Chapter 10

Combat Risk and Pay: Theory and Some Evidence

Curtis J. Simon
Shirley H. Liu
Saul Pleeter
Stanley A. Horowitz

Executive Summary

The Department of Defense (DoD) has long acknowledged the importance of recognizing, in the form of monetary compensation, servicemembers' sacrifice during times of conflict. Currently, combat-related compensation takes the form of Hostile Fire Pay/Imminent Danger Pay (HFP/IDP) and the Combat Zone Tax Exclusion (CZTE). HFP/IDP is currently set at $225 per month for any part of a month while in a designated area or exposed to hostile activities. The CZTE designation permits servicemembers to forgo paying federal and state income tax on service-related income earned while in a combat zone. Under current policy, CZTE designation and payment of HFP/IDP is based solely on geography. Despite the original intention of such pays to compensate only those who face significant probabilities of death or injury, in practice they cover individuals who face a wide range of risks to life and limb. For this reason, the 11th Quadrennial Review of Military Compensation (QRMC) is reexamining the way in which combat pays are determined.

This report examines the relationship between total cash compensation and risk in the U.S. military. Total military cash compensation includes a variety of special pays and bonuses that are relevant to an examination of compensation servicemembers receive and the risks to which they are exposed. In addition, the current report examines the relationship between total cash compensation and combat risk using information on individuals deployed both inside and outside combat zones.

This report uses the conceptual model of compensating differences, which is well known to economists. The model posits that total compensation must rise with combat risk to induce individuals to accept that level of risk. In practice, individual servicemembers may sort themselves across different military occupations so that

The views expressed in this paper represent those of the authors and are not necessarily those of the Department of Defense.

those least averse to risk choose the most dangerous occupations. In that case, the most economically efficient combat compensation scheme conceivably would involve paying servicemembers in more dangerous occupations smaller increments for risk than servicemembers in safer occupations. By that logic, the rule that incremental compensation for risk should rise at higher levels of risk applies only within occupations.

This report uses data drawn from two sources. The information on combat killed and wounded was taken from individual-level "event" information that covered the period FY 2003–2009. Information on deployment and years served was collected from calendar year payroll observations that included every individual who deployed to a combat zone at any time between 2003 and 2009.

Military service is a *very* dangerous way of life, particularly when the member is deployed in a combat zone. Using data from between 2003 and 2009, the probability of being killed per year served averaged 0.014 per 1,000 servicemembers deployed in non-combat zone assignments and 1.164 per 1,000 servicemembers deployed in combat zone assignments. The figure for those deployed to a combat zone is orders of magnitude higher than in the civilian sector. For example, Viscusi (2004) estimates a probability of being killed in a manufacturing environment of just 0.03 per 1,000 full-time workers.

To analyze the relationship between compensation and combat risk, a regression model was estimated using data on enlisted personnel for the period 2003–2009. Information on both compensation and the risk of death was categorized by location, occupation, Service, and pay grade. Using data on individuals deployed to combat zones and those not deployed, we estimated that an increase in risk of death of one per thousand personnel was associated with $551 per person more in annual compensation. Variation in compensation within the combat zone was found to be much less strongly related to risk.

1. Introduction

Since September 11, 2001, the United States has been engaged in a number of conflicts of varying intensity. The Armed Forces were reasonably well adapted to staffing an All-Volunteer Force (AVF) during times of relative peace, although recruiting challenges arose occasionally during times of a particularly healthy civilian economy. Staffing a force that is at constant war posed new challenges, particularly for the Army, which has incurred the brunt of the casualties.

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Fire Pay/Imminent Danger Pay (HFP/IDP) and the Combat Zone Tax Exclusion (CZTE). HFP/IDP is currently set at $225 per month for any part of a month while in a designated area or exposed to hostile activities. The CZTE designation permits servicemembers to forgo paying federal and state income tax on service-related income earned while in a combat zone. Under current policy, CZTE designation and payment of HFP/IDP is based solely on geography. Despite the original intention of such pays to compensate only those who face significant probabilities of death or injury, in practice they cover individuals who face a wide range of risks to life and limb. For this reason, the 11th Quadrennial Review of Military Compensation (QRMC) is reexamining the way in which combat pays are determined.

The notion that individuals must be compensated for facing above average risks has its roots in Adam Smith's (1776) theory of compensating differences, and Rosen (1986) devised what has become the standard neoclassical economic theory relating wages to the differing conditions (including risk) of various occupations. In its modern form, what economists call hedonic wage theory has been used to measure the willingness of individuals to accept employment in jobs that pose high levels of risk. In particular, the dollar increment to compensation necessary to induce an individual to accept a given increase in the probability of being killed on the job is called the value of a statistical life (VSL), a metric that has become widely used for the purposes of cost-benefit analysis by economists as well as by the U.S. government.

While VSL is a widely accepted way of thinking about wage differentials in the civilian sector, this is less true of the U.S. military. For example, Koopman and Hattiangadi (2002, 151) identify special and incentive pays as being "recognition pays" for hazardous or unpleasant duty, with no indication that HFP/IDP might be related to the values that individuals place on their own lives, or that combat pay should be commensurate with the risks involved.

The purpose of this paper is to further examine the relationship between the total cash compensation individuals in the U.S. military receive and the risk they face. Total military cash compensation includes a variety of special pays and bonuses that, although not serving a strictly combat-pay purpose, may in part reflect what must be paid to induce individuals to accept the greater risk inherent in particular occupations or other circumstances. These elements of compensation thus may augment, or even substitute for, combat pays as compensation for risk. This paper will examine the relationship between total cash compensation and combat risk, using information on individuals deployed both inside and outside combat zones.

The paper is organized as follows. Section 2 briefly reviews the history of combat compensation. Section 3 uses the well-known model of compensating differences to illustrate how the various special and incentive pays might be used in an economically efficient combat pay system. Section 4 describes the data and presents new estimates of the annual probability of being killed or seriously wounded in action, and how this probability varies over time, across Services, across occupations, and between countries. Section 5 presents evidence on the empirical relationship between combat risk and total monetary compensation during the period 2003–2009. This is presumably linked to how much servicemembers must be paid to bear additional risk. Section 6 concludes with a brief summary and suggestions for future research.

2. Combat Pay: Background

Since World War I, members of the U.S. military have received war-related compensation in addition to their regular pays and allowances. The CZTE was originally established in World War I (WWI) "to alleviate the burden of war finance from those who fought in the nation's conflicts" (Pleeter et al. 2011, 23). Recognition for combat risks in the form of additional cash pay originated during World War II (WWII) with Badge Pay for combat infantry (Gould and Horowitz 2011, 21). These pays were limited in temporal and geographical scope and not intended to reproduce the operations of a voluntary labor market.

Another benefit received as combat compensation is the payment of Servicemembers' Group Life Insurance (SGLI) premiums for the duration of the member's deployment to a combat zone. Premiums amount to $.065 per $1,000 of life insurance (or $26 per month for the maximum coverage of $400,000), plus $1 per month for the SGLI Traumatic Injury Protection Program (T-SGLI).[1] Other combat zone benefits include programs such as student loan repayment, income replacement for Reservists, a savings program, and the Marine GYSGT John David Fry Scholarship[2]—to name a few—that are not automatically distributed to members and not widespread in terms of the number of members receiving them. (Pleeter et al. 2011, 5).[3]

1. Servicemembers normally are permitted to purchase up to $400,000 worth of life insurance. The decision to purchase life insurance, like the decision to purchase other assets, is a component of the consumption-saving decision extended to a world of state-dependent utility (see, for example, Lewis 1989). If priced actuarially fairly, payments into the system equal payments out and the expected value of the insurance is zero for servicemembers as a group. To the extent that insurance is subsidized¾for example, the insurance fee is waived for servicemembers deployed to a combat zone¾one should count the actuarially fair value of the insurance premiums as compensation received by servicemembers when they are alive.

2. Marine GYSGT John David Fry Scholarship is a GI Bill benefit paid to surviving dependent children.

3. Cash compensation for military personnel can be divided into regular military compensation (RMC), special and incentive (S&I) pays, and miscellaneous allowances and cost-of-living allowances (COLAs). RMC is the sum of basic pay, housing allowance, subsistence allowance, and the federal tax advantage owing to the non-taxability of allowances. The various special and incentive pays have different rationales. Bonuses, for example, enable the recruitment and retention of personnel in critical skill areas. The retirement system

DoD has considerable flexibility with respect to the assignment of military personnel once someone has enlisted or received a commission. However, it must attract individuals to join in the first place. The military is confronted with a constant need to attract and motivate large numbers of individuals from a population with heterogeneous tastes for different types of careers and with different attitudes toward risk.

Staffing a volunteer military during periods of conflict and casualties may require higher levels of compensation than are necessary during periods of peace. The fact that individuals value life and limb implies that some increase in compensation will be necessary. This may be offset in part or in whole by patriotic motivation—the desire to embrace an obligation of citizenship. The theoretical framework of this paper focuses on aversion to risk and the increased compensation that must be provided when risk rises, but the empirical portion of the paper is agnostic with respect to which effect dominates.

Historically, the military compensation system has tended to vary along only two dimensions: rank and years of service. However, the advent of the AVF led DoD to develop a range of new compensation tools to enable it to meet the nation's defense manpower requirements. Various special pays have long been considered to be good policy.[4] DoD has taken advantage of the flexibility given it by the Congress to differentiate compensation across individuals who possess particularly desirable and scarce initial qualifications. Recently, DoD has implemented a wide range of differential compensation in the form of initial enlistment bonuses for occupational and term commitments (Simon and Warner 2009), College Funds for High Quality recruits, bonuses for native language speakers, and differentiation of pay across location (e.g., the Navy's Assignment Incentive Pay (AIP) System).[5]

However, when it has come to combat pay, DoD has implemented little variation either geographically or with regard to the risks faced (Pleeter et al. 2011). Much of the variation in the value of combat compensation, whether by chance or design, bears little or even an inverse relation to the risk faced by military personnel.

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creates a strong incentive for military personnel to stay beyond 10 years and to leave after 20 years (Asch et al. 2008, 8).

4. The Selective Reenlistment Bonus (SRB) was established in 1974, which provides re-enlistees in selected occupations with a bonus in return for at least 3 additional years of service. In addition to occupation, the SRB has varied with experience level. In 1999, the Army further refined the SRB with the Targeted SRB, which varied by assignment location, unit, and Special Qualification Indicator (SQI). The Location SRB was introduced to award higher multipliers for personnel in units mobilized to Afghanistan, Iraq, and Kuwait (Simon and Warner 2010, 508-9).

5. In AIP, sailors submit bids online for the amount of additional compensation they would require to accept an assignment listed in AIP up to a preset maximum The Navy selects the "winner" based on the total cost to the Navy, defined to be the sum of AIP payments, training costs, Permanent Change of Station costs, and the costs of any "gap" in the billet (quoted from Carrell and West 2005, 807).

As noted earlier, combat compensation is not the only element of total military pay and benefits that can compensate for bearing risk. Questions naturally arise as to how much the overall compensation scheme compensates for risk and it how efficiently it does so. The next section presents a theoretical model to show how total compensation should vary with risk in an efficient system.

3. Theory of Compensating Differentials

The theory of compensating differentials can be traced to Smith (1776), but modern developments of the theory are found in Rosen (1986). In its simplest form, individuals are assumed to maximize utility over just two job characteristics, the wage rate W and the level risk as measured by the probability of an adverse event, p. The indifference curves reflect fixed values of utility $U=U(W,p)$, and, drawn in p-W space, are upward sloping and convex to the origin, indicating that higher levels of job risk must be compensated in the form of higher wages.

