Attack Assignments in Terror Organizations and The Productivity of Suicide Bombers*

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Abstract

This paper studies the relation between human capital of suicide bombers and outcomes of their suicide attacks. We argue that human capital is an important factor in the production of terrorism, and that if terrorists behave rationally we should observe that more able suicide bombers are assigned to more important targets. We use a unique data set detailing the biographies of Palestinian suicide bombers, the targets they attack, and the number of people that they kill and injure to validate the theoretical predictions and estimate the returns to human capital in suicide bombing. Our empirical analysis suggests that older and more educated suicide bombers are being assigned by their terror organization to more important targets. We find that more educated and older suicide bombers are less likely to fail in their mission, and are more likely to cause increased casualties when they attack.

Introduction

Since the onset of the Palestinian Intifada in September 2000 through August 2005, 151 Palestinian suicide bombing attacks have been launched against Israeli targets, killing 515 people and injuring almost 3,500 more. Estimates of the number of casualties from suicide bombing in Iraq suggest that since 2003 thousands of people, mostly Iraqi civilians, have been killed. According to Pape (2005), from 1987 to 2001, the Tamil Tigers launched 76 suicide bombing attacks, killing a total of 901 people, including two regional leaders - India's former prime minister Rajiv Gandhi in 1991, and Sri Lanka's President Ranasinghe Premadasa in 1993. However, while suicide terrorism is rising around the world, there is little empirical academic research in economics that analyzes suicide terrorism. This paper studies the individual rationality of suicide bombing using micro-level data.

Recent theories have suggested that suicide terrorism can be explained using rational choice modeling. For example, Becker and Posner (2005), Berman (2004), Berman and Laitin (2005), and Iannaccone (2006) analyze the costs and benefits to suicide bombers and terror organizations that are associated with suicide attacks. The theoretical approach of the analysis of participation in terrorism relies on Becker's theory of rational crime (Becker 1968), which predicts that crime decreases as one's market wage increases relative to the rewards associated with crime. However, existing empirical evidence suggests that Palestinian suicide bombers do not come from poor economic conditions and are more educated compared to the Palestinian population (Berrebi 2003, Krueger and Malečková 2003).

In this paper, we study the relation between human capital of suicide bombers and the outcomes of their suicide attacks. We follow the approach of 'rational sacrifice' developed in Iannaccone (1992, 2006), where rational actors who sacrifice their lives obtain benefits from their suicide related activities. Similar to Becker and Posner (2005), we assume that human capital is an important factor in the production of suicide terrorism, and thus more able suicide bombers should be assigned in equilibrium to targets that are associated with greater rewards.

The equilibrium outcome of the market for suicide bombers has two important predictions. First, more able suicide bombers will be assigned to targets that are associated with greater rewards. Second, more able individuals are more productive when assigned to more important targets. The intuition behind our analysis is straightforward; an individual will engage in suicide bombing if and only if the payoff from sacrificing himself is larger than his reservation wage in the productive

sector. Since there are returns to human capital in both the productive and the terror sectors, high ability individuals will become suicide bombers if the expected payoff from suicide bombing is higher than their skill-adjusted expected lifetime earnings in the productive sector. Similarly, rational terror organizations will assign suicide bombers to targets according to their abilities.

The key assumption in our analysis is that human capital is an important input in the production of suicide terrorism. Suicide attacks are complex tasks that require a considerable level of task specific and general human capital. Suicide bombers have to reach their targets and often have to disguise themselves to blend into local population. After reaching the target, suicide bombers must decide on the timing and the exact location of their attack. For example, when attempting to blow up a bus, a suicide bomber has to trade-off the expected number of passengers that will get on and off in the next stop against the likelihood that he will be captured if he waits before detonating his explosive device.

We use a unique database that was constructed from reports of the Israeli Security Agency (ISA). The data detail the biographies of Palestinian suicide bombers between the years 2000 and 2005, including detailed information about the targets they attacked, and number of people that they killed and injured. We analyze the assignment of suicide bombers to targets as a function of their ability. We assume that older suicide bombers have more general human capital than younger suicide bombers, and that educated suicide bombers are either more able or have acquired specific human capital compared to those who are not educated. We find that the suicide bomber's age and education and the importance of the target are strongly correlated; older and more educated suicide bombers are assigned to attack more important targets.

Next, we turn to analyze the productivity of suicide bombers by estimating a production function of suicide bombing. We use the number of people that were killed or injured in a suicide attack as our output measures. We estimate the effects of educational attainment and age of suicide bombers on the number of people killed and injured. Our empirical analysis suggests that the returns to the age and education of a suicide bomber in the production of suicide attacks are positive and increasing in the target's ranking. Older and more educated suicide bombers kill more people when they attack more important targets. Finally, we find that more educated and older Palestinian suicide bombers are less likely to fail or to be caught during their attacks, emphasizing the importance of human capital in the production of suicide bombing.

