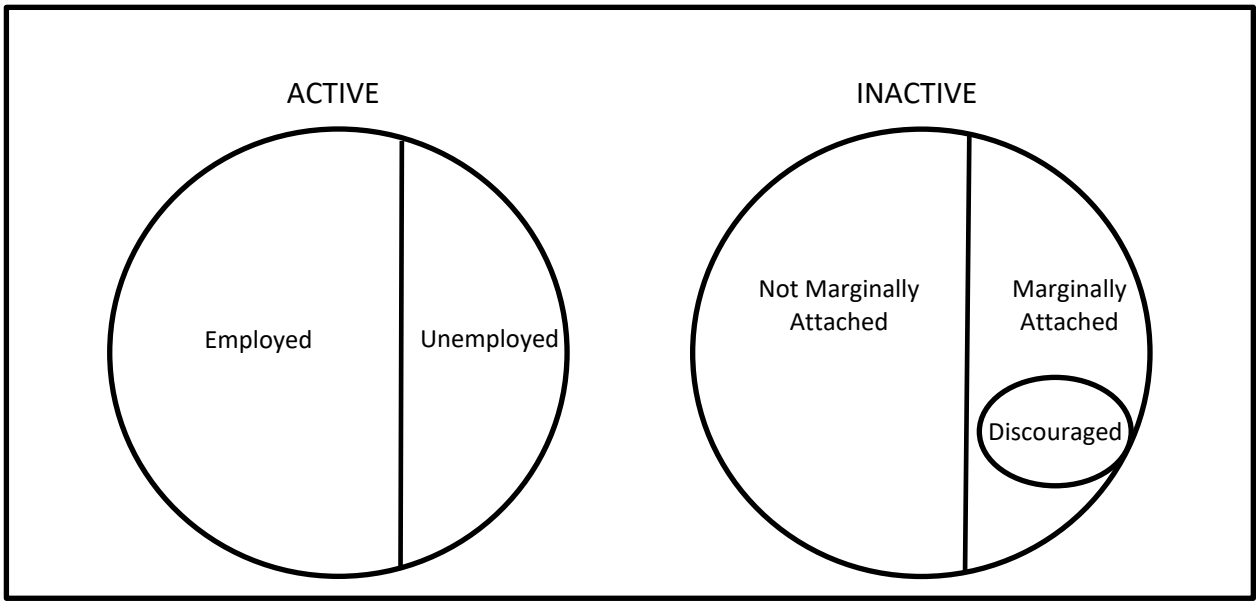
The typical Markov worklife model relies on transitions between active and inactive labor market states to determine years of labor market activity.[1] The active labor market state includes both the employed and unemployed. Consequently, years active may be different than years employed. While a forensic expert may consider some adjustment to a worklife estimate to account for possible bouts of unemployment, the active-inactive dichotomy masks the complexity that lack of employment brings to worklife estimation. It ignores important distinctions between those unemployed and those who are either marginally attached or discouraged workers. This paper explores adjusting for various states of non-employment and how they bear on typical worklife estimates.[2]

The Bureau of Labor Statistics (BLS) classifies persons as unemployed if they meet the following three criteria: 1) do not have a job; 2) have actively looked for work in the prior four weeks; and 3) are currently available for work.[3] Another classification of workers separate from the unemployed are the marginally attached. The marginally attached are those persons not in the labor force who want and are available for work, and who have looked for a job sometime in the prior 12 months. They are not counted as unemployed, however, because they have not searched for work in the past four weeks. The marginally attached can be subdivided into two distinct groups: discouraged and non-discouraged workers. Discouraged workers are not

[1] See, for example, Skoog, et al. (2019).
[2] Millimet, et al. (2003) explore a worklife model that allows for unemployment. Their work diverges from the traditional worklife models such as Skoog, et al. (2019) by estimating switching probabilities econometrically.
[3] Persons who are not working and are waiting to be recalled to a job from which they have been temporarily laid off are also included as unemployed. See https://www.bls.gov/cps/lfcharacteristics.htm#unemp.

currently looking for work specifically because they believe no jobs are available for them or there are none for which they would qualify.[4] Non-discouraged workers are the remainder of the marginally attached. Non-discouraged workers may not have looked for work in the past four weeks because of childcare or transportation issues, or because they are in school. They are not, however, discouraged from looking for work. Figure 1 illustrates the different labor market states.

Figure 1
Labor Market States



All marginally attached are included as inactive in the traditional two-state model. However, some individuals almost certainly will not become discouraged workers over their working lives and may not become non-discouraged marginally attached workers. This might be someone in the construction industry, for example, who faces periods of unemployment during

[4] https://www.bls.gov/cps/lfcharacteristics.htm.

downturns in the economy but continues looking for work. This worker would be either employed or unemployed, but not likely marginally attached during their working life. For this worker, the two-state model overstates the size of the inactive state since the inactive state includes all marginally attached workers. This may bias transition probabilities and worklife estimates. In these situations, it is important to account for periods of unemployment, but not necessarily allow that worker to become marginally attached.