Notice that wages must rise with risk at an increasing rate. To see why, consider how much any particular individual would be willing to sacrifice in wages in return for additional safety. It is intuitively plausible that as risk declines, the willingness to sacrifice wages in return for additional increments in safety declines. Put informally, a given individual is less willing to sacrifice a dollar of wages in return for additional safety in an office job than, for example, in a job felling trees.[6] In a more formal sense, it is the result of the diminishing marginal rate of substitution (MRS) between goods. Here the two goods are safety and everything else (wages). Diminishing MRS means a convex indifference curve in wage-safety space. The less safety one has, the more one will be willing to pay for a given increment.

Figure 1 shows indifference curves for two different individuals. The red upward-sloping curve shows the indifference curve for an individual of type A and the blue upward-sloping curve shows the indifference curve for an individual of type B. Individual A is less averse to risk because the indifference curve is flatter at any given level of risk, indicating that a smaller increment in the wage rate is required to compensate for any given increase in risk. Looking at the intersection of the two curves, it can be seen that the indifference curve of individual A is flatter than that of individual B, meaning that individual B is willing to sacrifice more in the form of lower wages for a given reduction in the level of risk.

6. Bommier and Villeneuve (2010) extend the life-cycle consumption model to incorporate what they call mortality risk aversion in addition to risk aversion over consumption levels. Their correction leads to greater weight being placed on mortality risk reduction of the young.

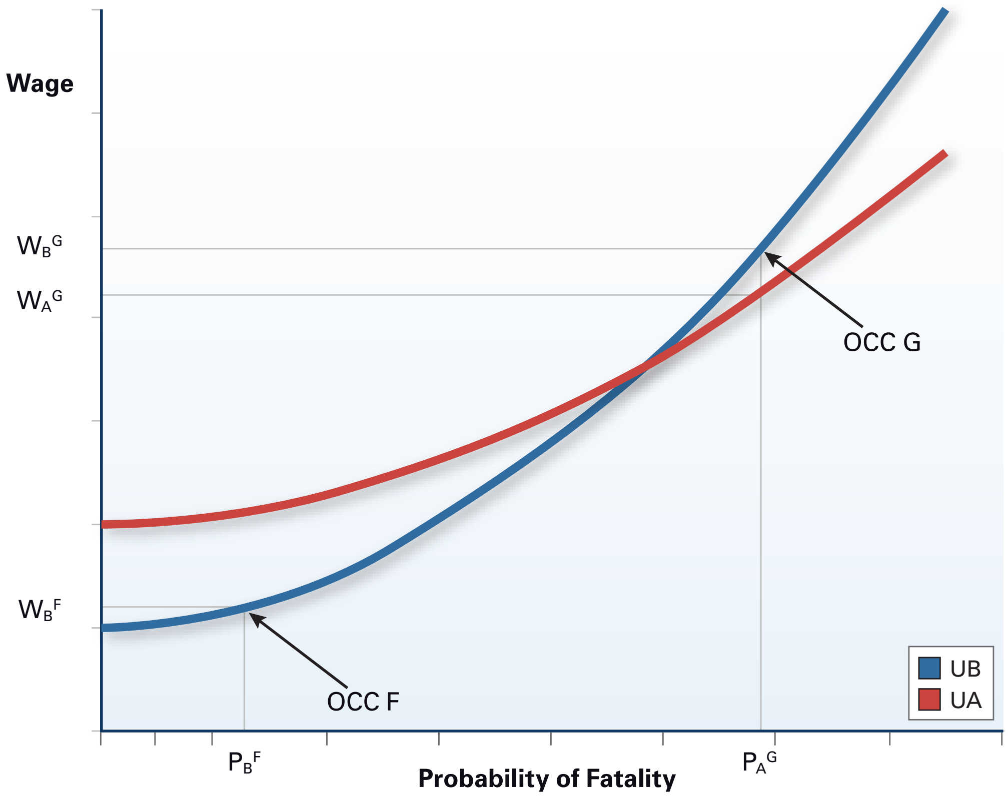

Figure 1. Individuals Least Averse to Risk Choose to Work in the Most Dangerous Firms

Suppose that there are two occupations, F and G, where the probability of fatality in occupation G, p_A^G is higher than in occupation F, p_B^F.[7] In competitive equilibrium, individuals of type A will match up with firms of type G and individuals of type B will match up with firms of type F. The VSL approximately determines the wage differential necessary to induce an individual to accept the increase in risk when moving from occupation F to occupation G. As can be seen, the VSL is higher for

7. In order to simplify the presentation, it is assumed that risk in each occupation is fixed. In the more general hedonic model, the preferences of firms are a function of profits. Because safety is costly, reductions in risk must be accompanied by a reduction in wages in order to keep profits constant at any given level. Therefore, the curves that show combinations of W and p that deliver equal profit, or iso-profit curves, must be positively sloped. Under the assumption that the cost of reducing risk on the job is increasing at an increasing rate, the iso-profit curves will be concave. A firm is said to be more dangerous when wages must be reduced more in order to achieve any given reduction in risk, that is, when the iso-profit curve is steeper. In competitive equilibrium, all firms earn zero economic profit. This equilibrium entails a tangency between each firm's zero-profit iso-profit curve and the indifference curve of the workers willing to supply their labor at the lowest possible price.

individual B than individual A because of their different preferences with respect to wages and risk.[8]

Suppose for the moment that individual B is offered a wage sufficiently high to accept the more dangerous occupation, W_B^G. The wage differential per unit increase in risk required for workers of type B to accept the more dangerous job is equal to $(W_B^G - W_B^F)/(p_A^G - p_B^F)$. Assume that the job in occupation G has a risk of being killed 1/1000 higher than firm F, and that individual B requires $4,000 per year in order to accept the more dangerous job. Then the wage differential per unit increase in risk is $4,000 x 1,000 = $4 million. One thousand, individuals such as B would require $4 million collectively in order to accept the possibility that an average of 1 more of them would die each year than in firm F. The wage differential per unit increase in risk is called the VSL. The differential illustrated in Figure 1 is the discrete approximation to person B's VSL. As the denominator becomes infinitesimally small (say by reducing the level of risk in assignment G), this ratio measures the marginal rate of substitution (MRS) between wages and risk, or the true VSL evaluated at (p_B^F, W_B^F).[9]

If individuals of Type A are available, it is not efficient for individuals of type B to work in occupation G. The reservation price of workers of type A for working in occupation G is lower. The VSL for individuals of type A when they work in occupation G, which is equal to the slope of the indifference curve, is flatter at the point p_A^G than individual B's, indicating that A's VSL is lower than B's.[10]

8. Matching worker B to firm G ("too dangerous") would require paying B wages sufficiently high so as to make him at least as well off as he is at F, meaning that one would have to keep B along his indifference curve. This would entail higher wage costs and lower (that is, negative) economic profits. Similarly, matching worker A to firm F ("too safe") would allow firm F to pay lower wages, but not as low a wage as they can pay worker B. The firm would have to keep A along his indifference curve , meaning that the firm would have to earn a negative profit.

9. Formally speaking, VSL is the marginal rate of substitution between money and mortality risk per unit time period, that is, the slope of an indifference curve between risk and wealth at a point. It is *not* the value of saving an individual's life with certainty (Cropper et al. 2000, 2, emphasis added).

10. The VSL is the most useful metric for valuing life, especially when compared with values imposed by the system of jurisprudence, for several reasons. First, it is market behavior that is relevant for how individuals value their own lives and safety and not the judgments of others. Second, Viscusi (1999) found that although judges avoided many pitfalls exhibited by jurors and the population at large, such as hindsight bias (59), they nevertheless exhibited systematic errors, particularly for small probability-large loss events (26). Third, Viscusi (2001) shows that jurors "fall substantially short of what one might hope for in terms of a desired pattern of decisions, particularly in small-probability, large-loss cases.. . . Jurors fault companies for thinking systematically about risk, even in situations in which on the basis of the usual economic criteria the firm was not negligent and complied with state-of-the-art economic evaluation practices employed by the responsible regulatory agencies" (135). Interestingly, though, Cohen and Miller (2003, 165) find that "pain and suffering" awards in a sample of 1200 consumer product related injury and intentional assault cases implied a VSL of between $1.4 and $3.8 million, "well within the range of estimates derived independently from wage-risk studies."

A. Implications for Military Compensation

Like employers in the model presented above, the military has to attract and retain people in occupations that face different degrees of risk and, to a first approximation, desires to do so without spending more on compensation than is necessary. For now, it will be assumed that the "production process" of the military is separable into two occupational tasks, F and G.[11] In addition to two occupations (OCCs), it will be assumed that individuals can either be stationed within the Continental United States (CONUS) or deployed overseas, where it is assumed that all deployments are alike within an occupation. It will be assumed that occupations F and G are both "safe" when individuals are in the U.S., while F is relatively safer than G when deployed.

The various assignments possible are shown in Figure 2. For now, it is assumed that there are only individuals of type B in the population. For stateside assignments, the efficient combination of W and p is found along the indifference curve. For example, OCCs F and G must pay a wage W^{CONUS} at risk level P_B^{CONUS} in order to attract volunteers.[12] In order for individuals in occupation F to deploy voluntarily, they must be paid a wage of at least $W_B^{F.DEP}$. In order for individuals employed in occupation G to be willing to deploy voluntarily, they must be paid a wage of at least $W_B^{G.DEP}$. Because mission G is more dangerous than mission F when deployed, $W_B^{G.DEP} > W_B^{F.DEP}$.[13]

11. The probability of mission success is a function of the number of personnel, the quantity and quality of capital, and other factors. Incorporating the probability of mission success is well beyond the scope of this paper. Another distinguishing feature of military service, compared with the civilian sector, is that the matrix of threats typically evolves at a much faster pace (e.g., improvised explosive devices (IEDs) and suicide bomber vests).

12. For individuals to be willing to volunteer in the military, B's indifference curve must lie at or above the indifference curve that corresponds to the level of utility offered in the civilian sector. This indifference level is not shown, to reduce clutter in the figure.

13. The same analysis could be applied to the case of a single occupation and two possible deployments, one more dangerous than the other.

