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Abstract

An expected-net-national-benefit-maximizing enlistment-age is analytically derived for small countries engaged in external conflicts by considering the effects of the enlistment age on army size, probability of war, military performance, forgone civilian output, remunerations in the case of injury or death, and costs of readjusting to civilian life. The numerical simulations reveal the effects of the model parameters on the expected-net-national-benefit-maximizing enlistment-age. Despite the substantial changes in parameter values, the computed values of the enlistment age are distributed within an advanced phase of life.

Keywords: *Economics, enlistment-age, risk, cost and benefit, decision rule*

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[*] The author was conscripted at eighteen years of age. He is a veteran of two wars.

1. Introduction

Throughout the course of history countries engaged in external conflicts have maintained conscript armies with an early enlistment age—a legacy, perhaps, of our long agrarian past where life expectancy was short and boys were hardened by physical work, hunting, and protecting their clan's livestock and crops. Despite the considerable increase in the number of years of schooling, in life expectancy and in the average age of marriage, despite the transformation in the structure of households and earning responsibilities, and despite the changes in warfare technology (which have made military operations more sedentary and increased the distance of engagement and the accuracy and potency of munitions), the enlistment-age has not been significantly changed in countries that have continued practicing compulsory military service. Modern males are likely to be swift and powerful at eighteen years of age, but their comfortable upbringing does not prepare them mentally for war. Enlisted in early age, many experience severe difficulties in coping with national expectations, hazardous missions and the horror of war.[1]

The suitability and the morality of an early enlistment-age are also disputed on political grounds. Most of the pre-service people do not have direct access to political power. Consequently, they are politically underrepresented and do not have direct influence on current recruitment laws that hinder their personal security and liberty. In the absence of adequate, direct political representation, it took years of anti-draft demonstrations and civil riots to end the conscription in the United States—a super power and one of the most progressive countries—in mid 1973. Small countries that

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[1]Anecdotal evidence suggests that in combat situations during World War II only about twenty percent of the young combatants returned fire. In contrast, one may note the reliable performance of the middle-age troops in Alexander the Macedonian's army.

face severe and close-to-home geopolitical risks cannot afford civil riots. Nor can they rely on an all-volunteer army.[2] Responsibly, most of their young residents obey the existing recruitment rules.

The construction of a non ad-hoc enlistment-age rule for small countries maintaining a conscript defensive army is the objective of this paper. Section 2 presents the relationship between the army size, deterrence capacity, probability of war and the enlistment age. Section 3 details the expected national benefits and costs from enlisting at a given age. Section 4 derives the expected-net-national-benefit-maximizing enlistment-age. Section 5 displays the numerical-simulation's results of the expected-net-national-benefit-maximizing enlistment-age for a wide range of parameter-values as well as the effects of the model parameters on this enlistment age. Section 6 concludes.

2. Enlistment age, army size and war deterrence and probability

One of the main argument in favor of an early enlistment age is that it allows a country facing geopolitical risks to enjoy a large reserve of trained soldiers. Consider a country in which military service is compulsory due to hostile geopolitical conditions. The physically lower-bound on military service age is t_{min}. The physically upper-bound on military service age coincides with the retirement age, t_{max}. During peace-periods, the army is a force of conscripts and its size is equal to the size of the

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currently enlisted cohort. At wartime the reserves are called. The reserves comprise

all ex-conscripts aged t_{max} and less. Hence, the country's potential wartime-army is

$$N(t) = \int_t^{t_{max}} n(t)dt \tag{1}$$

where $t \in (t_{min}, t_{max})$ denotes the drafting age and $n(t)$ the size of the cohort aged t.