The assumption that a worker would not become marginally attached sometime in their working life may be too extreme. Workers may temporarily leave the labor market for a variety of reasons. However, for many people, the probability of becoming a discouraged worker is small. If a person may become non-discouraged but marginally attached, the two-state model still overstates the size of the inactive state. To be more accurate, the inactive state would include marginally attached workers who are not discouraged but should exclude discouraged workers.

To account specifically for periods of unemployment, and to address the issue of marginal attachment, the traditional two-state Markov model is adjusted in two ways. First, it is expanded into three states. In this three-state Markov model, the active state is divided into two mutually exclusive states, the employed and unemployed. The third state is inactive. To account for marginal attachment, three separate scenarios are developed. The first assumes that person may become unemployed but would not become marginally attached. This leads to a modified three-state Markov model, where the states are: 1) employed, 2) unemployed, and 3) inactive but not marginally attached. In the second scenario, a person may become marginally attached, but would not become discouraged. Hence, only discouraged workers are

removed from the inactive state. Marginally attached workers who are non-discouraged remain in the inactive state. This leads to a modified three-state Markov model, where the states are: 1) employed, 2) unemployed, and 3) inactive but not discouraged. The third scenario still excludes the discouraged, but assumes the non-discouraged marginally attached are more like the unemployed than the inactive. Hence, their inclusion in the unemployed state. In this final modified three-state Markov model, an individual is either: 1) employed, 2) unemployed or non-discouraged marginally attached, or 3) inactive but not discouraged. [5]

To summarize, the traditional two-state worklife model is augmented to account for unemployment in three specific ways. First, the model expands to three state; the inactive state remains, and the active state is split into the employed and the unemployed. Second, discourage workers are removed from the inactive state. Third, worklives are estimated when the remaining marginally attached but not discouraged workers are either *i*) removed from the inactive state as well, *ii*) included in the inactive state, or *iii*) included in the unemployed state.

Plaintiffs for whom these scenarios are relevant include individuals with current job skills, who are unlikely to face discrimination, and would likely continue to look for work if they became unemployed. These individuals may even temporarily leave the labor market, but would not become discouraged. Identifying relevant plaintiffs may depend on factors such as age, education or training, skills, geographic area, type of occupation, and motivation. A younger head of household with family responsibilities and good job skills applicable to

[5] For the interested reader, Appendix 6 compares three-state transition probabilities for the non-discouraged marginally attached to those of the discouraged, unemployed and inactive. It suggests that the non-discouraged marginally attached are not similar to either the inactive of the unemployed. Hence, the inclusion of both scenarios II and III is revealing.

industries that are growing, would likely not become marginally attached and certainly not become discouraged. In contrast, an older worker with few or no dependents, who has limited skills that may be applicable only in declining industries is much more likely to be marginally attached or discouraged.

Some examples may be illustrative. Consider a married woman with three children. She is a CPA and the main earner in her family. Given her education, employment and family situation, she could potential become unemployed but would not likely become marginally attached – either non-discouraged or discouraged. The second example is a single male with a college degree currently employed. He is considering returning to school for an MBA. While in school, he may become marginally attached, but he is unlikely to become a discouraged worker. These two examples illustrate the potential bias inherent in the traditional two-state model. The inclusion of discouraged workers in the inactive state inflates the size of that segment of the labor market and may skew the worklife results. As a third example, suppose a case involves a 58-year-old factory worker with few transferable skills. Other firms in this industry have been moving production offshore. For this worker, there is a distinct possibility of becoming discouraged. In this case, the traditional two-state model may apply.

Current Population Survey data from 2009 - 2018 are used to estimate worklives in these three-state models. This period includes a significant economic downturn, years of recovery and eventually years of relatively low unemployment. The model estimates years of employment, years of unemployment and years of inactivity for individuals of any age starting in any one of those three labor market states. Years of employment are also combined with years of unemployment to estimate years in the “active” state, akin to the active state in the

two-state model. Estimates are derived for men and women in four education categories: less than high school degree; high school degree; some college; and at least a college degree.[6]

Results from each three-state model are compared to worklife estimates from the same initial data using the traditional two-state model. If years employed in the three-state models are very similar to years active in the two-state model, then using the two-state active results to project years of employment (for those who are unlikely to become marginally attached or alternatively, discouraged) is a reasonable approach. The closer the three-state employed worklives are to the two-state active worklives, the more comfortable forensic experts should be with using the traditional two-state model to project worklives without having to worry about an adjustment for unemployment.