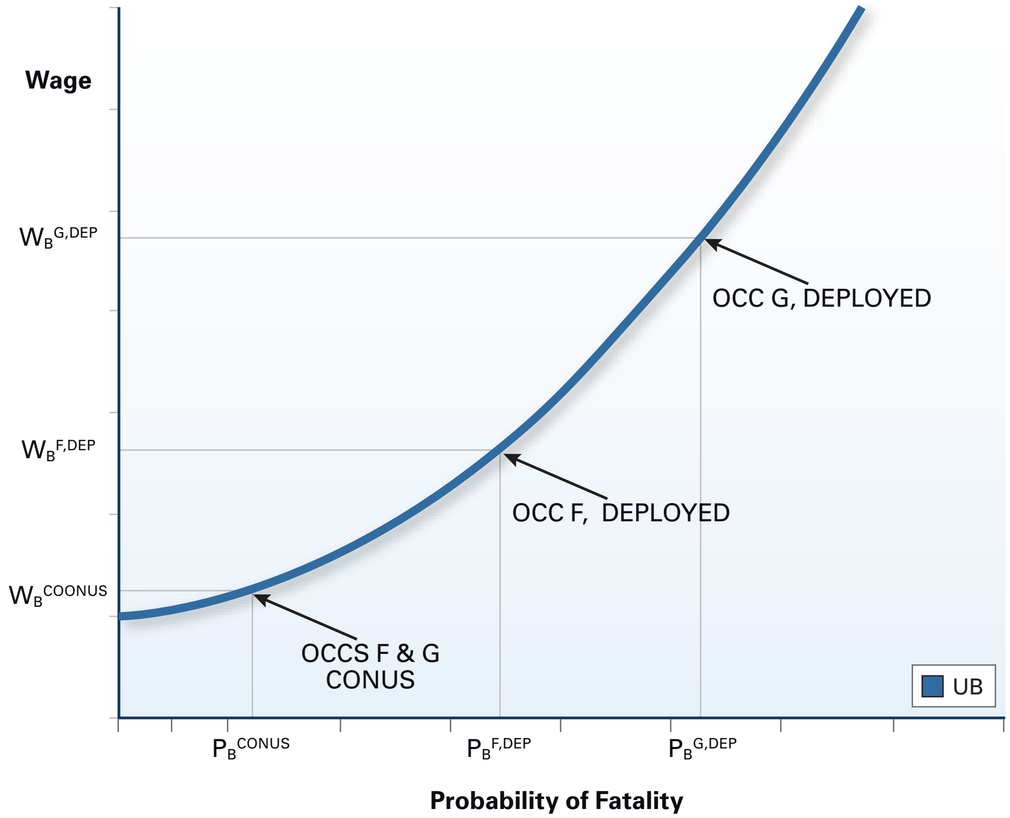

Figure 2. Wages Rise to Compensate Individuals for the Risk of Being Deployed

B. Cost-Minimizing Compensating Wage Differentials in the Military

The cost-minimizing combat compensation policy is one that just compensates individuals in occupations F and G for the added risk due to deployment. Because deployment increases risk by more in occupation G than occupation F, the cost-minimizing combat pay policy requires a higher pay differential in G than F. Under current compensation policy, all individuals deployed within a country designated as a combat zone receive an additional $225 HFP/IDP per month or part of month that they are in theater. By design, then, it is not possible to differentially compensate individuals who face different levels of combat risk using HFP/IDP alone. However, there are a number of other components of pay that might serve such a purpose, including Hardship Duty Pay (HDP), Special Duty Assignment Pay (SDAP), or enlistment (and re-enlistment) bonuses (EB).[14]

14. The analysis here abstracts from tax considerations, that is, CZTE. Hardship duty pays include compensation for undesirable locations (HDP-L), difficult missions (HDP-M), or for involuntary extension of contract. Currently, the maximum combined HDP is capped at $1,500 per month. The military also pays a variety of

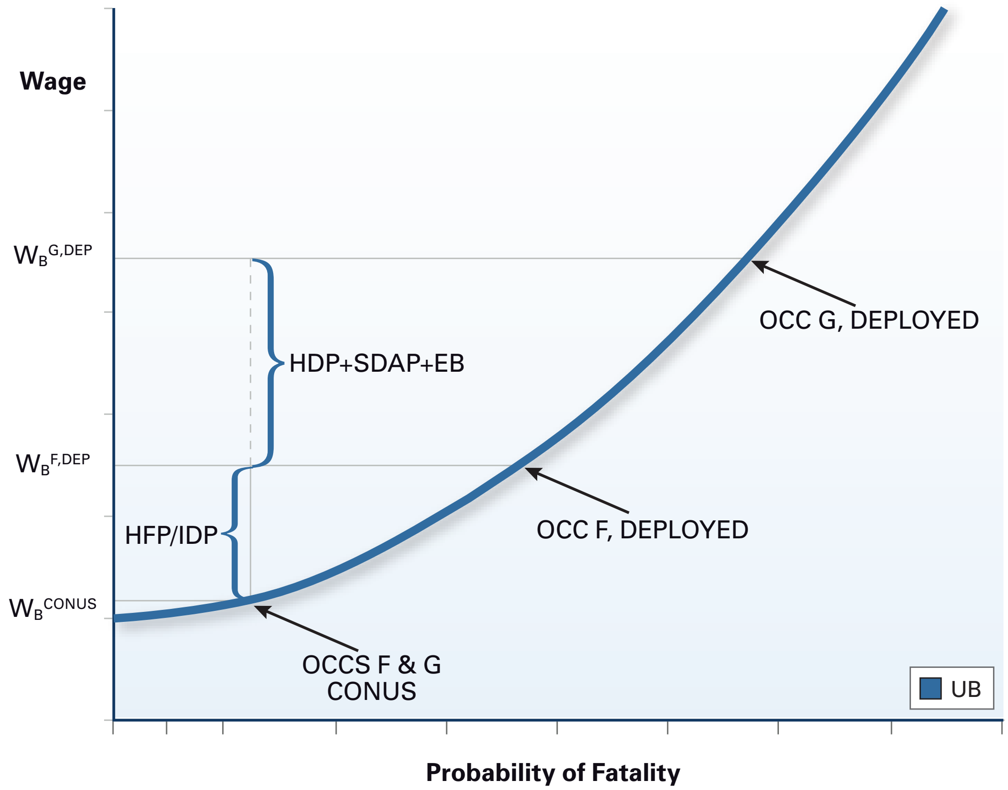

Figure 3. Optimal Compensating Wage Differentials in the Military

The efficient compensation policy is seen in Figure 3. HFP/IDP is used to ensure that individuals deployed in occupation F are no worse off deployed than in CONUS, and a combination of HDP, SDAP, and EB is used to compensate further individuals employed in the more dangerous occupation G.

C. Consequences of Overpaying HFP/IDP

Because current DoD policy pays all individuals HFP/IDP of $225 per month for serving in a combat zone, the possibility arises that DoD will overpay some individuals for combat risk, in the sense that they would be willing to serve at lower levels of total pay.[15] This scenario is depicted in Figure 4. HFP/IDP has been set at a level higher than necessary to compensate individual B for the risk of deployment in occupation F. It is assumed that the sum of HFP/IDP, HDP, SDAP, and EB just compensates individual B for the risk of deployment in occupation G when deployed.

Special Duty Assignment Pays (SDAP). DoD has been aware that reductions in one component of pay can be offset by increases in others (see, for example, Kapp 2003).

15. With heterogeneous tastes and incomplete sorting, such overpayment is inevitable; overpayment occurs when the marginal individual—the individual most averse to risk—would be willing to serve at lower pay.

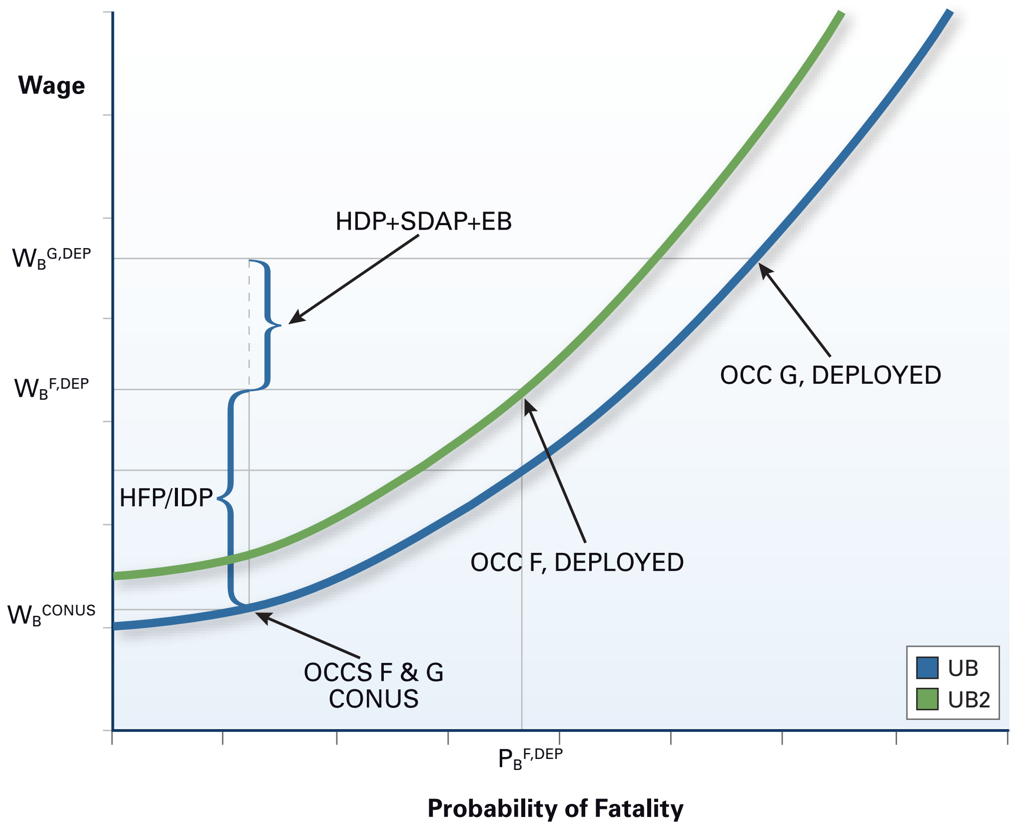

Figure 4. Overcompensation of Individuals in Less Risky Deployments

There are three undesirable consequences of overpaying HFP/IDP. First, DoD is not accomplishing the mission at the lowest possible cost to the taxpayer. Second, if all individuals were given the option of deploying in their choice of occupation, F or G, no one will want to deploy in occupation G. By overcompensating individuals deployed in occupation F, utility is higher than utility in either F or G in CONUS, and higher than being deployed in occupation G. The third consequence of overpaying HFP/IDP concerns the issue of fairness. The U.S. military does not give individuals the option of freely choosing their occupation at each point in time. When all individuals who deploy to a designated combat zone receive the same level of HFP/IDP, it is not possible to ensure that individuals would not prefer to switch to the safer occupation when deployed.[16]

16. An important part of military training is getting individuals to establish an identity, and resist the temptation to make interpersonal comparisons or engage in counterfactual exercises such as the one being carried out here. For example, the military might want to endow personnel with a utility function that would suffer a loss if an individual trained in occupation G were to opt for occupation F when deployed, even if given the choice. This amounts to saying that the indifference curve of such switchers would

D. Heterogeneity in Individual Types

Suppose now that individuals of type A, who are relatively less averse to risk than individuals of type B, become available for service. It is assumed that Type A individuals are so rare in the population that the military cannot solely recruit volunteers from this group. Figure 5 shows that the most cost-effective way to employ such individuals is in relatively dangerous missions such as deployments in occupation G. The reason is that the wage is determined by the most risk-averse individual employed in the occupation. As can be seen, the military must continue to pay sufficient HFP/IDP in order to entice individuals of type B to deploy in occupation F. However, the amount of HDP, SDAP, and EB necessary to compensate for the risks of deployment in occupation G is smaller for individuals of type A than for individuals of type B.