Assuming, for tractability, that all cohorts have an identical size, n, then the wartime

army size is

$$N(t) = (t_{max} - t)n . \tag{2}$$

Suppose that the opponent is more populous, but possesses the same warfare

technology. For simplicity, its wartime army, N^E, is fixed, yet always ready to match

the smaller country's army:[3]

$$N^E = \max N(t) = (t_{max} - t_{min})n . \tag{3}$$

In the absence of warfare technological advantage, size is crucial: the greater the ratio

of the country's potential wartime army to its rival's wartime army the higher the

country's war deterrence. In other words, the probability of war breaking-out

$(0 < p < 1)$ is given by

$$p(t) = p_{max}[1 - m(N(t)/N^E)] \tag{4}$$

where the scalar $0 < m < 1$ is the army's deterrent gradient, reflecting (with $m \neq 1$) that

the probability of war cannot be eliminated, and where $0 < p_{max} < 1$ is a scalar

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[3] A more elaborate, but greatly complicated, framework may consider reaction functions and a Stackelberg-type equilibrium.

denoting the probability of war when the country is unarmed. Recalling equation (2), the probability of war is rendered as

$$p(t) = p_{\max}[1 - \boldsymbol{m}(t_{\max} - t)/(t_{\max} - t_{\min})].$$ (5)

In this framework, the earlier the enlisting age the greater the country's war-deterrence and the lower the probability of war. However, additional factors may be taken into account in setting the enlistment age.

3. Expected net national benefit from enlistment at age t

The expected net national benefit (*ENNB*) from enlisting a person aged $t \in (t_{\min}, t_{\max})$ is the difference between that person's military contribution (*M*) and the sum of his forgone civil output (*C*), his costs of readjusting to civilian life upon release (*S*), and the remuneration (including hospitalization costs) in the event of his injury in war (R^I) or the remuneration to his kin in the event of his death in war (R^D). The probabilities of being injured or killed in war are $\boldsymbol{q}$ and $\boldsymbol{f}$ ($0 < \boldsymbol{q}, \boldsymbol{f} < 1$ and $\boldsymbol{q} + \boldsymbol{f} < 1$), respectively, and the probability of war is given by equation (5). Thus, the expected net national benefit from enlisting a person aged *t* is expressed as

$$ENNB(t) = M(t) - C(t) - S(t) - p(t)[\boldsymbol{q}R^I(t) + \boldsymbol{f}R^D(t)]$$ (6)

where *M*, *C*, *S*, R^I and R^D are measured in present-value nominal units.

Consistent with the life-cycle hypothesis (Ando and Modigliani, 1963; Modigliani, 1966), a person's military contribution and civil output are assumed to be

5

twice differentiable and single-peaked in the interval $(t_{\min}, t_{\max})$. Similarly, the remuneration paid to kin for a conscript killed in war at age t is taken to be twice differentiable and single-peaked in the interval $(t_{\min}, t_{\max})$. For convenience, the following second-order polynomials are considered:

$$M(t) = M_{t_{\max}} + \boldsymbol{a}(t_{\max} - t) - \tilde{\boldsymbol{a}}(t_{\max} - t)^2 \tag{7}$$

$$C(t) = C_{t_{\max}} + \boldsymbol{b}(t_{\max} - t) - \tilde{\boldsymbol{b}}(t_{\max} - t)^2 \tag{8}$$

$$R^D(t) = R^D{}_{t_{\max}} + \boldsymbol{g}(t_{\max} - t) - \tilde{\boldsymbol{g}}(t_{\max} - t)^2 \tag{9}$$

where, $M_{t_{\max}}$, $C_{t_{\max}}$ and $R^D{}_{t_{\max}}$ are the military contribution and civil output of a person aged $t_{\max}$ and the remuneration to kin for the loss of such a person, respectively, and $(\boldsymbol{a}, \tilde{\boldsymbol{a}}), (\boldsymbol{b}, \tilde{\boldsymbol{b}}), (\boldsymbol{g}, \tilde{\boldsymbol{g}})$ are pairs of positive scalars, expressed in present-value nominal units, determining the marginal effect of youth and its evolution on military contribution, civil output and death remuneration, respectively.