The results show that for two common cases, the two-state active worklives and the three-state employed worklives are indeed very similar. Those starting employed in the three-state models have years of employment very close to years active for those starting active in the two-state model. Those starting unemployed in the three-state models have years of employment very close to years active for those starting inactive in the two-state model. These results holds across all three scenarios. Hence, the two-state active worklives are good proxies for years of employment in a three-state model that explicitly accounts for unemployment. Interesting results are also found for those starting unemployed. Forensic experts can be relatively confident using the traditional two-state models results without making adjustments for unemployment.

[6] This latter group includes those with Masters Degrees, Ph.Ds. or professional degrees.

The remainder of the paper is organized as follows. Section II discusses the data sources used to create the worklife estimates. This is followed in Section III with a description of the methods used to estimate transition probabilities and worklives. Section IV discusses worklife estimates and their decomposition between the different states. Comparisons are made of worklife estimates between educational levels for each sex as well as between sexes with the same level of education. This paper ends with a conclusion.

II. Data Sources

Data on labor market states were derived from the Current Population Survey (CPS). The CPS is a survey of about 60,000 occupied households conducted over the course of 16 months. Households complete the survey each month for four months, are off for eight months, and then complete the survey for four more months. This sequencing allows individual data to be matched across years. Matching permits determination of beginning and ending labor market states. IPUMS-CPS provides a harmonized data set which allows matching individuals across years using unique identifiers. Extracting and matching basic monthly data for years 2009 - 2018 from IPUMS-CPS generated a large sample of unique records for households in outgoing rotations.[7]

Those in the employed state have a CPS data code indicating that they are "at work" or "has job, not at work last week".[8] The unemployed are those who are either "unemployed", "unemployed, experienced worker" or "unemployed, new worker".[9] The marginally attached

[7] For a more detailed description of the CPS data, see Flood, et al. (2020).
[8] These are codes 10 and 12 for the variable EMPSTAT.
[9] These are codes 20, 21 and 22 for the variable EMPSTAT.

are defined as not in the labor force, could have started a job if one were offered, and cannot find work for a variety of reasons.[10] Discouraged workers are contained within the set of the marginally attached.[11] The inactive are those not in the labor force and not marginally attached. Sample weights are used to estimate the number of individuals in each of the three states at every age, as well as transitions among states for contiguous ages. Mortality rates were taken from the U.S. Centers for Disease Control and Prevention 2015 mortality tables. (See Arias, 2018.) The data show the probability of mortality by sex and age.

Worklife estimates are developed for men and women with less than a high school education, a high school degree, some college, or at least a college degree.[12] The estimation process begins at exact ages 17, 18, 20 and 22 for the respective education levels. At all education levels, the worklife tables are closed by assuming that all living persons ages 80 and over are inactive.

III. Calculating Transition Probabilities and Worklife Estimates

Estimating Transition Probabilities

Underlying the first-order Markov model are transition probabilities -- the probabilities that an individual will move among states in the labor force. Transition probabilities are calculated by matching data from year-apart surveys. In this three-state model, there are nine possible labor market transitions:

[10] In order of description, these are code 1 for the variable LABFORCE, code 1 for WRKOFFER, and codes 1 through 11 for WNLOOK.
[11] These are the subset of codes 1 through 5 in WNLOOK.
[12] The college degree category includes those with advanced or professional degrees.

1. inactive-to-inactive
2. inactive-to-employed
3. inactive-to-unemployed
4. employed-to-inactive
5. employed-to-employed
6. employed-to-unemployed
7. unemployed-to-inactive
8. unemployed-to-employed
9. unemployed-to-unemployed

Of course, individuals can also transition from any labor market state to death.

Supplementing Krueger, et al.'s (2006) and Rosenbaum, et al.'s (2018) notation, for a given gender and education level, the following are defined:

- $\widetilde{N}_x$ is the number of persons at age *x* who are either employed, unemployed or inactive;
- ${}^{j}\widetilde{N}_x$ is the number of persons at age *x* and in labor market state *j*, where *j* ∈{*i, e, u*} and *i* is inactive, *e* is employed, and *u* is unemployed;
- ${}^{j}\widetilde{N}^{k}{}_{x}$ is the number of persons at age *x* starting in labor market state *j* and ending in labor market state *k*, where *j*, *k* ∈ {*i*, *e, u*}.