The military may have difficulty filling occupation G entirely with individuals of type A. It can then assign some type B individuals to deploy in occupation G

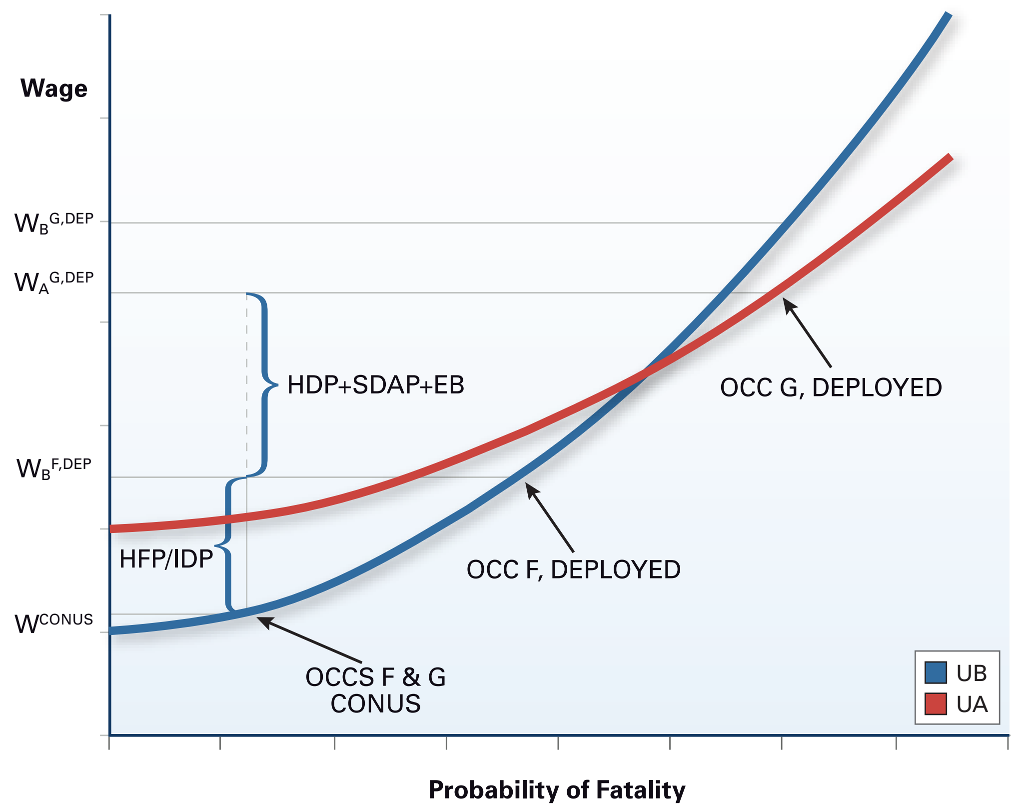

Figure 5. Individuals Least Averse to Risk Should be Assigned to the Most Dangerous Deployments

actually lie below and to the right of the blue indifference curve. Hosek, Kavanagh, and Miller (2006, 15ff.) review the sociological literature on combat motivation, and, in particular, the importance of group cohesion.

when they would prefer to be in occupation F.[17] Alternatively, some other means can be adopted to encourage individuals who would prefer to be in occupation F to deploy in occupation G. For example, the Services have used enlistment bonuses and college funds to attract individuals into hard-to-fill occupations. Such tools are not used in all cases. Recruiters are less likely to have to resort to such "deal-closers" for individuals of type A than they are for individuals of type B, thus generating a degree of inequity in compensation across individuals within an occupation.

The presence of individual heterogeneity poses difficulties for studying the relationship between compensation and combat risk, especially because occupations differ in characteristics other than combat risk. If individuals of type A have a preference for occupation G independently of wages and risk, they may be willing to enter occupation G even if the probability of being killed is higher and the wage lower than in occupation F. The model illustrated in Figure 1 through Figure 5 assumes that no such element enters preferences.

Absent occupational characteristics beyond wages and risk, and assuming that the military tries to employ individuals in their preferred occupations, the model presented in this section leads one to expect a positive relationship between total compensation and combat risk. To be sure, the magnitude of this relationship will reflect the preferences of servicemembers. Strong occupational preferences could attenuate (or exacerbate) the relationship. A strong patriotic response to a crisis could even eliminate it. It is, therefore, an empirical question as to whether this relationship can be detected using simple statistical techniques.

4. Measuring Combat Risk

This section presents evidence on the magnitude of combat risk across Services, occupations, ranks, and countries.

17. Random assignment of personnel across assignments with different risk levels compounds inefficiency when personnel are risk-averse. As of the early 2000s, the services tended to employ a "share the pain, share the gain" approach to filling assignments (Hogan and Mackin 2003, 1). For example, prior to the implementation of its AIP system, the Navy used a sea-shore rotation policy in which a shipboard tour—a bad assignment—would be followed by a shore-based (good) assignment. Hogan and Mackin (7) compare the compensation necessary to staff the force under two systems: random assignment and voluntary assignment. They demonstrate that an incentive system such as AIP enhances efficiency by better matching individuals of heterogeneous tastes to jobs at the lowest possible cost to the Navy. A random assignment system requires that the Navy pay an expected wage sufficient to attract all individuals—say, those with lower and higher aversion to sea-based assignments. The uncertainty over assignments is costly to the Navy. Because individuals are likely to be risk-averse, the incremental compensation necessary exceeds the probability-weighted premium demanded if they were to receive assignments with certainty.

A. Data Sources

Data are drawn from two sources: "event" information from the period FY 2003–2009 and calendar-year payroll records for the same period. The information on combat killed and wounded is taken from individual-level "event" information covering the period FY 2003–2009. For each event that occurs—killed, very seriously wounded, seriously wounded, or not seriously wounded—information is available on the individual's service, the fiscal year and country in which the event occurred, and the individual's occupation. The number of events of each type is summed for each combination of service, fiscal year, event country, and DoD occupation group. The resulting figures become numerators used to calculate the probability of being killed or wounded.

The probability of being killed or wounded in a country is equal to the number killed or wounded divided by the number of individuals at risk. The information on deployment and time in the combat zone was collected from calendar-year payroll observations that included every individual who deployed at any time between 2003 and 2009 to a combat zone. Each individual record contained up to three deployments, and included information on deployment country, deployment start date, and deployment end date. The information on start date and end date was used to convert the calendar year information on time served and deployed into fiscal years. When a single deployment included time spent in more than one country, the time deployed was calculated separately for each country, when possible.

Although the probability of being killed in a year of deployment is informative about the relative risks of various assignments, estimating the relationship between compensation and risk requires measuring each variable over the same time period. Because compensation is reported as a calendar year total, it is therefore necessary to know the probability that an individual is killed or wounded during a year of service. Although both the payroll and casualty data identify whether the individual is serving in an Active, Reserve, or Guard component, information on time served on active duty (as opposed to time deployed) is not available for Reservists. Therefore, information on the probability of being killed or wounded per year of service is calculated only for Active component (AC) personnel. The probability of being killed or wounded in a given country, service, year, and occupation cell is calculated as the number of individuals in that cell who were killed or wounded divided by the person-years served by individuals in that cell at some time in the fiscal year. The denominator will be referred to as years served.

To summarize, all our econometric analyses are based on casualty rates and compensation for individuals in specific calendar years, which are referred to as years served. In many cases individuals were deployed for only part of a year. We have information on casualties, but not compensation, per year deployed. Some of the following tables and figures present information on both casualties per year served (only for AC personnel) and casualties per years deployed (for both AC and Reserve personnel).

Information on cash compensation information includes basic pay, total pay, total bonuses, HFP/IDP, HDP, and SDAP.[18] The value of the CZTE was estimated based on cash compensation and number of dependents. Because the information on pay is valid as of December 31 of each calendar year, the various pays are allocated across deployment locations according to the fraction of time spent in each.

B. Overview of Combat Risk

Table 1 summarizes the total numbers of observations and events in the data. The data cover only enlisted personnel because data on service and deployment times for officers were not available. The data set contained a total of 8,694,822 service-year observations and 3,743,253 deployment-year observations. In total, 5,101 individuals were killed, 4,856 of them in a combat zone between 2003 and 2009. Another 5,027 individuals were seriously or very seriously wounded, 4,898 of them in combat zones.[19]

Table 2 shows the probability of being killed or seriously wounded, expressed as expected values per 1,000 servicemembers in a year. The probability of being killed per year deployed is calculated to be 1.447 per 1,000 servicemembers, and per year deployed in a combat zone, 3.679 per 1,000. The probability of being killed per year served averages 0.433 per 1,000 servicemembers: 0.014 per 1,000 servicemembers who deployed only in non-combat zone assignments in a year and 1.164 per 1,000 servicemembers who deployed at some time during the year in a combat zone.

Data from Viscusi (2004, 33) help put these estimates into perspective. Referring to Viscusi's Table 1, for example, the probability of being killed in manufacturing is 0.03 per year per 1,000 full-time workers across all occupations, and ranges from a high of 0.16 per 1,000 for transportation and material mover occupations to a low of 0.006 per 1,000 for clerical and administrative support occupations. The most dangerous industry-occupation cell is handlers, equipment cleaners, helpers, and laborers within the mining industry, at 0.46 per 1,000.

18. The data also included information on Family Separation Allowance and Basic Allowance for Housing, which are not used in this analysis.

19. The data on wounded includes those seriously or very seriously wounded, and excludes those not seriously wounded. For the sake of exposition, the data are referred to as "seriously wounded."

Table 1. Numbers of Observations and Events

	Combat Zone	Observations		Event Data		
		Served	Deployed	Killed (K)	Seriously Wounded (SW)	Both (KSW)
		8,694,822	3,743,253	5,101	5,027	10,128
	No	5,526,426	574,846	245	129	374
	Yes	3,168,397	3,168,407	4,856	4,898	9,754
Service						
Army	Yes	2,034,258	2,034,267	3,533	2,731	6,264
Coast Guard	Yes	4,093	4,093	-	-	-
Air Force	Yes	479,515	479,516	78	314	392
Marines	Yes	446,918	446,918	1,121	1,492	2,613
Navy	Yes	203,613	203,613	124	361	485
Fiscal Year						
2003	Yes	313,946	313,947	433	581	1,014
2004	Yes	439,999	440,002	778	1,037	1,815
2005	Yes	443,798	443,799	812	615	1,427
2006	Yes	483,338	483,339	775	688	1,463
2007	Yes	470,742	470,743	904	700	1,604
2008	Yes	502,977	502,978	390	391	781
2009	Yes	513,598	513,599	378	319	697
DoD Occ						
Combat	Yes	866,521	866,525	2,908	2,457	5,365
Eeq_Repair	Yes	172,512	172,512	53	76	129
Comint	Yes	288,040	288,040	426	361	787
Health	Yes	150,912	150,913	172	231	403
Techn	Yes	93,301	93,302	91	124	215
Supp	Yes	437,433	437,435	158	247	405
Meq_Repair	Yes	514,479	514,482	273	249	522
Craft	Yes	144,810	144,810	78	130	208
Supply	Yes	456,632	456,632	399	433	832
Other	Yes	43,756	43,756	283	118	401

Table 2. Expect Number of Individuals Killed or Seriously Wounded per Year per 1,000 Personnel

		Expected Number per 1,000			
		Killed Per Year		Killed or Seriously Wounded per Year	
	Combat Zone	Deployed	Served (AC)	Deployed	Served (AC)
		1.447	0.433	4.411	0.799
	No	0.167	0.014	2.975	0.030
	Yes	3.679	1.164	6.917	2.139
Service					
Army	Yes	4.002	1.305	6.785	2.209
Coast Guard	Yes	-	-	-	-
Air Force	Yes	0.432	0.124	2.223	0.508
Marines	Yes	6.692	1.976	12.987	3.819
Navy	Yes	1.565	0.444	6.110	1.635
Fiscal Year					
2003	Yes	3.079	1.175	6.146	2.403
2004	Yes	5.719	1.415	11.767	2.909
2005	Yes	4.478	1.246	7.706	2.119
2006	Yes	4.338	1.373	7.897	2.407
2007	Yes	4.589	1.741	8.097	2.967
2008	Yes	1.877	0.675	3.739	1.334
2009	Yes	1.920	0.625	3.659	1.112
DoD Occ					
Combat	Yes	8.299	2.653	14.952	4.762
Eeq_Repair	Yes	0.743	0.250	1.657	0.534
Comint	Yes	3.362	1.170	6.003	2.059
Health	Yes	2.502	0.830	5.912	1.925
Techn	Yes	2.187	0.666	5.577	1.610
Supp	Yes	0.842	0.211	2.215	0.539
Meq_Repair	Yes	1.173	0.368	2.343	0.662
Craft	Yes	1.210	0.188	3.311	0.562
Supply	Yes	2.001	0.526	4.073	1.092

Note: Figures per year served are for active duty personnel only.

