Women's Income and Marriage Markets in the United States: Evidence from the Civil War Pension

Laura Salisbury*

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A Theory Appendix: A Search Model of Marriage and Pensions

Suppose there are three otherwise identical types of widows: those who are receiving a pension (indexed by P), those who never receive a pension (N), and those who have pending claims (denoted with tildes). Married women are indexed by M. Assume for simplicity that there is no divorce. A marriage generates flow utility θ, which is drawn from a distribution $F(\theta)$, and discounting occurs at a rate r. Each state, married or single, is associated with a lifetime expected value, V. For all women, the value of being in a marriage with match quality θ is given by:

$$rV^M = \theta$$

In words, this is the present discounted value of receiving utility θ forever. The value of being single is different for pensioned and unpensioned women. Suppose remaining single generates a flow utility s, and women with pensions receive additional utility p. Marriage proposals have a poisson arrival rate α, which depends on search effort. Specifically, it costs a widow $c(\alpha)$ in utility to obtain a rate of proposals α. I assume that costs are increasing

*Department of Economics, York University, 4700 Keele Street, Toronto, Ontario, Canada, M3J 1P3; email: lsalisbu@yorku.ca.

and convex in α, so $c'(\alpha) > 0$ and $c''(\alpha) > 0$. Then, the value to a pensioned woman of remaining single with proposal rate α_P^* can be written

$$rV^P = s + p - c(\alpha_P^*) + \alpha_P^* E[\max\{V^M - V^P, 0\}] \tag{1}$$

This is composed of two elements: the instantaneous utility a woman receives ($s + p - c(\alpha_P^*)$) and a term that reflects additional value, over and above the value of remaining single, from anticipated future proposals of marriage. It is a standard result that these unmarried women will have a reservation match quality, θ_P, which means they will accept any match carrying quality $\theta \geq \theta_P$. This has the property that $V^M(\theta_P) = V^P = \theta_P/r$. In other words, the reservation match quality is such that the woman is indifferent between remaining single and accepting the match. Substituting this into (1), and re-writing the expectation as an integral, we get the following equation that implicitly defines this reservation match quality:

$$\theta_P = s + p - c(\alpha_P^*) + \frac{\alpha_P^*}{r} \int_{\theta_P}^{\infty} (\theta - \theta_P) dF(\theta)$$

Women will choose α_P^* that maximizes the value of being unmarried. The maximizing level α_P^* will solve the following first order condition (Mortensen 1986):

$$rc'(\alpha_P^*) = \int_{\theta_P}^{\infty} (\theta - \theta_P) dF(\theta)$$

Similarly, for women who do not receive pensions, the reservation match quality is

$$\theta_N = s - c(\alpha_N^*) + \frac{\alpha_N^*}{r} \int_{\theta_N}^{\infty} (\theta - \theta_N) dF(\theta)$$

It is straightforward to show that θ_P is increasing and α_P^* is decreasing in p (Rogerson et al 2005); therefore, $\theta_P > \theta_N$ and $\alpha_P^* < \alpha_N^*$. In other words, women with pensions should be more selective and should spend less effort on search in the marriage market.

The above results are a straightforward application of search theory to this particular problem (Rogerson et al 2005). I now derive the value of being unmarried for women with pending pension claims. Suppose that the (endogenous) arrival rate of marriage proposals for a woman with a pending claim is $\tilde{\alpha}^*$, and the arrival rate of pension decisions is λ. The probability that the decision will be favorable is π. Then, the value of being a widow with a pending pension claim ($\tilde{V}$) can be written:

$$r\tilde{V} = s - c(\tilde{\alpha}^*) + \tilde{\alpha}^*\Big(E[\max(V^M - \tilde{V}, 0)]\Big) + \lambda\Big(\pi V^P + (1-\pi)V^N - \tilde{V}\Big) \tag{2}$$