Our paper also sheds additional light on the link between education and terrorism. Given the

quality of the data, we were able to update the estimates of educational attainment of Palestinian suicide bombers. Consistent with the estimates in Berrebi (2003), the share of academic degree holders in our sample is larger than the reported share of degree holders among the overall comparable Palestinian population. However, our estimates are much smaller. We attribute the difference to both the different periods from which the samples were drawn, as well as a potential upward bias in Berrebi's data due to the exclusion of failed suicide bombers that may result in a selection bias.

The paper is organized as follows. The next section presents a theoretical framework for the analysis of the market for suicide bombers. Data sources and summary statistics are described in Section II. Section III discusses the empirical analysis of the model. Section IV studies the determinants of caught suicide bombers. Section V concludes.

I. The Market for Suicide Bombers

In this section we review the literature on the market for suicide bombers. We discuss how the interaction between ability of suicide bombers and the availability of potential targets affect the demand and supply for suicide bombers.[1]

A. The Demand for Suicide Bombers

Recent work by Bueno de Mesquita (2005), and Ianaconne (2006) analyze the demand for suicide bombers. According to Iannaccone (2006), the high cost of incompetent, unreliable or untrustworthy suicide bombers predicts that, on the demand side, suicide bombers will tend to be relatively well educated and mentally stable. Likewise, Bueno de Mesquita (2005) develops a model in which terrorist organization wants to recruit only the most effective, highly skilled terrorists, since higher ability people are more likely to succeed at terrorist attacks. While our work is motivated by the relation between ability and terrorism that Bueno de Mesquita (2005) and Ianaconne (2006) analyze, we relax the assumption of a constant wage for all terrorist operatives. Some terrorist tasks are more demanding than others and require a considerable level of task specific and general human capital. Since some targets are more important and thus are more rewarding from the suicide bomber's perspective, it is not clear that suicide bombers in all targets will be higher ability, better

[1]There is a growing body of literature that analyze the rationality of terror organizations (i.e. Berman (2004), Berrebi and Klor (2005), Iannaccone (2006), Kydd and Walter (2002)).

educated people.

B. The Supply of Suicide Bombers

To analyze the supply side we follow Iannaccone's approach of 'rational sacrifice', where rational actors who sacrifice their lives obtain benefits from their suicide related activities.[2] He writes: "[T]he benefits will start well before the sacrificial acts (as when the volunteer is honored by his comrades or rewarded by his leaders) and extend well beyond (and, perhaps into a life after death)." The benefits of suicide related activities include: fame, honor, and recognition; moral status; value of accomplishment; beneficial consequences and rewards for significant others; beneficial consequences and rewards for self, and the magnitude of harm and humiliation imposed on enemies. It is likely that the benefits that Iannaccone lists are increasing in the suicide bomber's ability. For example, fame, honor, and recognition are higher for suicide bombers that are successful in killing more enemies. If able suicide bombers are capable of launching more successful attacks, rational talented individuals will be willing to participate in large scale suicide attacks. Likewise, value of accomplishment, beneficial consequences and rewards for self, and harm and humiliation imposed on enemies, are all increasing in the expected impact of a suicide bombing attack.

Similarly, Becker and Posner (2005) develop a model where suicide bombers derive utility from sacrificing their life and killing members of a hated group. In their model, persons with high reservation wages would only accept suicide missions that have high expected payoffs. The Becker and Posner model suggests that successful suicide attacks, such as the 9/11 attacks, are produced by suicide bombers who have high reservation wages and are potentially more educated and older. If terror organizations match able individuals to targets with larger impact, then more able suicide bombers enjoy a higher expected stream of benefits well before the sacrificial act.

C. Equilibrium in the Market for Suicide Bombers

In an earlier version of this paper [Benmelech and Berrebi (2006)], we developed a price theory model of attack assignments in terror organizations. In our model, human capital is an important factor in the production of suicide terrorism, and more able suicide bombers are assigned in equilibrium to targets that are associated with greater rewards. Our analysis is similar to Becker and

[2]While there is empirical evidence on the relation between economic distress and unemployment, and suicide in general (e.g. Krug et al. 1998, Aihara and Iki 2002, Kposowa 2001), and between income and suicide rates (Helliwell 2004), the typical profile of suicide bombers is different than those who commit suicide in general (Berrebi 2003, Krueger and Malečková 2003).