In addition to transitioning from one labor market state {*i*, *e, u*} to another, there is also the probability that an individual of a given age dies between responses. Following Krueger's (2004) naming convention, let ${}^{j}p_x^d$, *j* ∈{*i*, *e, u*} represent the probability than an individual who is in labor market state *j* ∈{*i*, *e, u*} at age *x*, dies by age *x*+1. Mortality data is independent of labor market status, so it is assumed that

$${}^{i}p_x^d = {}^{e}p_x^d = {}^{u}p_x^d = {}^{\bullet}p_x^d.$$

Six of the nine transition probabilities (from {*e, u, i*} to {*e, u*}) are calculated as:

(1) $$ {}^{e}p_x^e = \left[\frac{{}^{e}\widetilde{N}_{x-1}^{e} + {}^{e}\widetilde{N}_x^e}{{}^{e}\widetilde{N}_{x-1} + {}^{e}\widetilde{N}_x}\right](1 - {}^{\circ}p_x^d)$$

(2) $${}^{e}p_x^{u} = \left[\frac{{}^{e}\tilde{N}_{x-1}^{u} + {}^{e}\tilde{N}_{x}^{u}}{{}^{e}\tilde{N}_{x-1} + {}^{e}\tilde{N}_{x}}\right](1 - {}^{\circ}p_x^{d})$$

(3) $${}^{u}p_x^{e} = \left[\frac{{}^{u}\tilde{N}_{x-1}^{e} + {}^{u}\tilde{N}_{x}^{e}}{{}^{u}\tilde{N}_{x-1} + {}^{u}\tilde{N}_{x}}\right](1 - {}^{\circ}p_x^{d})$$

(4) $${}^{u}p_x^{u} = \left[\frac{{}^{u}\tilde{N}_{x-1}^{u} + {}^{u}\tilde{N}_{x}^{u}}{{}^{u}\tilde{N}_{x-1} + {}^{u}\tilde{N}_{x}}\right](1 - {}^{\circ}p_x^{d})$$

(5) $${}^{i}p_x^{e} = \left[\frac{{}^{i}\tilde{N}_{x-1}^{e} + {}^{i}\tilde{N}_{x}^{e}}{{}^{i}\tilde{N}_{x-1} + {}^{i}\tilde{N}_{x}}\right](1 - {}^{\circ}p_x^{d})$$

(6) $${}^{i}p_x^{u} = \left[\frac{{}^{i}\tilde{N}_{x-1}^{u} + {}^{i}\tilde{N}_{x}^{u}}{{}^{i}\tilde{N}_{x-1} + {}^{i}\tilde{N}_{x}}\right](1 - {}^{\circ}p_x^{d})$$

These probabilities are averaged over ages *x* and *x*-1, which re-centers the data to exact ages. The remaining three transition probabilities are calculated under the identity that the sum of probabilities must equal one. That is, an individual starting in any labor market state can only remain in the same state, switch states, or die over the course of the year. Thus, in any starting state, the probability of going from that state to inactive at age *x*+1 is defined as follows:

(7) $${}^{i}p_x^{i} = 1 - {}^{i}p_x^{u} - {}^{i}p_x^{e} - {}^{\bullet}p_x^{d}$$

(8) $${}^{u}p_x^{i} = 1 - {}^{u}p_x^{u} - {}^{u}p_x^{e} - {}^{\bullet}p_x^{d}$$

(9) $${}^{e}p_x^{i} = 1 - {}^{e}p_x^{u} - {}^{e}p_x^{e} - {}^{\bullet}p_x^{d}$$

All relevant transition probabilities are now defined. The raw transition probabilities are smoothed across age groups using a seventh-order centered moving average. The choice of seven years represents a compromise between the variance stabilizing effect of wider filters and the bias induced by averaging across ranges in which transition probabilities change sharply. A similar moving average filter is typical in the literature.[13]

[13] For a review of earlier worklife analyses and the use of centered moving averages, see Krueger, 2004.

Expected Employment and Worklives

The method for estimating employment from transition probabilities mirrors the model by Krueger, et al. (2006).[14] Based on that methodology, it is possible to estimate, for individuals at any age *x*, the remaining years of employment given that at age *x* that individual started in any of the labor market states. Augmenting Krueger, et al.'s (2006) notation, ${}^{e}e_x^e$ is the expected years of employment (the upper right *e* superscript) having started employed (the upper left *e* superscript) for a person exact age *x*. Similar notation can be used in deriving ${}^{e}e_x^u$, the expected years unemployed having started employed and ${}^{e}e_x^i$, the expected years inactive having started employed. It is also possible to calculate ${}^{u}e_x^e$, ${}^{u}e_x^u$, ${}^{u}e_x^i$, ${}^{i}e_x^e$, ${}^{i}e_x^u$ and ${}^{i}e_x^i$ using similar notation.

Borrowing again from Krueger, et al. (2006), let w_e, w_u and w_i represent the proportion of the population employed, unemployed and inactive at age *x*, suppressed in the notation. Then the overall duration of employment at age *x* regardless of starting state is:

(10) $$\overset{\circ}{e}_x^e = w_e * {}^{e}e_x^e + w_u * {}^{u}e_x^e + w_i * {}^{i}e_x^e$$

To make these results more closely correspond to traditional two-state worklife models, years of active worklife can also be defined as the sum of time in the employment and unemployment:

(11) $$\overset{\circ}{e}_x^a = \overset{\circ}{e}_x^e + \overset{\circ}{e}_x^u.$$

Where $\overset{\circ}{e}_x^u$ is defines similar to equation (10).