Proof. This follows Rogerson et al (2005). Suppose the arrival rate of pension decisions is λ, the arrival rate of marriage proposals is α, and the probability of an acceptance is π. Take Δ to be an arbitrarily small period of time, and note that, for search effort $c(\alpha)$, the probability of receiving a marriage proposal during this interval is $\alpha\Delta$; similarly, the probability of receiving a decision from the pension bureau is $\lambda\Delta$. Call V^S the expected value of being single, which will be a weighted average of the value of being single in each potential state of "singlehood". Then, it must be that

$$\begin{aligned}
\tilde{V} &= \Delta(s - c(\alpha)) + \frac{\Delta\alpha}{1+\Delta r}\Big(E[\max(V^M, V^S)]\Big) + \frac{1-\Delta\alpha}{1+\Delta r}E[V^S] \\
&= \Delta(s - c(\alpha)) + \frac{\Delta\alpha}{1+\Delta r}\Bigg(\Delta\lambda\Big(\pi E[\max(V^M, V^P)] + (1-\pi)E[\max(V^M, V^N)]\Big) + (1-\Delta\lambda)E[\max(V^M, \tilde{V} \\
&\quad + \frac{1-\Delta\alpha}{1+\Delta r}\Bigg(\Delta\lambda\Big(\pi V^P + (1-\pi)V^N\Big) + (1-\Delta\lambda)\tilde{V}\Bigg) \\
&= \Delta(s - c(\alpha)) + \frac{\Delta\alpha}{1+\Delta r}\Bigg(\Delta\lambda\Big(\pi E[\max(V^M - V^P, 0)] + (1-\pi)E[\max(V^M - V^N, 0)]\Big) + \\
&\quad + (1-\Delta\lambda)E[\max(V^M - \tilde{V}, 0)]\Bigg) + \frac{\Delta\lambda}{1+\Delta r}\Big(\pi V^M + (1-\pi)V^N - \tilde{V}\Big) + \frac{1}{1+\Delta r}\tilde{V}
\end{aligned}$$

Re-arranging, dividing by Δ, and taking the limit as $\Delta \to 0$, we get (4). □

Because V^M is strictly increasing in θ, the right hand side of this equation is also strictly increasing in θ. This implies that there exists a reservation match quality $\tilde{\theta}$ for women with pending pension applications:

$$\tilde{\theta} = s - c(\tilde{\alpha}^*) + \frac{\tilde{\alpha}^*}{r}\int_{\tilde{\theta}}^{\infty}(\theta - \tilde{\theta})dF(\theta) + \frac{\lambda}{r}\Big(\pi\theta_P + (1-\pi)\theta_N - \tilde{\theta}\Big) \tag{3}$$

The optimal $\tilde{\alpha}^*$ will be defined similarly to those of the other two groups.

Proposition. For $\pi \in [0,1]$, $\tilde{\theta} < \theta_P$ *and* $\tilde{\alpha}^* > \alpha_P^*$.

Proof. Throughout, I use the well known result that $\int_{\theta_i}^{\infty}(\theta - \theta_i)dF(\theta) = \int_{\theta_i}^{\infty}(1 - F(\theta))d(\theta)$ First notice that $\tilde{\theta}$ is strictly increasing in π:

$$\frac{\partial \tilde{\theta}}{\partial \pi} = -\frac{\tilde{\alpha}^*}{r}(1 - F(\tilde{\theta}))\frac{\partial \tilde{\theta}}{\partial \pi} + \frac{\lambda}{r}(\theta_P - \theta_N) \Rightarrow$$
$$\frac{\partial \tilde{\theta}}{\partial \pi} = \frac{\lambda(\theta_P - \theta_N)}{r + \tilde{\alpha}^*(1 - F(\tilde{\theta}))} > 0$$

Now, define $\tilde{\theta}^1 = \tilde{\theta}$ when $\pi = 1$. Because $\tilde{\theta}$ is strictly increasing in π, if $\theta_P > \tilde{\theta}^1$, then $\theta_P > \tilde{\theta}$ for every $\pi \leq 1$. When $\pi = 1$:

$$\tilde{\theta} = s - c(\tilde{\alpha}^*) + \frac{\tilde{\alpha}^*}{r}\int_{\tilde{\theta}}(1 - F(\theta))d(\theta) + \frac{\lambda}{r}(\theta_P - \tilde{\theta})$$

Suppose $\tilde{\theta} \geq \theta_P$. Because the optimal α^* is decreasing in reservation θ (see below), it follows that $\alpha_P^* \geq \tilde{\alpha}^*$. Two inequalities follow from this: First,

$$\frac{1}{r}\int_{\tilde{\theta}}(1 - F(\theta))d(\theta) \leq \frac{1}{r}\int_{\theta_P}(1 - F(\theta))d(\theta)$$