Let $t_m^* \in (t_{\min}, t_{\max})$ and $t_c^* \in (t_{\min}, t_{\max})$ be the prime ages as regards military contribution and civil output, respectively, and $t_d^* \in (t_{\min}, t_{\max})$ the age of death associated with maximum remuneration to kin,[4] then

$$M'(t_m^*) = -\boldsymbol{a} + 2\tilde{\boldsymbol{a}}(t_{\max} - t_m^*) = 0 \tag{10}$$

$$C'(t_c^*) = -\boldsymbol{b} + 2\tilde{\boldsymbol{b}}(t_{\max} - t_c^*) = 0 \tag{11}$$

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[4] t_d^* may be determined by a combination of the number of life-years lost and the number and age composition of dependents.

6

$$R^{D\,\prime}(t_d^*) = -g + 2\tilde{g}(t_{\max} - t_d^*) = 0 \qquad (12)$$

and implying

$$\tilde{a} = \frac{0.5a}{t_{\max} - t_m^*} \qquad (13)$$

$$\tilde{b} = \frac{0.5b}{t_{\max} - t_c^*} \qquad (14)$$

$$\tilde{g} = \frac{0.5g}{t_{\max} - t_d^*} \,. \qquad (15)$$

Consequently, the military contribution of a person aged t is given by

$$M(t) = M_{t_{\max}} + a[1 - 0.5(t_{\max} - t)/(t_{\max} - t_m^*)](t_{\max} - t) \qquad (16)$$

his forgone civil output by

$$C(t) = C_{t_{\max}} + b[1 - 0.5(t_{\max} - t)/(t_{\max} - t_c^*)](t_{\max} - t) \qquad (17)$$

and the remuneration to his remaining kin in the event of being killed at t is

$$R^D(t) = R^D{}_{t_{\max}} + g[1 - 0.5(t_{\max} - t)/(t_{\max} - t_d^*)](t_{\max} - t)\,. \qquad (18)$$

It is assumed that in addition to an initial nominal cost $\hat{R}^I$ (in present value) of hospitalization, a time-invariant (in present value) remuneration, d, is paid each instance to an injured person, or to his remaining closest relative, over a period that is equal to the potential remaining life expectancy had there been no injury, $T - t$. That is, the rehabilitation costs of a person injured at age t are given by

$$R^I(t) = \hat{R}^I + \boldsymbol{d}(T - t).$$ (19)

The costs of adjusting to civilian life for a released soldier are represented by

$$S(t) = \hat{S} + \boldsymbol{l}t$$ (20)

where $\boldsymbol{l}$ is a positive (negative) scalar if the difficulty in adjusting to civilian life increases (decreases) with the conscripted soldier's age, and where $\hat{S}$ is an age-insensitive portion of the adjustment costs.

By substituting equations (16) to (20) and equation (5) into equation (6), the expected net national benefit from military service at age t can be rendered as:

$$
\begin{aligned}
ENNB(t) = {}& M_{t_{\max}} - C_{t_{\max}} - \hat{S} - \boldsymbol{l}t - \boldsymbol{q}p_{\max}[1 - \boldsymbol{m}(t_{\max} - t)/(t_{\max} - t_{\min})]\hat{R}^I \\
& - \boldsymbol{f}p_{\max}[1 - \boldsymbol{m}(t_{\max} - t)/(t_{\max} - t_{\min})]R^D{}_{t_{\max}} \\
& + \{\boldsymbol{a} - \boldsymbol{b} - \boldsymbol{f}p_{\max}[1 - \boldsymbol{m}(t_{\max} - t)/(t_{\max} - t_{\min})]\boldsymbol{g}\}(t_{\max} - t) \\
& - \{\boldsymbol{q}p_{\max}[1 - \boldsymbol{m}(t_{\max} - t)/(t_{\max} - t_{\min})]\boldsymbol{d}\}(T - t) \\
& - 0.5\left[\frac{\boldsymbol{a}}{t_{\max} - t_m^*} - \frac{\boldsymbol{b}}{t_{\max} - t_c^*} - \frac{[\boldsymbol{f}p_{\max}[1 - \boldsymbol{m}(t_{\max} - t)/(t_{\max} - t_{\min})]\boldsymbol{g}}{t_{\max} - t_d^*}\right](t_{\max} - t)^2
\end{aligned}
$$
.(21)