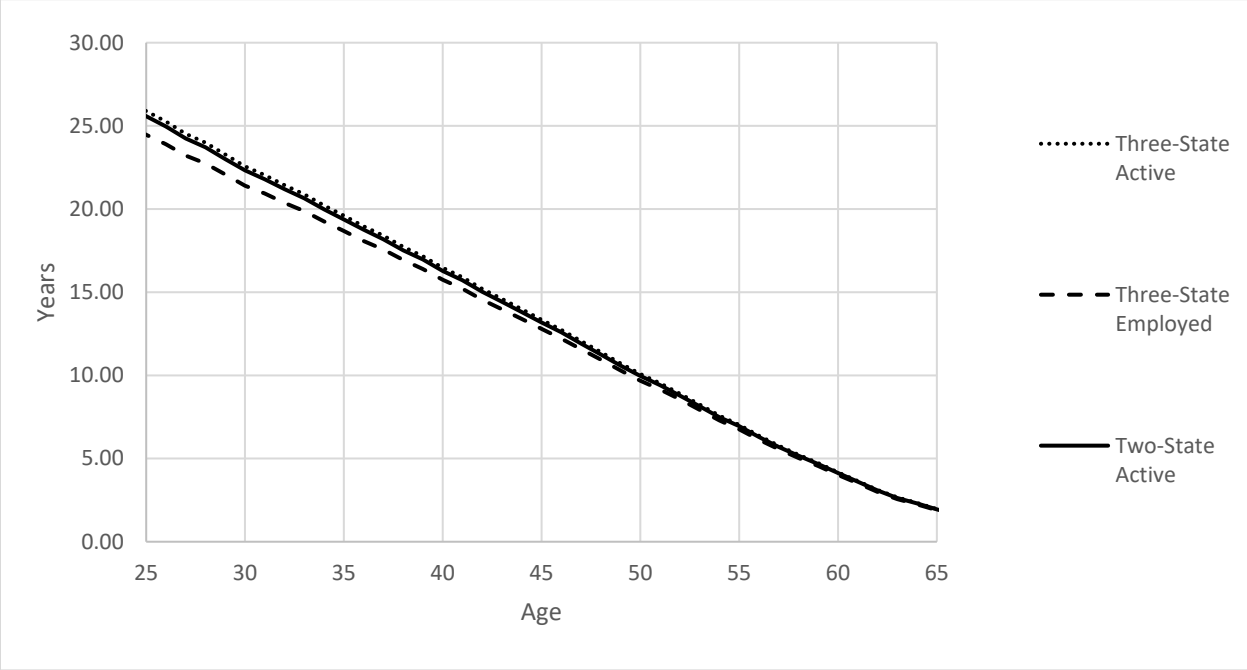
[14] Readers interested in the details of estimating worklives should refer to the Krueger, et al. (2006) paper. A similar three-state model is developed in Krueger and Slesnick (2014).

IV. Worklife Results

Scenario I – All Marginally Attached Excluded

In this scenario, all of the marginally attached (discouraged and non-discouraged) are removed from the inactive state. These results apply to individuals who may become unemployed but would likely not become marginally attached. Figure 2 shows comparative worklife estimates for women with high school degrees. At any age, an individual spends the fewest years as employed in the three-state model (as defined by equation (10) above). The same individual spends slightly more time as active in the two-state model and the most time as active in the three-state model (as defined by equation (11) above). A 40-year-old woman with a high school degree, for example, spends 15.75 years employed in the three-state model, 16.28 years active in the two-state model, and 16.47 years active in the three-state model. At any age, the differences are not large and they compress with age.

Figure 2
Worklife Estimates for Women with High School Degrees:
Employed and Active