And, from convexity of $c(\alpha)$, we get the following inequality:

$$-c(\tilde{\alpha}^*) \leq -c(\alpha_P^*) + c'(\alpha_P)(\alpha_P^* - \tilde{\alpha}^*)$$

This implies the following:

$$
\begin{aligned}
\tilde{\theta} &= s - c(\tilde{\alpha}^*) + \frac{\tilde{\alpha}^*}{r}\int_{\tilde{\theta}}(1-F(\theta))d(\theta) + \frac{\lambda}{r}(\theta_P - \tilde{\theta}) \\
&\leq s - c(\tilde{\alpha}^*) + \frac{\tilde{\alpha}^*}{r}\int_{\theta_P}(1-F(\theta))d(\theta) \\
&\leq s - c(\alpha_P^*) + c'(\alpha_P^*)(\alpha_P^* - \tilde{\alpha}^*) + \frac{\tilde{\alpha}^*}{r}\int_{\theta_P}(1-F(\theta))d(\theta) \\
&= s - c(\alpha_P^*) + \frac{1}{r}\int_{\theta_P}(1-F(\theta))d\theta(\alpha_P^* - \tilde{\alpha}^*) + \frac{\tilde{\alpha}^*}{r}\int_{\theta_P}(1-F(\theta))d(\theta) \\
&= s - c(\alpha_P^*) + \frac{\alpha_P^*}{r}\int_{\theta_P}(1-F(\theta))d(\theta) \\
&= \theta_P - p < \theta_P
\end{aligned}
$$

This is a contradiction. So, it must be that, when $\pi = 1$, $\theta_P > \tilde{\theta}$, which further implies that $\theta_P > \tilde{\theta}$ for all $\pi \leq 1$.

The result that $\alpha_P^* < \tilde{\alpha}^*$ follows from the fact that α^* is decreasing in reservation match quality. Recall that, for reservation match quality θ_i, α^* is defined by the following condition:

$$
rc'(\alpha^*) = \int_{\theta_i}^{\infty}(1-F(\theta))d(\theta)
$$

Then, $\partial\alpha^*/\partial\theta_i$ is given by:

$$
\frac{\partial\alpha^*}{\partial\theta_i} = \frac{-(1-F(\theta_i))}{rc''(\alpha^*)} < 0
$$

This follows from the convexity of search costs. □

It is a well known result that lower reservation match qualities and greater search effort cause the hazard rate of remarriage to be greater. So, this model predicts that women with pending pension claims should marry at a faster rate than women with claims in hand.

B Data Appendix

B.1 Detailed Data Description

The sample of widows is drawn from Union Army (UA) database created by the Center for Population Economics (CPE) at the University of Chicago (Fogel et al 2000). The data are drawn from three principal sources: the military, pension and medical records are compiled from sources at the National Archives including military service records and Civil War pension records; data from the Surgeons Certificates contain detailed information about veterans' health status, which was used to determine pension eligibility; further socioeconomic information is gathered by linking veterans to the Federal Censuses of 1850, 1860, 1900 and 1910. These data have primarily been used to study health and aging in the late 19th and early 20th centuries. See for example Costa 1997, 1995, 1993; Fogel 2004; Eli 2010. They have also been used to analyze group dynamics in military settings (Costa and Kahn 2003, 2008). The data contain information about every soldier who enlisted in 303 randomly sampled companies of white volunteer infantry regiments. The database contains 39,341 observations and 3,230 variables (Fogel et al. 2000).

Information on widows' pension and marital outcomes are compiled from pension records at the National Archives in Washington, DC. Using the indices to the Civil War pension files available on ancestry.com and fold3.com, I compile a list of all pension applications made and certificates issued on behalf of soldiers married to the women in my sample. Then, I request these files from the National Archives. In approximately 93 percent of cases, these files are successfully located, and I am able to collect digital images of them. Files that could not be located had either been taken out by another user (30% of cases), or the file number was incorrectly recorded, and the record puller was unable to find it (70% of cases). Where possible, I make use of digital images of widows' pensions from the website fold3.com. This website is in the process of uploading images of accepted widows' pensions, which they are doing chronologically. It is not possible to make exclusive use of this resource for several reasons. First, this project is expected to take several years to complete. Second, they do not include rejected pension applications. In total, 33 percent of my sample can be collected from this resource.