4. ENNB-maximizing enlistment-age

Let t^o denote the $\arg\max\{ENNB(t)\}$. Recalling equation (20), the necessary and sufficient conditions for interior solution are:

$$-(\tilde{a}t^{o2} - \tilde{b}t^o + \tilde{c}) = 0$$ (22)

$$\tilde{b} - 2\tilde{a}t^o < 0$$ (23)

where,

$$\tilde{a} \equiv \frac{1.5 \boldsymbol{gmf} p_{\max}}{(t_{\max} - t_d^*)(t_{\max} - t_{\min})} \tag{24}$$

$$\tilde{b} \equiv \frac{\boldsymbol{m} p_{\max}}{t_{\max} - t_{\min}} \left[2(\boldsymbol{qd} + \boldsymbol{fg}) + \frac{3 \boldsymbol{fgt}_{\max}}{t_{\max} - t_d^*} \right] + \frac{\boldsymbol{b}}{t_{\max} - t_c^*} - \frac{\boldsymbol{a}}{t_{\max} - t_m^*} \tag{25}$$

and

$$\tilde{c} \equiv (\boldsymbol{a} - \boldsymbol{b} + \boldsymbol{1}) + \frac{p_{\max}}{t_{\max} - t_{\min}} \{ \boldsymbol{qd}[\boldsymbol{m}(T + t_{\max}) - 1] + \boldsymbol{m}(\boldsymbol{q}\hat{R}^I + \boldsymbol{f}R_{t_{\max}}^D) \}$$
$$+ \left[\frac{\boldsymbol{b}}{t_{\max} - t_c^*} + \frac{\boldsymbol{gf} p_{\max}}{t_{\max} - t_d^*} + \frac{2 \boldsymbol{gfm} p_{\max}}{t_{\max} - t_{\min}} - \frac{\boldsymbol{a}}{t_{\max} - t_m^*} \right] t_{\max} + \frac{1.5 \boldsymbol{gfm} p_{\max} t_{\max}^2}{(t_{\max} - t_{\min})(t_{\max} - t_d^*)} \tag{2}$$

If the second-order condition (23) is satisfied, the expected net-national-benefit maximizing enlistment age is given by

$$t_{1,2}^o = \frac{\tilde{b} \pm \sqrt{\tilde{b}^2 - 4\tilde{a}\tilde{c}}}{2\tilde{a}}. \tag{27}$$

If the second-order condition (23) is not satisfied, the expected net-national-benefit maximizing enlistment age is either the minimum age $t_{\min}$ (when $ENNB(t_{\min}) > ENNB(t_{\max})$) or the maximum age $t_{\max}$ (when $ENNB(t_{\min}) < ENNB(t_{\max})$).

5. Numerical simulations

The numerical simulation of the expected net-national-benefit maximizing enlistment-age formula (26) considers a country where $t_{\min} = 18$ years, $t_{\max} = 65$ years, and $T = 80$ years. The main simulation was performed with medium parameter

values for that country. These medium parameters values and the simulation result are presented in bold numbers by the middle column of Table 1. The nominal figures are per annum.

$$[\textit{Insert Table } 1 \textit{ here}]$$

The effects of the model parameters on the *ENNB* maximizing enlistment age can be assessed by inspecting the rest of the table's columns. The entries in these columns are computed by changing the value of one parameter at a time from its medium level while holding the rest of the parameters at their medium levels.

In all of the numerical simulations the interior solution was only obtained with $t^o = (\widetilde{b} - \sqrt{\widetilde{b}^{\,2} - 4\widetilde{a}\widetilde{c}}\,)/2\widetilde{a}$ and, reasonably, as long as **b** sufficiently exceeds **a** + **l**. In the absence of a clear assessment of the relationship between released soldiers' costs of adjusting to civilian life and age, the medium value of **l** was set to be equal to zero.

Despite the substantial parameter change, the numerical simulations reveal that the *ENNB* maximizing enlistment-age results are quite tightly distributed around the value obtained with the medium parameter-value vector—55.714 years of age.