Posner's model in which different missions have different payoffs, and a terrorist organization allocates different missions to potential suicide bombers given their incentive-compatibility constraints. Likewise, Krueger and Malečková (2003) suggest that on the supply side terrorism may offer greater benefits for those with more education, and that on the demand side terrorist organization may prefer to choose those who have better education.

The equilibrium predictions of this theoretical framework is that more able individuals will be assigned to more important targets ex-ante, and that more able individuals have a comparative advantage in more important targets and thus are more effective (i.e. kill more) when assigned to more important targets.

II. Data and Descriptive Statistics

We use a unique data set that includes characteristics of Palestinian suicide bombers and the outcomes of their attacks. The data set contains detailed information on all suicide attacks by Palestinian against Israeli targets in Israel, the West Bank and the Gaza strip between September 2000 and August 2005. The data is taken from reports of the Israeli Security Agency (ISA) that include a brief biography of the suicide bombers, a detailed description of the attack (including a description of the target and its location), and detailed information about the number of people killed and injured in the attack. We augment the data (when possible) with information from the web sites of the Hamas and Palestinian Islamic Jihad (PIJ).[3] The unusual nature and sources of the dataset are important for the reliability of the data. Since praising *Shahids* (martyrs) is a divine obligation in Islam, it is possible that terror organizations will praise suicide bombers as part of a religious obligation or mere propaganda. However, since we have detailed information about the biographies of suicide bombers from the ISA, we were able to check the reliability of the information reported by the terror organizations. After translating the biographies from the web sites of the Hamas and PIJ, (which is in Arabic), and the data from the ISA, (which is in Hebrew) we find no disparities between the two sources in the biographies of the suicide bombers.

A. Suicide Attacks

Our data set spans almost 5 years of the Israeli-Palestinian confrontation from September 2000 to August 2005. The ISA reports cover 151 suicide bombing attacks carried out by 168 suicide bombers

[3]See Berrebi (2003) for details on the Hamas and the PIJ web sites.

in Israel, the West Bank and Gaza. In the 151 suicide attacks that are included in the data set, 515 Israelis were killed and 3,428 were injured. According to the ISA, there were about 25,000 Palestinian attacks against Israeli citizens and residents between September 2000 and August 2005. In those attacks more than 1,000 Israelis were killed. While suicide attacks account for only 0.6% of the total number of attacks, the number of Israelis who were killed in suicide attacks is more than half the number of Israelis killed in Palestinian attacks during this period. We restrict our sample to attacks in which we have information about the age and education of suicide bombers. We also eliminate suicide attacks that were launched by non Palestinians or in which we could not identify the target. After imposing these requirements on the data we end up with 135 suicide bombing attacks carried out by 148 suicide bombers. Our sample represents 89.4% of the total number of suicide attacks between September 2000 and August 2005, 88.1% of the suicide bombers, and 98.1% of the Israelis who were killed in suicide attacks.

Figure 1 displays the number of suicide attacks, number of people killed, and number of those who were injured in suicide attacks from September 2000 to August 2005. The al-Aqsa intifada[4] began on September 29, 2000 and thus there were fewer suicide attacks in the year 2000. There were 60 suicide attacks in 2002 (out of which 55 are included in our sample), almost twice as many as the number of attacks in the years 2001 and 2003. There was a gradual decline in the number of attacks in the years 2004 and 2005.

There is positive correlation between the number of suicide attacks and the number of people killed and injured in these attacks. For example, in 2000 there are 3 suicide attacks in our sample in which there were no casualties. In contrast, in 2002 there are 55 suicide attacks in our sample that killed 216 and injured 1,308 people. The correlation between the number of suicide attacks and the number of people killed in these attacks within a year is 0.95. Likewise the correlation between the number of suicide attacks and the number of people injured in these attacks within a year is 0.95. Finally, the correlation between the number of people killed and the number of those who were injured in suicide attacks within a year is 0.94. All correlations are significant at the 1 percent level. Table 1 reports detailed summary statistics for the number of people killed and injured in suicide attacks. The mean number of individuals killed (injured) in a suicide attack in the full sample is 3.7 (24.2). The average number of killed (injured) people in suicide attacks was 2.8 (27.9) in 2001, 3.9 (23.8) in 2002, 5.6 (27.4) in 2003, 4.2 (21.8) in 2004, and 1.2 (16.4) in 2005.

[4] *Intifada* is an Arabic word for uprising - literally translated as 'shaking off'.

As Figure 2 demonstrates, 39.9% of the suicide attacks in our sample were carried out by Hamas, 25.7% by the Palestinian Islamic Jihad (PIJ), 26.4% by the Fatah, 5.4% by the Popular Front for the Liberation of Palestine (PFLP), and 2.7% by other organization. The Hamas and the PIJ, the two Islamic Palestinian terrorist organizations carried out 65.5% of the suicide attacks in our sample.