Because of the importance of these variables to the paper, I describe the source of information on pension outcomes and marriages in the body of the text. However, there are other important variables collected from the pension files. Other available information includes the widow's age and place of residence, as she had to furnish this information in her pension application. If a remarried widow applied to be restored to the pension rolls under the act of March 3, 1901, her file will contain further information about her second husband. For example, she had to provide proof of her husband's death, which usually meant furnishing a death certificate. In some cases, these death certificates contain the age, birthplace, and occupation of the husband.

C Proportional Hazards Model: Details

I estimate this model by maximum likelihood. The survival function, or the probability of remaining a widow (m) or not having a pension (p) at time t, is denoted $S_i(t)$, and it has the following form:[1]

$$S_i(t) = \exp\left(- \int_{t_0}^{t} \theta_i(s)ds \right), \qquad i \in \{m, p\}$$

If t is a random variables denoting time an event occurs, its density is given by

$$f_i(t) = \theta_i(t) S_i(t)$$

So, the likelihood of an event occurring at t depends on both the hazard function and the survival function. For pensions, the survival function is straightforward to define:[2]

$$S_p(t|X, v_p) = \exp\left(- \int_{t_0}^{t} \lambda_p(t) \exp(X\beta_p + v_p) \right)$$

The survival function for marriage is somewhat more complicated, because it shifts at a point in time. The survival function before and after receiving a pension are given by the following two equations, respectively:

$$S_{m,1}(t|X, v_m) = \exp\left(- \int_{t_0}^{t} \lambda_m(t) \exp(X\beta_m + v_m) \right)$$

$$S_{m,2}(t|X, v_m, t_p) = S_{m,1}(t_p|X, v_m) \times \exp\left(- \int_{t_p}^{t} \lambda_m(t) \exp(X\beta_m + \delta + v_m) \right)$$

To understand the definition of $S_{m,2}$, consider the meaning of its two parts separately. Suppressing X and v_m, the first term reflects $Pr(t_m \geq t_p)$, and the second term reflects $Pr(t_m \geq t | t_m \geq t_p)$.

There are four possible outcomes for women in the sample, which I index below by

[1] See Lancaster (1990).

[2] This construction follows Abbring and van den Berg (2005), who apply this model to evaluating the effect of unemployment insurance sanctions on the rate of transition to employment.

$k \in \{1, 2, 3, 4\}$. A woman can remarry before she gets her pension ($k = 1$); she can remarry after her claim is granted ($k = 2$); she can be censored before her claim is granted, meaning that she dies or disappears from the sample ($k = 3$); or she can be censored after her claim is granted ($k = 4$). Each of these events is associated with a different likelihood. Conditional on her unobserved heterogeneity terms, the likelihood contribution of woman i can be written as

$$L_i(t) = \begin{cases} \theta_m(t|X, v_m, t_p)S_{m,1}(t|X, v_m)S_p(t|X, v_p) & \text{if} \quad k = 1 \\ \theta_m(t|X, v_m, t_p)S_{m,2}(t|X, v_m, t_p)\theta_p(t_p|X, v_p)S_p(t|X, v_p) & \text{if} \quad k = 2 \\ S_{m,1}(t|X, v_m)S_p(t|X, v_p) & \text{if} \quad k = 3 \\ S_{m,2}(t|X, v_m, t_p)\theta_p(t_p|X, v_p)S_p(t_p|X, v_p) & \text{if} \quad k = 4 \end{cases}$$