Clearly, military service is a relatively dangerous way of life, particularly when deployed in a combat zone. The mean estimates of risk are generally orders of magnitude higher than in the civilian sector on average, but vary widely across geographic space and time. For example, Figure 6 shows that within combat zones, the probability of fatality per location year deployed varied between about 2 per 1,000 to nearly 6 per 1,000. The probability of being killed per year served varied from a low of about 0.6 per 1,000 individuals in FY 2008 and a high of 1.4 in FY 2004. Recall that casualties per year served reflect events that occurred during a year in which there was some deployment; casualties per year deployed reflect events per twelve months of time actually deployed.

The risk of being killed per year served also varied across the services. The probability of being killed per year served ranged from 0.124 per 1,000 in the Air Force to 1.976 per 1,000 in the Marine Corps. The figures for the Army and Navy are 1.305 and 0.444 per 1,000. Figure 7 shows how the probabilities varied over time in each of the four Services. The risk of being killed in the Marine Corps was especially high in FY 2004, and in the Army in FY 2007.

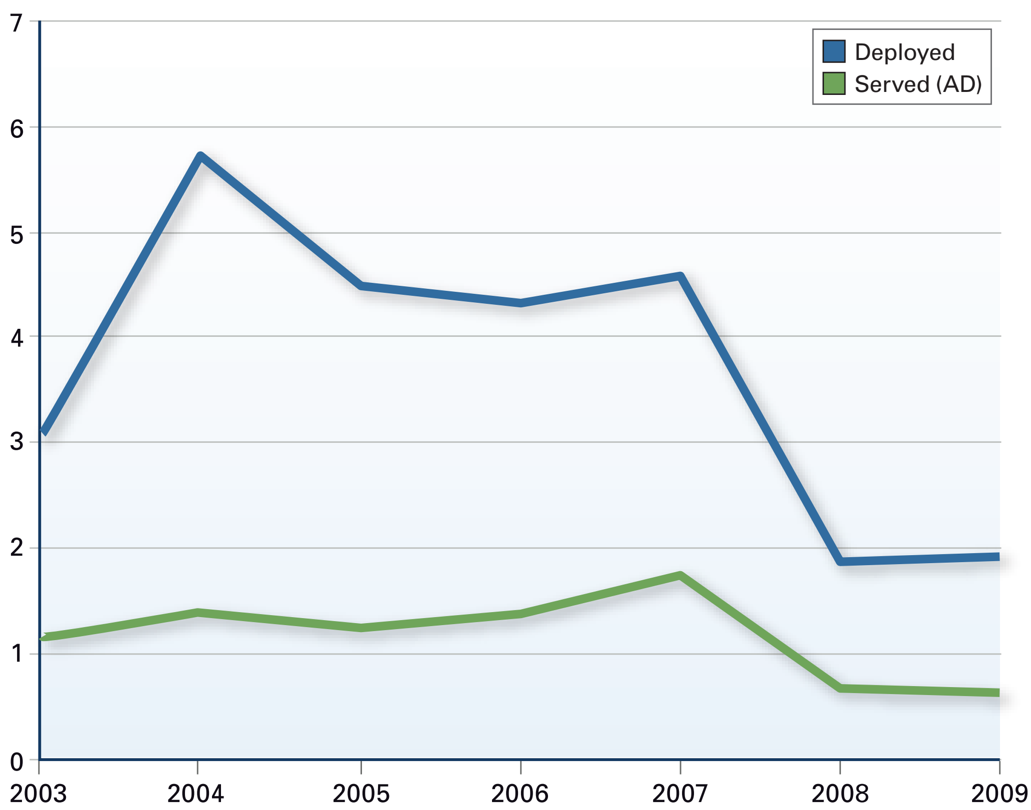

Figure 6. Expected Number of Individuals Killed per Year per 1,000 Personnel

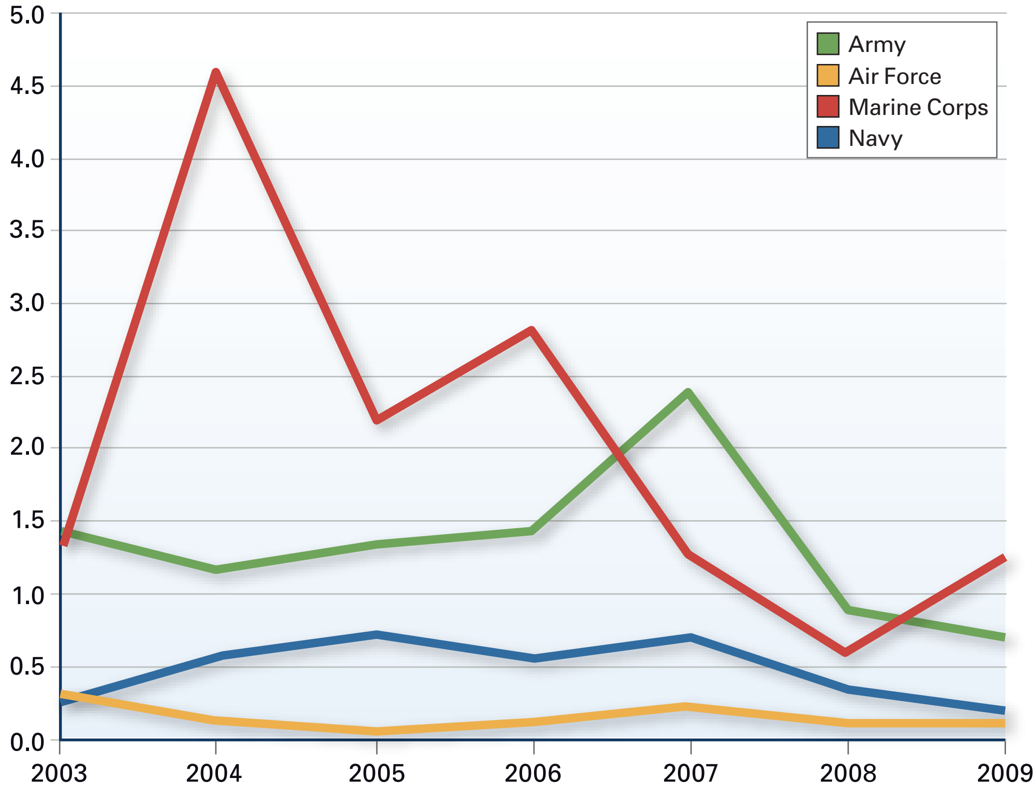

Figure 7. Expected Number of Individuals Killed per Year per 1,000 Personnel: By Service

Figure 8 shows how the probability of being killed varies across two-digit DoD occupation groups. The risk of death per year served is highest in combat arms occupations (DoD occupation group 10) at 2.653 per 1,000. The lowest level of risk is found in craft occupations (DoD occupation group 17), at 0.188 per 1,000. Comparing these figures with those in Viscusi (2004), within a combat zone, the safest DoD occupation group is slightly more dangerous than the most dangerous occupational group in the manufacturing sector (transportation and material movers), and the most dangerous DoD occupation is about 30 times as dangerous as the most dangerous industry-occupation cell (handlers in mining).

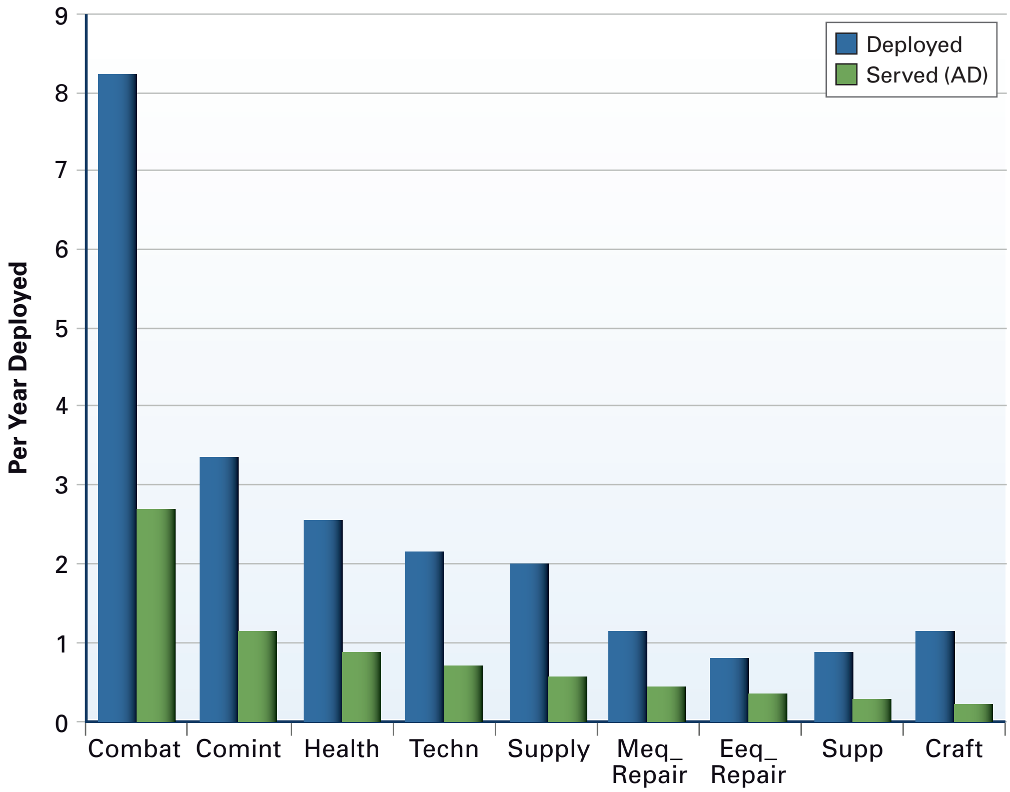

Figure 8. Expected Number of Individuals Killed per Year per 1,000 Personnel: By DoD Occupation

Table 3 shows how combat risk varied over countries in the sample. The countries listed are limited to combat zones in which at least 1,000 individuals served over the FY 2003–2009 period. The data have been sorted by the probability of being killed per year deployed, from high to low.[20] However, the risk of combat is arguably better measured by the probability of being killed or seriously wounded, conditional on deployment. Deployments to Iraq and Afghanistan are clearly most dangerous, with an estimated 6.72 and 5.47 personnel killed per 1,000 servicemembers per year deployed, and an estimated 12.49 and 9.81 personnel per 1,000 killed or seriously wounded per year deployed.

Finally, Table 4 shows how combat risk varied across ranks. From E2 through E9, the risk of being killed or severely wounded generally declined with rank.

20. Because servicemembers typically deploy for periods of less than a year, and because those deployments may overlap fiscal years, the probability of being killed during a given 365-day period is distinct from the probability of being killed during a year-long deployment to that country.

Table 3. Expected Number of Individuals Killed or Seriously Wounded per Year per 1,000 Personnel, by Country

Country	Expected Number per 1,000			
	Killed Per Year		Killed or Seriously Wounded per Year	
	Deployed	*Served (AC)*	*Deployed*	*Served (AC)*
Iraq	6.72	2.13	12.49	3.87
Afghanistan	5.47	1.81	9.81	3.22
Philippines	0.97	0.25	1.11	0.30
Bahrain	0.43	0.16	0.89	0.35
Djibouti	0.34	0.00	1.78	0.28
United Arab Emirates	0.32	0.09	1.25	0.27
Qatar	0.16	0.02	0.66	0.12
Kuwait	0.13	0.02	0.42	0.09
Saudi Arabia	0.10	0.06	0.58	0.29
Jordan	0.00	0.00	0.00	0.00
Kyrgyzstan	0.00	0.00	1.07	0.22
Oman	0.00	0.00	0.46	0.00
Pakistan	0.00	0.00	2.37	0.44
Turkey	0.00	0.00	0.00	0.00
Uzbekistan	0.00	0.00	1.01	0.26

Table 4. Expect Number of Individuals Killed or Seriously Wounded per Year per 1,000 Personnel, by Pay Grade

	Expected Number per 1,000			
	Killed Per Year		Killed or Seriously Wounded per Year	
Rank	*Deployed*	*Served (AC)*	*Deployed*	*Served (AC)*
E1	4.29	1.75	7.86	3.19
E2	10.59	3.77	19.42	7.10
E3	6.38	2.14	11.64	3.75
E4	3.48	1.07	6.23	1.91
E5	2.76	0.83	5.54	1.61
E6	3.26	1.02	6.15	1.88
E7	2.10	0.59	4.47	1.27
E8	1.91	0.52	3.89	0.91
E9	1.81	0.54	3.76	1.13

Note: Data are for individuals who deployed to a combat zone at some time during a calendar year.