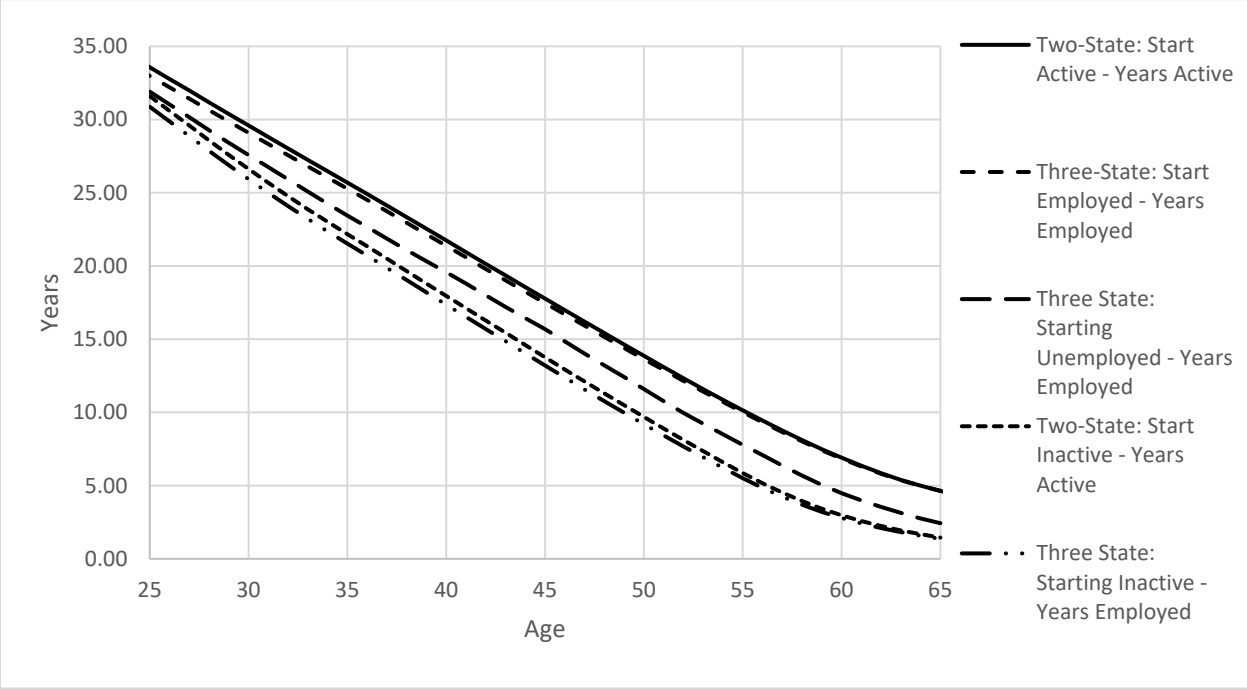
Appendix 1 shows graphical results for women and men of all four education levels. The graphs are derived from data in Appendix 2, showing years spent in each state, by starting state and age, as well as worklives from both the three-state and the two-state models. The results for men and women of all education levels are consistent with those in Figure 2. The three-state model active worklives are the longest at any age. The two-state model produces active worklives slightly longer than the three-state employed worklives. Regardless of the combination of sex, age and education, however, the spread between the largest and smallest worklives is relatively small – almost always less than one year. The spread decreases with age. At any age, it also decreases with education. The spread is slightly larger, for any age/education combination, for men than for women.

Comparing across education levels, for both women and men, worklife increases in education. This occurs in both the two-state and three-state models. Comparing across sexes,

for any given age and level of education, men have longer worklives than women. Again, this occurs in both the two-state and three-state models.

Figure 3 shows the years in either the employed or the active state depending on the starting state and model. The graph is for women with at least a college degree. Appendix 3 shows similar graphical results for women and men across all four education categories and the underlying numerical results are again in Appendix 2. There are three interesting outcomes to note in Figure 3 and the associated figures and tables in the appendices. The first is a comparison of worklives between those starting active in the two-state model and those starting employed in the three-state model. Years employed for those starting employed (in the three-state model) are nearly identical to years spent active for those starting active (in the two-state model). A forty-year-old woman with at least a college degree who starts active in the two-state model spends 21.74 years active. The same woman who starts employed in the three-state model, spends 21.37 years employed – a difference of just over four months.

Figure 3
Worklife Estimates for Women with at Least a College Degree:
Employed and Active by Starting State



Aggregating across sexes, education groups and ages, years employed-starting employed are less than one percent different than years active-starting active. Just over half (51.8%) of the age/education/sex combinations have years employed-starting employed less than two percent different than years active-starting active. For 97 percent of the observations, years employed-starting employed are no more than four percent different than years active-starting active. If the plaintiff was employed at the time of injury (or death), a forensic expert can be relatively confident using the traditional two-state model results without adjusting for unemployment. Years active starting active in the two-state model mirror years employed when starting employed in the three-state model – a model that explicitly controls for unemployment.

The second interesting outcome in Figure 3 and the associated appendices is a comparison across models of worklives for those starting in the inactive state. Years active starting inactive (in the two-state model) are similar to years employed for those starting inactive (in the three-state model). A forty-year-old woman with at least a college degree who starts inactive in the two-state model spends 17.96 years active. The same woman who starts inactive in the three-state model, spends 17.36 years employed – a difference of 7.2 months.

Aggregating across sexes, education groups and ages, years employed-starting inactive are within six percent of years active-starting inactive. For 84 percent of the sex/education/age combinations, years employed-starting inactive are within eight percent of years active-starting inactive. The largest difference has years employed-starting inactive equal to 91.4 percent of years active-starting inactive. If the plaintiff was inactive – neither employed nor unemployed, but not marginally attached – at the time of injury (or death), a forensic expert can be relatively confident using the traditional two-state model results. Years active starting inactive in the two-state model reasonably mirror years employed when starting inactive in the three-state model. The three-state model accounts for unemployment and produces results close to the results from the two-state model.