To estimate this model, I make certain parametric assumptions about the baseline hazard rate and the joint distribution of the unobserved heterogeneity terms, v_m and v_p. I attempt to make the least restrictive parametric assumptions possible. For the baseline hazard, I use a piecewise constant function, where time is divided into discrete "bins," and $\lambda(t) = \lambda_t$ takes on some unrestricted value in each of these bins. I use bins of one year, with a single bin for the tail of the time distribution, extending from $t = 8$ until the last observation leaves the sample. Following eight years after widowhood, first marriages and pensions occur with insufficient frequency to identify hazard rates at finer intervals. Following Abbring and Van den Berg (2005), I assume that the unobserved heterogeneity terms both obey a discrete distribution with two unrestricted mass points: $v_m \in \{v_m^{low}, v_m^{high}\}$ and $v_p \in \{v_p^{low}, v_p^{high}\}$. Thus, there are four possible combinations of v_m and v_p, each of which is associated with a certain probability. The location of each of these mass points and the probability of each combination of the two are estimated in the model. A discrete distribution is considered the most flexible parametric assumption that can be made about the joint distribution of unobserved heterogeneity terms, as it allows any correlation between the two variables to be achieved.[3] I estimate the model parameters using the EM algorithm (Heckman and Singer 1984).

[3] Heckman and Singer (1984); Abbring and Van den Berg (2005); Van den Berg (1996).

Appendix Tables and Figures

Table A1: Variable Definitions and Sources

Variable	Source	Notes
Date of first husband's death	Union Army database (Fogel et al 2000)	Based on dependents' pension applications or military death records
Date of pension application	Widows' pension database (Salisbury)	Date at which widow filled out pension declaration form; if missing, date at which pension application received by pension bureau
Date of pension receipt	Widows' pension database	Date of issuance on pension certificate; if missing, date of pension approval on pension brief
Date of remarriage	Widows' pension database	Based on marriage certificates or affadavits rendered in support of minors' pension application or application for widow to be restored to the pension rolls under a later act.
Date of death	Widows' pension database	Based on pension drop cards, or death records filed in support of minors' pension application.
Age at widowhood	Widows' pension database	Deduced from widow's first pension declaration, in which age and date of application are both provided.
Number of children	Union Army database	Equal to number of children under the age of 16 when widow first filed for pension.
Potential minor pension	Union Army database	Calculated as \$8/mo until youngest child turns 16, or \$8/mo plus \$2/mo for each child under 16 if widowed after July 25, 1866.
No pension attorney	Widows' pension database	Equal to one if the widow did not hire an attorney at the time of filing her first claim
Washignton pension attorney	Widows' pension database	Equal to one if the widow first hired an attorney from a Washington firm at the time of filing her first claim
First husband: height	Union Army database	Solderi's height at enlistment
First husband: log occupational wage	Union Army database; Preston and Haines (1991); United States Census of Agriculture (1900)	Based on soldier's occupation at enlistment
First husband: age at death	Union Army database	Based on implied birth year from age at enlistment
County of residence	Widows' pension database	County listed on first pension application form
County male-to-female ratio	Haines and ICPSR (2010)	Weighted mean of male-to-female ratio in 1860, 1870 and/or 1880, depending on date of application.
County percent urban	Haines and ICPSR (2010)	See above.
County population density	Haines and ICPSR (2010)	See ablve.
Name homogeneity index	Ruggles et al (2010); Atack and Bateman (1992)	Herfindahl index of concentration of unique spellings within phonetic surname groups among household heads in 1 percent IPUMS sample from 1860-1880. Phonetic groups created using NYIIS algorithm.
Last name: mean occupational income	Ruggles et al (2010); Preston and Haines (1991); United States Census of Agriculture (1900)	Mean occupation status of household head, calculated using 1900 wage distribution, by phonetic name group in IPUMS 1 percent sample from 1860-1880.
Last mean: mean immigrant status	Ruggles et al (2010)	Mean literacy of household head by phonetic name group in IPUMS 1 percent sample from 1860-1880.
Last name: mean literacy	Ruggles et al (2010)	Mean immigrant status of household head by phonetic name group in IPUMS 1 percent sample from 1860-1880.
Last name: mean farm residence	Ruggles et al (2010)	Mean farm status of household head by phonetic name group in IPUMS 1 percent sample from 1860-1880.
Literacy	Linked widow sample (Salisbury); ancestry.com	Literate in census of 1870 or 1880
Immigrant stats	Linked widow sample; ancestry.com	Immigrant in census of 1870 or 1880