5. Combat Risk and Compensation

A. Are Total Pay and Risk per Year Served Related?

This section presents estimates of the relationship between compensation and risk. To facilitate the empirical analysis, it was decided to analyze data averaged by Service, country, DoD two-digit occupation groups (10 through 18), grade (E1 through E9), and fiscal year cell. The following regression model is specified:

$$W_c = \alpha + \beta_r Risk_c + YOS_C + Service + Pay\ Grade + OCC_{DOD} + CYear + \varepsilon_c \quad (1)$$

where W_c is annual mean total pay, YOS_C is average years of service, $Risk_C$ is a measure of the probability of being killed, *Service, Pay Grade, CYear* (calendar year), and Occ_{DOD} represent vectors of those factors, and ε_c is a random error term, all in cell *c*, where cells are defined by country, Service, year, occupation, and pay grade.[21] The regressions are estimated for the Army, Air Force, Marine Corps, and Navy.[22] Reserve Component personnel are not included because some key data for them were not available.

The coefficient β_r is an estimate of *Additional Compensation per Fatality* (ACF).[23] It is the additional compensation received by those whose service involved higher risk. More precisely, it is the total additional amount received by 1,000 people, each of whom faced an added chance in a thousand of being killed during a year that involved service in a combat zone.

The risk variable is meant to reflect workers' expected probability of being killed. The measure chosen here assumes that members of the U.S. military are relatively well informed about the relative risks faced as a function of Service, country, occupation, and pay grade.[24] This measure varies by Service, country, occupation, and pay grade. Use of measures that vary only at higher levels of aggregation—for example, only by Service and occupation—ignores valuable information on variation across occupations and pay grade that servicemembers themselves would be expected to

21. Appendix A contains a brief review of the empirical literature. Equation (1) departs from this literature by specifying the dependent variable in levels rather than as a natural log. The reason is that most military pays are defined in dollars per month rather than in percentage terms. For example, HFP/IDP is $225 per month (or part of month) spent in a combat zone.

22. Casualty data for the Coast Guard were not available. Unfortunately, the casualty data classified a sizeable number of individuals in DoD occupation group 19—a catch-all group—but very few such individuals were so classified in the pay record data.

23. Because of the timing of payments, especially enlistment and reenlistment bonuses, it is possible that some compensation for combat risk is received while not deployed. The estimates here may therefore underestimate the ACF.

24. The review of the literature in Appendix A discusses at some length the issue of how to measure risk.

use in their forecast of risk. It was decided not to allow the measure of risk to vary over time because it does not seem reasonable that servicemembers would be able to forecast accurately variation in combat risk that is a function of factors beyond their ken and scope, especially in light of how much risk can vary from one day or hour to the next.

Pleeter et al. (2011) found that the CZTE was the dominant component of combat compensation and was not related to variations in risk within the combat zone. Unfortunately, precise information on the value of the CZTE is not available for the individuals in the payroll data set. Instead, CZTE was accounted for by assigning a federal tax liability using the tax tables in effect each year, and a state tax liability based on averages computed from the Current Population Surveys. The federal tax liability was assigned assuming that individuals used the standard deduction, and exemptions were assigned based on the number of dependents reported on the payroll records. No allowance was made for the possibility of a working spouse, and no attempt was made to incorporate the Earned Income Credit. Because these calculations are necessarily rough, and one can imagine biases operating in both directions—for example, the CZTE could be worth less than computed here if individuals itemize, or more if the spouse works—results are reported both including and excluding the calculated value of the CZTE in the dependent variable.

Our work extends that of Pleeter et al. (2011) by including compensation related to special pays and bonuses. Also, this paper incorporates variation in risk and compensation between deployed personnel and those in CONUS. Near the end of the paper, the analysis focuses on deployed personnel specifically, a closer parallel to the earlier work.

Table 5 reports the regression results. To reduce clutter, only the estimated coefficients on the risk variables are presented. The means and standard deviations of total cash compensation are shown in the first two rows to help put the estimated effects in perspective. The first column reports regression estimates of the additional compensation per fatality for the sample as a whole. Excluding the value of the CZTE, the estimated compensation associated with an increase in risk of death of one per thousand personnel is $292. The table shows an estimated ACF of just over $292,000. Including the value of the CZTE, the estimated ACF is equal to $551,341.[25]

The estimated ACF varies considerably across services. For example, the estimated ACF in the Army is $357,236 excluding the value of CZTE, and $656,889 including

25. The standard errors are $111,289 and $211,201, respectively, indicating that both estimates are statistically significant at conventional levels. Further references to the standard errors, reported in the tables in parentheses underneath the estimated coefficients, are left to the reader. Note, too, that the figures that include the value of CZTE are shown only for those who served in a combat zone at some time during the year.

Table 5. Estimated Additional Compensation per Fatality

		By Service				By Pay Grade			
	All Services	Army	Air Force	Marine Corps	Navy	E2–E3	E4–E5	E6–E7	E8–E9
Mean Annual Cash Pay									
CZTE Excluded	$29,608	$29,718	$31,068	$26,055	$30,239	$19,690	$26,962	$39,653	$52,810
Standard Deviation	($9,110)	($8,747)	($9,173)	($9,113)	(9,438)	($2,522)	($3,925)	($4,345)	($6,116)
CZ only, CZTE Included	$31,988	$32,534	$32,228	$28,476	$33,736	$22,569	$29,379	$43,580	$58,920
Standard Deviation	($9,198)	($8,923)	($9,462)	($9,076)	($9,816)	($2,436)	($4,221)	($5,129)	($6,808)
Additional Compensation per Fatality									
CZTE Excluded	$292,614	$357,236	$1,996,771	$247,470	$58,005	$123,743	$287,625	$215,763	$230,767
Standard Error	($111,289)	($132,680)	($318,792)	($79,090)	($30,002)	($62,683)	($132,407)	($177,282)	($41,001)
CZTE Included	$551,341	$656,889	$3,633,864	$442,044	$207,684	$224,870	$679,554	$766,765	$982,278
Standard Error	($211,201)	($258,349)	($856,362)	($127,303)	($74,392)	($109,532)	($288,681)	($326,773)	($315,668)
Observations	8,782	2,656	2,769	1,425	1,932	1,725	3,129	2,538	1,045

Note: The entries in this table are derived from the estimated coefficients on risk variables that measure the probability of being killed averaged over the period FY 2003–2009. The dependent variable is mean total compensation in a calendar year in a given country, service, occupation, pay grade, and year cell. The risk variable is the number of fatal casualties in that cell per thousand personnel. The estimated coefficients reflect the increase in compensation associated with an increase in risk of death of one per thousand personnel. The additional compensation per fatality (the numbers in this table and subsequent similar tables) is the estimated coefficient times one thousand. All regressions control (when relevant) for service, two-digit DoD occupation, years of service, and fiscal year. Standard errors clustered on country are shown in parentheses. The regressions are weighted by the number of individuals serving in each cell. Cells with fewer than 25 individuals are excluded from the regressions.

the value of CZTE. By contrast, the figures for the Air Force are $1.996 million and $3.66 million. The estimates for the Marine Corps are slightly lower but of the same magnitude as those for the Army—$247,470 and $442,044 excluding and including the CZTE, while those for the Navy are markedly lower—$58,005 and $207,684. Further analysis revealed that the estimated ACF for the Navy was sensitive to the inclusion of relatively small cells. For example, when we focus on cells that contained at least 125 individuals (results not shown to reduce clutter), the estimated ACFs for the Navy rise to $354,469 and $1.2 million. The estimates for the Army and Marine Corps, by contrast, are relatively unaffected by smaller cells. It is also important to keep in mind that the Navy accounted for a relatively small number of casualties compared with the Army and Marine Corps. It is not evident why the Air Force estimates are so much higher than those for the other Services.

The estimated ACF also varies by pay grade, from a low of $123,743 for E2s and E3s to a high of $287,625 for E4s and E5s, excluding the value of CZTE, and from a low of $224,870 for E2s and E3s to a high of $982,278 for E8s and E9s, including the value of CZTE.

B. Allowing for a Non-Linear Relationship between Compensation and Risk

In this section, the model in equation (1) is augmented to include the risk variable raised to the second power. This is done because the literature leads us to expect it to enter positively: the additional compensation for a unit of risk is expected to be greater at higher risk levels. Table 6 reports the estimated coefficients on the linear and quadratic risk terms for the same groups as in Table 5. In every case, the estimated coefficient on the linear risk term is positive and the estimated coefficient on the quadratic risk term is negative, indicating that compensation rises at a decreasing rate as a function of the risk of being killed, contrary to theoretical expectations.

To put the estimates in perspective with those in Table 5, the ACF has been calculated for two values of risk: the mean probability of being killed per year in a combat zone of 1.164 per 1,000 (fifth column from the left, third line of Table 2) and the mean probability of being killed in Iraq of 2.13 per 1,000 (fourth column, first line of Table 3). Focusing on the results that include the value of CZTE, the estimated ACF at the overall combat zone sample mean is $831,757, while the estimated ACF at the mean for Iraq is equal to $765,615, a difference of $64,142. The estimates for the Army show a greater difference: $1.057 million versus $755,634, a difference of more than $300,000.[26]

26. These findings do not mean that total cash compensation declines with combat risk in the relevant range. Compensation is maximized at the value for which ACF=0, which occurs at 1.3 per *hundred* (0.013) for the sample as a whole, and at values of 0.0046, 0.0015, 0.0102, and 0.0261 for the Army, Air Force, Marines, and Navy, respectively.