The third interesting outcome is for years employed starting unemployed in the three-state model. For those starting unemployed, the two-state model starting inactive under-estimates their active worklives and the two-state model starting active over-estimates their active worklives. However, the three-state years employed (starting unemployed) ranges from 93 to 107 percent of the average of the two-state years active for those starting active and those starting inactive. For example, the three-state model shows that a 40-year-old woman

with at least a bachelor's degree who is currently unemployed can expect 19.57 years of future employment.[15] The two-state model shows that a 40-year-old woman with at least a bachelor's degree could expect 17.96 active years if she starts inactive and 21.74 active years if she starts active. The average of these two results from the two-state model is 18.85 years – close to the years employed (starting unemployed) from the three-state model. Hence an average of years active across states in the two-state model may be a good proxy worklife that accounts for unemployment.

These results are applicable when the injured (deceased) was not likely to become marginally attached. This assumption may be too restrictive. Recall that the marginally attached can be divided into two distinct groups: discouraged workers who are not likely to return to the labor market and non-discouraged workers who more likely to have temporarily left the labor market. Scenarios II and III address this dichotomy.

Scenario II – Discouraged Excluded, Non-Discouraged Inactive

In this scenario, discouraged workers are still excluded from the inactive state. However, those who are marginally attached but not discouraged, remain in the inactive state. These non-discouraged, marginally attached individuals typically have left the labor market for schooling or other temporary issues. They may not likely become discouraged and could reasonably rejoin the labor market later. To convey some idea of the magnitude the different groups bring to the analysis, Table 1 shows various unemployment rates for this study's sample. The most widely circulated unemployment rate, U3 is 6.2 percent. U4, which adds discouraged

[15] See Appendix 2.

workers, has an unemployment rate of 6.6 percent. Adding other marginally attached (the non-discouraged) raises the U5 unemployment rate to 7.1 percent.

Table 1
Sample Unemployment Rates

Unemployment Measure	Definition	Unemployment Rate
U3	$\frac{Unemployed}{Employed + Unemployed}$	6.2%
U4	$\frac{Unemployed + Discouraged}{Employed + Unemployed + Discouraged}$	6.6%
U5	$\frac{Unemployed + All\ Marginally\ Attached}{Employed + Unemployed + All\ Marginally\ Attached}$	7.1%

Appendix 4 contains the results of the models when discouraged individuals are excluded and non-discouraged, marginally attached individuals are included in the inactive state.[16] The appendix shows years spent in each state, by starting state and age, as well as worklives from both the three-state and the two-state models. The results are very similar to those in Scenario I where all marginally attached are excluded. Years employed for those starting employed (in the three-state model) are nearly identical to years spent active for those starting active (in the two-state model). Years employed for those starting inactive (in the three-state model) are similar to years active starting inactive (in the two-state model). For those starting unemployed, the two-state model starting inactive under-estimates their active worklives and the two-state model starting active over-estimates their active worklives. However, the three-state years employed is approximately equal to the average of the two-state years active for those starting active and those starting inactive.

[16] Their inclusion in the inactive state mirrors their treatment in the two-state model.

Scenario III – Discouraged Excluded, Non-Discouraged Inactive

In this scenario, discouraged workers are once again excluded from the inactive state. However, in this scenario, the non-discouraged marginally attached are included among the unemployed, rather than among the inactive as in scenario II. Results of this scenario are in Appendix 5. Compared to scenario II, in scenario III, individuals spend slightly more time in the unemployed and inactive states, and slightly less time in the employed and active states. The magnitudes of difference are so small, however, that the overall results are essentially unchanged. Years employed for those starting employed (in the three-state model) mirror years active for those starting active (in the two-state model). Years employed for those starting inactive (in the three-state model) reflect years active for those starting inactive (in the two-state model).

Discussion

The previous results beg the question, why are the two-state worklives so similar to the three-state worklives? This discussion will focus on the case where all of the marginally attached are excluded, but is applicable to the other two scenarios as well. First, consider the similarity between the active worklives across models. To analyze this similarity, start by focusing on the sub-sample of initially active individuals. In the two-state model, a person can transition from active to either active or inactive, where inactive includes the marginally attached. In the three-state model, the marginally attached are eliminated. Hence, there are fewer people transitioning to the inactive state, but an almost identical number remaining in

the active state.[17] This means, compared to the two-state transition probabilities, the three-state model has higher active-to-active transition probabilities and lower active-to-inactive transition probabilities.