Table A2: Test of Proportional Hazards Assumption

Variable:	p (proportional hazards) Marriage	Pension receipt
Age	0.176	0.153
Number of children	0.320	0.399
Husband's year of death	0.278	0.237
Time to pension application	0.079	0.025
Husband's age at death	0.920	0.271
First husband log occupational wage	0.561	0.471
First husband height	0.455	0.204
County percent urban	0.544	0.337
County male-to-female ratio	0.775	0.156
County population density	0.394	0.962
Potential pension	0.820	0.320
DC [pension lawyer	0.525	0.194
No pension lawyer	0.913	0.734
Mid Atlantic	0.092	0.126
East North Central	0.083	0.464
West North Central	0.267	0.695
South	0.087	0.682
Global Test	0.1399	0.1197

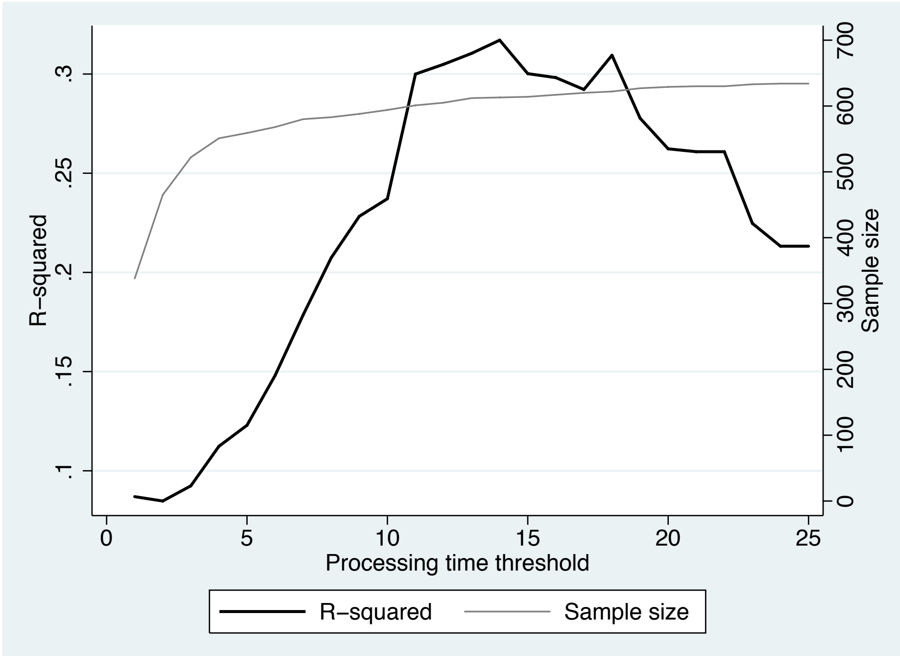
Notes. Test based on Schoenfeld residuals (Shoenfeld 1980; Grambsch adn Therneau 1994) from Cox proportional hazards models of timing of marriage and timing of pension receipt, starting from the date of pension application. The null hypothesis is that the impact of covariates on the hazard rate does not change over time; p values for this test are reported.

Table A3: Impact of Adding Covariates on Estimated Effect of Pension

Effect of pension	-0.036	-0.292**	-0.293**	-0.259*	-0.261*	-0.264*	-0.269*
	(0.130)	(0.143)	(0.143)	(0.152)	(0.153)	(0.153)	(0.154)
Controls:							
Age at widowhood		X	X	X	X	X	X
Year of widowhood		X	X	X	X	X	X
Number of Children			X	X	X	X	X
Time to pension application				X	X	X	X
Potential minor pension at widowhood					X	X	X
Attorney controls					X	X	X
First husband characteristics					X	X	X
County characteristics						X	X
Region controls							X
Log Likelihood	-2220.771	-1889.383	-1889.214	-1886.838	-1878.963	-1867.648	-1854.559

Notes. Estimated effect of pension receipt on hazard rate of remarriage, from simple model with no correction for unobserved heterogeneity. See notes to table 4 for variable definitions.

Figure A1: Fraction of Variation in Processing Times Explained by Covariates



Notes. R-squared from a regression of pension processing time on full set of covariates used in table 4, using samples consisting of processing times less than some cutuff, which varies from 1 to 25 years. Observables explain a large portion of the difference between very long and very short processing times; however, they explain very little of the short-run variation in processing times.

Figure A2: Survival Plots by Key Variables