Table 6. Estimated Additional Compensation per Fatality: Quadratic Model

	By Service					By Pay Grade			
	All Services	Army	Air Force	Marine Corps	Navy	E2–E3	E4–E5	E6–E7	E8–E9
Estimated Coefficients on Risk in Quadratic Model									
CZTE Excluded									
Linear risk term	$427,743	$769,079	$3,421,525	$516,945	$174,143	$371,218	$1,883,334	$1,742,786	$1,534,257
	($142,120)	($342,130)	($551,955)	($126,946)	($76,512)	($151,328)	($867,324)	($554,882)	($410,579)
Quadratic risk term	-$15,700,000	-$83,900,000	-$1,080,000,000	-$24,700,000	-$3,469,889	-$11,400,000	-$310,000,000	-$202,000,000	-$64,400,000
	($6,513,058)	($47,200,000)	($254,000,000)	($6,000,218)	($13,100,000)	($6,019,721)	($174,000,000)	($102,000,000)	($17,400,000)
Additional Compensation per Fatality evaluated at:									
Sample mean of 1.164 per 1,000	$391,193	$573,759	$907,285	$459,443	$166,065	$344,678	$1,161,654	$1,272,530	$1,384,334
Iraq mean of 2.13 per 1,000	$360,861	$411,665	-$1,179,275	$411,723	$159,362	$322,654	$562,734	$882,266	$1,259,913
Estimated Coefficients on Risk in Quadratic Model									
CZTE Included									
Linear risk term	$909,047	$1,420,194	$6,549,759	$948,786	$574,778	$371,218	$1,883,334	$1,742,786	$1,534,257
	($232,040)	($646,607)	($1,370,461)	($212,782)	($204,047)	($151,328)	($867,324)	($554,882)	($410,579)
Quadratic risk term	-$33,200,000	-$156,000,000	-$2,210,000,000	-$46,400,000	-$11,000,000	-$11,400,000	-$310,000,000	-$202,000,000	-$64,400,000
	($13,100,000)	($86,500,000)	($581,000,000)	($10,900,000)	($5,516,606)	($6,019,721)	($174,000,000)	($102,000,000)	($17,400,000)
Additional Compensation per Fatality evaluated at:									
Sample mean of 1.164 per 1,000	$831,757	$1,057,026	$1,404,879	$840,767	$549,170	$344,678	$1,161,654	$1,272,530	$1,384,334
Iraq mean of 2.13 per 1,000	$767,615	$755,634	-$2,864,841	$751,122	$527,918	$322,654	$562,734	$882,266	$1,259,913

Note: The entries in this table are derived from the estimated coefficients on risk variables that measure the probability of being killed averaged over the period FY 2003–2009. The dependent variable is mean total compensation in a calendar year in a given country, service, occupation, pay grade, and year cell. The risk variable is the number of fatal casualties in that cell per thousand personnel. The estimated coefficients reflect the increase in compensation associated with an increase in risk of death of one per thousand personnel. The additional compensation per fatality (the numbers in this table) is the estimated coefficient times one thousand. All regressions control (when relevant) for service, two-digit DoD occupation, years of service, and fiscal year. Standard errors clustered on country are shown in parentheses. The regressions are weighted by the number of individuals serving in each cell. Cells with fewer than 25 individuals are excluded from the regressions.

C. Estimates Using Combat Zones Only

The finding of a positive relationship between compensation and combat risk may at first appear to contradict the findings in Pleeter et al. (2011), which found no such relationship. There are two key differences between the present study and the earlier one. First, in contrast to the earlier study, which focused on the role of CZTE, compensation here includes special pays (HDP, SDAP), as well as enlistment and reenlistment bonuses. Second, the earlier study focused on variation within combat zones. By contrast, the estimates in Table 5 and Table 6 use information on observations both inside and outside combat zones.

To see the importance of non-combat zone observations, the models were re-estimated using information only for countries within a combat zone. The results are reported in Table 7. Focusing on the results including CZTE, the estimated ACF for the sample as a whole is $65,835. The estimated ACFs estimated on the combat zone subsample vary widely across Services and ranks. For example, the estimated ACF is $88,789 for the Army, $772,579 for the Air Force, and *negative* for the Marine Corps and Navy at -$63,642 and -$63,433. Notice, too, that the estimates of ACF are negative for individuals in all but the highest pay grades.

The results in Table 7 lead to two important conclusions. First, the positive estimated relationship between compensation and risk seen in Table 5 and Table 6 is nearly entirely due to the contrast between combat zone and non-combat zone countries. Second, the conclusions of Pleeter et al. (2011) are largely reinforced;

Table 7. Estimated Additional Compensation per Fatality: Combat Zone Observations Only

		By Service				By Pay Grade			
	All Services	Army	Air Force	Marine Corps	Navy	E2–E3	E4–E5	E6–E7	E8–E9
CZTE Excluded	$22,324	$92,848	$772,579	–$64,566	–$63,433	–$11,026	–$32,269	–$80,486	$74,098
	($45,740)	($34,850)	($124,159)	($27,614)	($9,803)	($26,538)	($85,486)	($207,220)	($169,614)
CZTE Included	$65,835	$88,789	$772,579	–$63,242	–$63,433	–$11,683	–$40,063	–$81,096	$76,115
	($23,217)	($32,561)	($124,159)	($26,688)	($9,803)	($25,776)	($84,809)	($203,297)	($167,554)
Observations	6,401	1,874	2,220	930	1,377	1,209	2,494	1,986	580

Note: The entries in this table are derived from the estimated coefficients on risk variables that measure the probability of being killed averaged over the period FY 2003–2009. The dependent variable is mean total cash compensation in a calendar year in a given country, service, occupation, pay grade, and year cell. The risk variable is the number of fatal casualties in that cell per thousand personnel. The estimated coefficients reflect the increase in compensation associated with an increase in risk of death of one per thousand personnel. The additional compensation per fatality (the numbers in this table) is the estimated coefficient times one thousand. All regressions control (when relevant) for service, two-digit DoD occupation, years of service, and fiscal year. Standard errors clustered on country are shown in parentheses. The regressions are weighted by the number of individuals serving in each cell. Cells with fewer than 25 individuals are excluded from the regressions.

accounting for the role of special pays and enlistment and reenlistment bonuses, the estimated relationship between compensation and risk is small and often tenuous across deployments of widely varying levels of risk.

D. Estimates that Correct for Differences in Preference Toward Risk

Differences in preferences toward risk can attenuate the estimated relationship between compensation and risk. One way to control for such differences is to estimate the model using data on individuals within two-digit DoD occupations, who presumably have similar occupational tastes. These estimates are contained in Table 8. As can be seen, the pattern found in Table 6 persists: total cash pay increases with combat risk at a decreasing rate. Table 8 also shows estimates of the ACF evaluated at the overall sample mean of 1.164 fatalities per 1,000 and the occupation-specific means from Table 2, reproduced for convenience in the first row. Evaluating the ACF at different levels of combat risk has a relatively minor impact for combat arms personnel, estimated to be equal to $584,726 using the sample mean risk versus $523,525 using their own mean of 2.653 per 1,000. However, for support personnel, the difference is substantial: $1.29 million versus $5.8 million, accounted for by the fact that the mean fatality risk for this group is just 0.2 per 1,000. The estimated own-risk ACFs are also larger than those estimated at the mean risk for mechanical repair, craft, and supply personnel, the differences ranging from $1.8 to $3.6 million.

E. Relationship between ACF and VSL

The estimated effect of mortality risk on military pay is generally far lower than the $6–$10 million estimates of VSL for the civilian sector. The ACF would be equal to the VSL if it were certain that we were observing wage-risk combinations along individuals' indifference curves. However, there are reasons to doubt that this is what is being observed; first, because the estimates indicate that compensation rises at a decreasing rate with the probability of being killed—the convex shape of the indifference curve suggests that compensation should increase at an increasing rate—and second, because estimates using data only on individuals deployed to a combat zone were small, imprecise, and often negative.

Another complication in estimating VSL is suggested in recent work by RAND (see Tanielian and Jaycox 2008), which indicates that major depression and post-traumatic stress disorder (PTSD) are highly associated with combat exposure. In statistical analyses, variables such as having been shot at and knowing someone who was killed (among others) were "consistently associated with increased likelihood of screening positive for PTSD." Indeed, exposure "to specific combat traumas was

Table 8. Estimated Additional Compensation per Fatality: By Two-Digit DoD Occupation

	Combat	Elect. Repair	COMINT	Health	Technical	Support	Mech. Repair	Craft	Supply
CZTE Excluded									
Linear risk term	$332,686	$1,530,347	$714,012	$964,996	$1,179,903	$3,471,990	$2,300,177	$3,567,116	$2,272,008
	($88,746)	($696,531)	($258,213)	($410,188)	($236,433)	($1,338,356)	($946,835)	($1,249,516)	($924,658)
Quadratic risk term	-$11,400,000	-$119,000,000	-$65,400,000	-$125,000,000	-$41,700,000	-$1,250,000,000	-$669,000,000	-$1,090,000,000	-$684,000,000
	($3,790,016)	($59,600,000)	($29,900,000)	($70,100,000)	($17,200,000)	($491,000,000)	($345,000,000)	($380,000,000)	($286,000,000)
Expected Number Killed per Thousand	2.653	0.250	1.170	0.830	0.666	0.211	0.368	0.188	0.526
Additional Compensation per Fatality evaluated at:									
Sample mean of 1.164 per 1,000	$306,147	$1,253,315	$561,760	$673,996	$1,082,825	$561,990	$742,745	$1,029,596	$679,656
Own mean	$272,198	$1,470,847	$560,976	$757,496	$1,124,359	$2,944,490	$1,807,793	$3,157,276	$1,552,440
CZTE Included									
Linear risk term	$631,767	$2,841,498	$1,502,262	$2,066,312	$2,132,897	$6,833,751	$4,207,626	$6,390,799	$4,475,051
	($190,673)	($1,284,413)	($581,466)	($769,144)	($525,243)	($2,565,972)	($1,729,018)	($2,165,744)	($1,743,287)
Quadratic risk term	-$20,400,000	-$215,000,000	-$162,000,000	-$328,000,000	-$94,600,000	-$2,380,000,000	-$1,260,000,000	-$1,850,000,000	-$1,420,000,000
	($8,097,082)	($109,000,000)	($76,500,000)	($142,000,000)	($37,400,000)	($930,000,000)	($637,000,000)	($634,000,000)	($550,000,000)
Additional Compensation per Fatality evaluated at:									
Sample mean of 1.164 per 1,000	$584,276	$2,340,978	$1,125,126	$1,302,728	$1,912,668	$1,293,111	$1,274,346	$2,083,999	$1,169,291
Own mean	$523,525	$2,733,998	$1,123,182	$1,521,832	$2,006,890	$5,829,391	$3,280,266	$5,695,199	$2,981,211
Observations	1,342	877	947	674	698	1,231	1,181	831	1,001

Note: The entries in this table are derived from the estimated coefficients on the probability of being killed averaged over the period FY 2003–2009, where the probability is measured at the country x service x occupation x pay grade level. The dependent variable is mean total compensation in a calendar year in a given country, service, occupation, pay grade, and year cell. The risk variable is the number of fatal casualties in that cell per thousand personnel. The estimated coefficients reflect the increase in compensation associated with an increase in risk of death of one per thousand personnel. The additional compensation per fatality (the numbers in this table) is the estimated coefficient times one thousand. All regressions control (when relevant) for service, years of service, and fiscal year. Standard errors clustered on country are shown in parentheses. The regressions are weighted by the number of individuals serving in each cell. Cells with fewer than 25 individuals are excluded from the regressions.

the single-best predictor for both PTSD and major depression." Because higher combat risk raises the probability of becoming psychologically impaired, the estimated ACFs will tend to overstate the true VSL in the military, increasing the apparent difference between military VSL and civilian VSL.

The estimated ACFs could understate the true VSL if military personnel derive satisfaction from other characteristics of the job that are not measured and hence left out of the statistical model of wage determination. It is also possible that the compensation for low-risk military positions is above the level of compensation for similar civilian positions. This would mean that the additional compensation associated with riskier military jobs need not be as high as is implied by the civilian VSL literature.

6. Summary

This paper has examined combat pays within the framework of hedonic wage theory. Because U.S. military personnel currently receive $225 HFP/IDP per month served in a combat zone independent of the level of combat risk, members who face low levels of risk may be overcompensated. However, because overall compensation must be sufficient to attract volunteers who undertake high levels of risk, it is appropriate to examine the relationship between combat risk and total cash compensation. In an economically efficient combat compensation scheme, total compensation should rise with combat risk. Using data on enlisted personnel for the period 2003–2009, compensation is estimated to rise by $551 per individual per year when there is an increase in risk of death of one per thousand personnel—a figure far smaller than the figure of $6,000–$10,000 found in studies of civilian labor markets. In addition, compensation is estimated to rise at a decreasing rate in combat risk, a pattern that persists even when the model is estimated separately for individuals who might be expected to have similar preferences toward combat risk.