Now focus on the initially inactive. In the two-state model, this group includes the marginally attached. In the three-state model, it does not. If the marginally attached are more likely than other inactive individuals to transition to active, then this depresses the inactive-to-active transition probability in the three-state model relative to the two-state model and increases the inactive-to-inactive transition probability. In the empirical estimation, these two forces nearly offset one another. Consequently, the two-state and three-state active worklives are very similar.

Now consider the similarity between years employed-starting employed in the three-state model and years active-starting active in the two-state model. Empirical evaluation indicates that the employed-to-employed transition probabilities in the three-state model are just below the active-to-active transition probabilities in the two-state model. This is reasonable given that employment is a restricted subset of active. However, since the marginally attached are removed from the inactive state in the three-state model, the aggregated transition probabilities from either unemployed or inactive to employed in the three-state model are greater than the inactive-to-active transition probabilities in the two-state model. The combined impact is to make years employed-starting employed in the three-state model close to years active-starting active in the two-state model.

[17] There are slightly fewer active in the three-state model as those who started marginally attached but transitioned to active are excluded, as are those who started active but transitioned to marginally attached.

V. Conclusion

A three-state, first-order Markov model is developed in which individuals can transition between three mutually exclusive states: employed, unemployed, or inactive. The model is estimated under three separate scenarios. In all scenarios, the discouraged are excluded from the inactive state. The non-discouraged marginally attached are either excluded, counted among the inactive, or counted among the unemployed. Current Population Survey data for the period 2009-2018 are used to estimate the model. Transition probabilities and worklives are generated for men and women of all ages in four separate education groups: those with less than a high school degree; those with a high school degree; those with some college; and those with at least a college degree.

A comparison of results under all three scenarios shows that:

- years employed for those starting employed in the three-state model are nearly identical to years spent active for those starting active in the two-state model;
- years employed for those starting inactive in the three-state model are very similar to years active starting inactive in the two-state model;
- years employed for those starting unemployed in the three-state model are similar to the mean of years active starting inactive or active in the two-state model;

Do traditional two-state worklife estimates need adjustment for unemployment? Based on these results, perhaps not for those who may become unemployed but not marginally attached (or at least not discouraged). Periods of unemployment may reduce worklives; however, removal of those marginally attached or discouraged from the inactive state tends to raise worklives. Forensic experts can be relatively confident using the traditional two-state

models results without making adjustments for unemployment. The two-state model results are very close to worklives estimated in a three-state model that explicitly controls for unemployment.

VI. References

Arias, Elizabeth. 2018. "United States Life Tables, 2015" *National Vital Statistics Report*, 67(7).

Baquet, Daniel., Cushing, Matthew. J. and David I. Rosenbaum. 2017. "Worklife by Occupation Physical Requirements." *Journal of Legal Economics*, 23(2): 1-30.

Cushing, Matthew J. and David I. Rosenbaum. 2014. "Evolving Labor Market Transition Probabilities and Their Impact on Worklife Estimates." *Journal of Forensic Economics*, 25(1): 25-50.

Flood, Sarah, Miriam King, Renae Rodgers, Steven Ruggles and J. Robert Warren. 2020. *Integrated Public Use Microdata Series, Current Population Survey: Version 8.0*. Minneapolis, MN: IPUMS. https://doi.org/10.18128/D030.V8.0.

Krueger, Kurt. 2004. "Tables of Inter-year Labor Force Status of the U.S. Population (1998-2004) to Operate the Markov Model of Worklife Expectancy." *Journal of Forensic Economics*, 17(3): 313-381.

Krueger, Kurt V., and Frank Slesnick. 2014. "Total Worklife Expectancy." *Journal of Forensic Economics*, 25(1): 51-70.

Krueger, Kurt V., Gary R. Skoog and James E. Ciecka. 2006. "Worklife in a Markov Model with Full-Time and Part-Time Activity." *Journal of Forensic Economics*, 19(1): 61-82.

Millimet, Daniel L., Michael Nieswiadomy, Hang Ryu, and Daniel Slottje. 2003. "Estimating Worklife Expectancy: An Econometric Approach." *Journal of Econometrics*, 113: 83-113.

Rosenbaum, David I., Matthew J. Cushing and Daniel Baquat. 2018. "Worklife by Occupation Physical Requirements: A Three-State Model." *Journal of Forensic Economics*, 27(2): 145-174.

Skoog, Gary R. and James E. Ciecka and Kurt V. Krueger. 2011. "The Markov Model of Labor Force Activity: Extended Tables of Central Tendency, Shape, Percentile Points, and Bootstrap Standard Errors." *Journal of Legal Economics*, 22(2): 165-230.

Skoog, Gary R., James E. Ciecka, and Kurt V. Krueger. 2019. "The Markov Model of Labor Force Activity 2012-17: Extended Tables of Central Tendency, Shape, Percentile Points, and Bootstrap Standard Errors," *Journal of Forensic Economics*, 28)1-2): 109-195.