The numerical simulations reveal that the *ENNB* maximizing enlistment age rises with the probability of war when the country is unarmed ($p_{\max}$), with the probability of being killed in war (**f**), with the probability of being injured in war (**q**), with the army's war-deterrence gradient (**m**), with the prime-age of people's civilian production (t_c^*), with the age of death associated with maximum remuneration to kin (t_d^*), with the military performance/youth coefficient (**a**), with

the death remuneration/youth coefficient (g), with the annual remuneration extended to injured soldiers (d), with the correlation between costs of adjusting to civilian life and age (l), and with the hospitalization costs of injured soldiers. The *ENNB* maximizing enlistment age declines with the prime-age of people's military performance (t_m^*) and with the civil performance/youth coefficient (b).

Finally, when the upper-bound on recruiting age is lowered from 65 to 60 the ENNB-maximizing enlistment-age drops slightly to 53.725. When the upper-bound is further reduced to 55 or 50, the ENNB-maximizing enlistment-age is reduced to 51.426 and 48.632, respectively.

6. Concluding remarks

Although enlisting at eighteen years of age maximizes army size and, in turn, war-deterrence, its application is not necessarily in the best interest of a nation. This paper demonstrated that when socioeconomic factors are taken into account, the expected net national benefit is maximized by enlisting people in a mature phase of their life. This non-orthodox recommendation can be supported by the fact that during the years that have passed since World War I warfare has become much more sedentary and technical. During the same period, awareness to fitness and health services have been improved, life expectancy have been increased, household structure has been changed, and the role of men as bread-earners and family-heads has been diminished.

There may be other arguments in favor of enlisting at mature, middle age. The most important one is the morality of risking very young people who have not contributed significantly to the evolution of their country geopolitical difficulties, who

have not tasted much of life, and who may play a significant role in the advancement of their nation and the world.

A compromise between this paper's non-orthodox recommendation and the current practice in countries maintaining a conscript army is a policy of mature-age compulsory military service (say, of one year—a period comparable to a sabbatical or temporary leave allowed in many places of employment) augmented by an initial military training and non-combatant service (say, of one year) at early age (say, eighteen) and refreshing training sessions (say, of up to four weeks per year) commanded by volunteer career-officers and supported by volunteer professional staff, so as to increase a small country's war-potential army and war-deterrence capacity, and where young-soldiers units are deployed to the frontline and battle as the last, rather than the first, resort.

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Table 1: The numerical simulations' results

Parameter & Enlisting age	Very Low	Low	Medium	High	Very High
$p_{\max}$ t^o (years)	0.1 51.228	0.25 52.985	**0.5** **55.714**	0.75 58.230	0.9 59.651
f t^o (years)	0.01 52.441	0.025 53.691	**0.05** **55.714**	0.075 57.670	0.1 59.571
q t^o (years)	0.01 54.533	0.05 55.071	**0.1** **55.714**	0.15 56.327	0.2 56.912
m t^o (years)	0.1 53.312	0.25 54.253	**0.5** **55.714**	0.75 57.059	0.9 57.817
t_m^* (years) t^o (years)	25 56.668	30 56.284	**35** **55.714**	40 54.779	45 52.963
t_c^* (years) t^o (years)	30 42.679	40 52.208	**45** **55.714**	50 58.634	60 63.193
t_d^* (years) t^o (years)	20 54.867	30 55.352	**35** **55.714**	40 56.220	50 58.226
a (dollars) t^o (years)	500 50.881	1000 52.975	**1500** **55.714**	2000 59.454	2500 64.887
b (dollars) t^o (years)	2000 64.855	2500 58.903	**3000** **55.714**	3500 53.720	4000 52.354
g (dollars) t^o (years)	1000 53.443	2500 54.310	**5000** **55.714**	7,500 57.071	10,000 58.386
d (dollars) t^o (years)	1000 55.074	2500 55.320	**5000** **55.714**	7500 56.089	10,000 56.447
l (dollars) t^o (years)	-1,000 46.608	-500 51.149	**0** **55.714**	500 60.305	1,000 64.922
$\hat{R}^I$ (dollars) t^o (years)	25,000 55.349	50,000 55.471	**100,000** **55.714**	150,000 55.958	200,000 56.201