When the relationship between compensation and risk was estimated using data only from combat zone observations, the relationship was smaller, less precise, and often negative. This reinforces the conclusion of Pleeter et al. (2011) that combat-related compensation within the combat zone does not systematically vary with the degree of risk faced.

Appendix A. Pitfalls in Estimating VSL

The most common way to estimate VSL is using hedonic wage regression, in which the dependent variable, the log wage, is regressed on a vector of individual and job characteristics, including the probability of fatal or nonfatal injury.[27] In their review of the empirical literature, Cropper et al. (2011) present and discuss the prototypical hedonic wage equation used to estimate the VSL as

$$lnW_i = \alpha + \sum_m \beta_m x_{im} + \gamma_0 r_i + \gamma_1 q_i + \gamma_2 q_i WC_i + u_i \quad (1)$$

where W_i is the worker's wage rate, α is a constant, the β_m are slope coefficients on various worker characteristics (e.g., age, race, education, years of job experience, union status) χ_m, r_i is the probability of a fatality, q_i is the probability of non-fatal job risk, WC_i is the level of worker's compensation, and u_i is a random error term, all for worker *i*. If wages are measured at an annual frequency, γ_0 multiplied by the average wage measures VSL.

Obtaining an unbiased and consistent estimate of VSL in equation (1) requires that the random error term be uncorrelated with all of the right-hand-side variables. This condition can fail for a number of reasons, including measurement error in fatal job risk, omitted variables, unobserved heterogeneity in the population, and bias in risk perceptions.

Measurement Error in Fatal Job Risk

Estimates of VSL in studies carried out prior to 2000 relied on measures of risk that varied only by industry. To the extent that this introduces classical measurement error into this variable, estimates of VSL will tend to be biased downward (that is, toward zero).[28] Newer studies use improved measures of job risk available in the Bureau of Labor Statistics (BLS) Census of Fatal Occupational Injuries (CFOI), which distinguishes risks by occupation as well as by industry. The CFOI is a census rather than a sample and is based on a comprehensive review of multiple records, including death certificates and workers' compensation reports.[29]

27. Other techniques for measuring VSL exist. For example, Ashenfelter and Greenstone (2004) used evidence on driver behavior in the presence of mandated speed limits to infer the VSL. Contingent valuation (stated willingness to pay) is also used; see Albinini (2005) for a review of this literature. Using contingent valuation, Hammitt and Haninger (2010) estimate a willingness to pay off $6–$10 million per adult life and $12–$15 million for children, very close to contemporary estimates based on the hedonic method.

28. Most studies prior to 2000 used data from either the Bureau of Labor Statistics (BLS) Survey of Occupational Injuries, reporting deaths by three-digit industry classification, or the National Institute of Occupational Safety and Health (NIOSH), reporting risks by one-digit industry and state. See Cropper et al. (2011) for details.

29. Most studies after 2000 use CFOI data on 3-year averages of death risk for 10 occupations and 72 two-digit industries (Cropper et. al. 2011, 8).

Omitted Variable Bias

Earlier studies failed to control for important worker or job characteristics that are correlated with job risk, and thus render estimates of the coefficient on job risk in hedonic wage regressions biased and inconsistent (Cropper et al. 2011, 8). The importance of selectivity has been paramount in researchers' minds for many years. For example, Viscusi and Hersch (2001, 279) found that smokers select riskier jobs but receive lower total wage compensation for risk than do nonsmokers.[30] More recently, DeLeire and Levy (2004) used family structure as a proxy for willingness to trade safety for wages to test the proposition that workers with strong aversion to this risk sort into safe jobs. They estimated conditional logit models of occupation choice as a function of injury risk and other job attributes (925). They found that single mothers and fathers were more averse to risk than their married counterparts (926). They also found that the effect of children on those who are married is larger for women than for men, which suggests that mothers view their contribution to raising children as more difficult to replace than do fathers (946).[31]

Other researchers try to control for omitted variables by including industry and occupation dummy variables among the χ_m in equation (1). Because earlier data on the probability of fatality were not well measured, estimates that included such controls tended to yield lower estimates of the VSL (Cropper et al. 2011, 9). Including these dummy variables often had the effect of washing out the effect of the risk variables because of the resulting reliance on within-industry or within-occupation variation in risk to identify VSL.

Still another way to control for omitted characteristics is to rely on panel data and use first-differences or worker fixed effects in equation (1). Such estimates control effectively for factors that are either fixed or change slowly for a given worker over time. This is the approach taken in Kniesner et al. (2010). Because most of the variation in job risk over time comes from job changes, the within-worker variation in panel data sets such as the Panel Study of Income Dynamics allows reasonably precise estimation of the VSL.

Heterogeneity in VSL

It has already been noted that some individuals (smokers or single, single men without children) have lower aversion to taking on risk than others. As Viscusi (2010,

30. Their findings suggest that smokers are not only more willing to incur risk, but are less efficient in the production of safety.

31. Evidence of sorting applies to characteristics of jobs other than the risk of fatality or injury. For example, Krueger and Schkade (2008, 4) found evidence that workers who are more gregarious as revealed by their behavior when they are not working are more likely to be in jobs that involve higher levels of social interaction.

1) put it in his introduction and overview of a recent special issue of the *Journal of Risk and Uncertainty*, VSL is not "a natural constant." Economic theory suggests that VSL should vary with other characteristics, as well.

For example, because safety is a normal good, workers with higher income levels will have higher VSL levels and will tend to choose jobs with lower risk levels (Kniesner et al. 2010, 16). Based on quantile regression estimates of the VSL using panel data, Kniesner et al. (2010) estimate a VSL of $7.5 million for individuals at the median of the wage distribution, compared with $4.9 million for individuals at the 25th percentile and $14.5 million for individuals at the 75th percentile. Viscusi (2010, 2) notes that this implies that VSL should rise over time along with incomes. Another example is age. Because individuals' life expectancies decline with age, a given reduction in risk gives rise to smaller increases in expected lifetimes (Viscusi and Aldi 2007, 243). In fact, though, recent estimates suggest that the VSL exhibits an inverted U-shaped relationship, mirroring the path of lifetime consumption (Viscusi 2010, 4). The extent to which such variation in VSL should be accounted for in public policy is an important question. For example, it is not clear that policy makers should value the lives of the wealthy more than the lives of those less well off (Kniesner et al. 2010, 16–17).[32]

Bias

Harrison and Rutström (2006, 326) note that objective measures of risk are only proxies for subjective ones. That is, individuals receive compensation not in return for true measures of risk, but for the ones that they perceive. Economic agents who act on the basis of misperceived risks can misallocate resources and induce lower levels of welfare as a result. For example, overestimation of the probability of death or injury by servicemembers could force the military to pay higher wages than otherwise.[33] Conversely, underestimation of the probability of death or injury by servicemembers could also lead them to make decisions that they otherwise would not.

Interestingly, the father of the theory of compensating wage differentials, Adam Smith (1776, I:125), believed that individuals were prone to systematic error in assessing probabilities of events with uncertain outcomes.

32. Indeed, legislation has been proposed that would ban "all recognitions of heterogeneity that reduced the VSL, as the SL can never be decreased 'based on age, income, race illness, disability, date of death, or any other personal attribute or relativistic analysis of the value of life' " (Viscusi 2010, 3).

33. See Fraser (1995), particularly the references in his note 2 (98). Fraser (1995) considers the role of worker learning from the experience of others in the context of a hazardous industry that might be competitive or monopolistic. He shows that the welfare changes in the information environment depend on market structure. His proposition (3) shows that a sharpening of priors regarding the probability of a hazard occurring can actually reduce welfare because loser priors lead to lower costs and hence higher output and social welfare.

> The over-weening conceit which the greater part of men have of their own abilities, is an antient evil remarked by the philosophers and moralists of all ages. … The chance of gain is by every man more or less over-valued, and the chance of loss is by most men under-valued, and by scarce any man, who is in tolerable health and spirits, valued more than it is worth.

Smith (1776, I:126) doubted, in particular, the judgmental capacities of young men of military age.

> The contempt of risk and the presumptuous hope of success, are in no period of life more active than at the age at which young people choose their professions. How little the fear of misfortune is then capable of balancing the hope of good luck, appears still more evidently in the readiness of the common people to enlist as soldiers, or to go to sea.

One of the most influential papers that supports Smith's (1776) concern is Lichtenstein et al. (1978, 551). They carried out a series of experiments to study how well people were able to estimate the frequency of death from various causes. They interpreted their findings as indicating that individuals tended to overestimate small frequencies and underestimate larger ones. In addition, they reported a tendency of individuals to "exaggerate the frequency of some specific causes" while underestimating the frequency of others.[34]

Benjamin and Dougan (1997) reinterpreted Lichtenstein et al.'s (1978) findings and suggest that their conclusions, rather than supporting the hypothesis of bias, merely indicate that individuals tend to be better informed about risks that are most relevant to their demographic, in particular, their age group. Lichtenstein et al. (1978) studied subjects drawn from two groups: college students and members of the League of Women Voters. Benjamin and Dougan (1997) argued that a re-examination of the evidence in Lichtenstein et al. (1978) reveals instead a lack of "salience." For example, causes that kill large numbers of people tend to kill older people (Benjamin and Dougan 1997, 123). The fact that college students did a poor job of predicting such risks reflects merely the "optimal acquisition of costly information" (129). As Benjamin, Dougan, and Buschena (2001, 36) state in a follow-on study, "young people who are aware that death from falling is a remote possibility for them know enough to know that they face a very low rate of return on investing in detailed information about the causes of falling."

34. Ironically (in light of the subject of this paper), Lichtenstein et al.'s (1978) research was supported by the Advanced Research Projects Agency of the Department of Defense and monitored by the Office of Naval Research.

Benjamin, Dougan, and Buschena (2001, 39) administered a survey to students that asked them to estimate death rates by cause among members of their own age groups. The results of their survey data are consistent with the hypothesis that people acquire and use information rationally. Although their respondents formed "extraordinarily biased" estimates of *population* death rates, "they made remarkably unbiased estimates of the death rates most relevant to them: those of their own age groups" (44, italics in original).

Following up on the results of Benjamin and Dougan (1997) and Benjamin, Dougan, and Buschena (2001), Harrison and Rutström designed a survey instrument to "differentiate the beliefs that subjects have about mortality risks of people in their own age group from those of other age groups." Their evidence is also consistent with the hypothesis that individuals have "better information about mortality risks that are relevant to them, such as those for their own age group" (2006, 342).

Hakes and Viscusi (1997) embed the insights of Benjamin and Dougan (1997) into a model that allows for the possibility that individuals use data from multiple sources to form their perceptions. They formulate a simple Bayesian model containing four independent sources of information in which the probabilities can be characterized by the beta distribution of prior beliefs, which can assume both skewed and symmetric shapes (136–7). Their results suggest that "individuals use three sources of information: the actual death risk, the discounted lost life expectancy associated with the cause of death, and to a lesser extent the age-specific hazard rate" (149). Hakes and Viscusi (149) find that the various risk variables were less helpful in predicting individuals' perceptions at lower levels of risk. They suggest that the various sources of information may not be as useful at lower risk levels.

The results of Hakes and Viscusi (1997) are particularly important in the case of combat risk because those risks are highly variable across Services, countries (and smaller units of geography), and time. Although the results of Benjamin and Dougan (1997), Benjamin, Dougan, and Buschena (2001), and Harrison and Rutström (2006) suggest that individuals are well-informed about the risks that affect them most, Hakes and Viscusi (1997) find that even within a demographic group, individuals do not appear to ignore information from other demographic groups. Put differently, although it is rational for individuals to collect information about risks that are most salient, it is not rational for individuals to ignore all other sources of information.

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