B. Suicide Bombers

Our sample includes 148 suicide bombers for whom we know their names, membership in terror organization, age, city of residence, marital status and whether they had an academic degree or were enrolled in a higher-education institution. There are 8 female and 140 male suicide bombers in the sample. The youngest suicide bomber is 12 years old, and the oldest is 48. The mean age of the suicide bombers is 21.1, the median is 20.5 and the standard deviation is 4.7 years. These results are similar to previous finding regarding the age of Palestinian suicide bombers. For example, using a sample of 63 suicide bombers, Berrebi (2003) finds that 8% of the suicide bombers were between the ages of 15 and 17, 67% were in the range of 18-24, and 25% were 25 or older. While the three suicide bombers that are in our sample for the year 2000 are 24, 25 and 27 years old, respectively, the mean age of the suicide bombers in the years 2001-2005 is between 17.6 and 23.4. We measure education using a dummy variable that equals 1 for those who went beyond high school education. We treat students in academic institutions as if they have higher education even if they did not graduate when they carried out a suicide attack. We find that 18.0% of the suicide bombers went beyond high school education, compared with only 8% in the Palestinian population as reported by Berrebi (2003).[5]

C. Measuring Target Impact

In order to estimate the relation between targets, suicide bombers and suicide attacks' outcomes, we need a measure of target importance. A sensible proxy for the importance of a target is the size of a city in which the target is located. A target in a large city is potentially more valuable than a target in a smaller city.[6] Likewise, a civil target in an Israeli city is potentially more valuable than a military target in Israel or in the West Bank and Gaza. We construct two measures of target

[5] Berrebi measures education attainment in the Palestinian society of Muslim males between the ages of 16 and 50 using the 1993 Labor Force Surveys in Judea, Samaria and Gaza.

[6] We measure city size using population within the metro area of the city.

importance. Our first measure is a dummy variable that equals to one for cities with a population of more than 50,000, and zero otherwise. We construct the "Target Index" using the Israeli Central Bureau of Statistics (CBS) population figures for the year 2003. Our second measure of target importance is a dummy variable that equals to one for civil targets, and equals zero for military targets.

Table 2 displays the ex-post outcomes of suicide attacks stratified by the two measures of target importance. As Table 2 illustrates, there is positive correlation between the number of people killed in attacks and the target's ranking; (correlation=0.38, p-value=0.00 for larger cities, and correlation=0.31, p-value=0.00 for civil targets). For example, the mean number of people killed (per attack) in targets in smaller cities is 1.4, and the mean number of people killed in targets in larger cities is 6.2. Furthermore, the mean number of people killed (per attack) in military targets is 0.3, and the mean number of people killed in civil targets is 5.0. There is also a positive correlation between the number of people injured in attacks and the target's ranking (correlation=0.51, p-value=0.00 for larger cities, and correlation=0.36, p-value=0.00 for civil targets). The mean number of people injured (per attack) in targets in smaller cities is 7.0, and the mean number of people injured (per attack) in targets in larger cities is 42.6. Similarly, the mean number of people injured in military targets is 2.4, and the mean number of people injured in civil targets is 32.5. The results are consistent with Berrebi and Lakdawalla (2006) findings that city population is strongly and positively correlated with terror attack frequency in Israel.

III. Empirical Analysis

In this section we attempt to test the relation between the age and education of suicide bombers and the outcomes of their attacks.

A. Evidence from Successful Suicide Bombers

Table 3 lists the top-five suicide bombers ranked based on the number of people killed in their attacks.[7] The table reports the characteristics of the suicide bombers (name, age, education, and terror organization affiliation) and detailed information about the attack (date, location, number of people killed and injured). The average age of the top-five suicide bombers is 25.8 compared to

[7]The list includes 'stand-alone' suicide bombers, and excludes suicide attacks with more than one suicide bomber such as the attack on January 5th, 2003 in which two suicide bombers blew themselves up in the old central bus station in Tel Aviv resulting in 23 killed and 106 wounded people.

an average age of 20.9 in the rest of the sample, (p-value of a t-test on the means=0.02). Three out of the top-five suicide bombers had academic degrees, 2 were masters' candidates and one had a degree in law, while only 17.0% of the suicide bombers in the rest of the sample had or were perusing academic degrees (p-value of a t-test on the means=0.02). The top-five suicide bombers which appear to be more educated and older than suicide bombers in the full sample, killed on average 22.8 people compared to the rest of the sample mean of 3.0 (t-test on the means=0.00), and injured on average 88.0 people compared with a mean of 25.2 in the rest of the sample (p-value of a t-test on the means=0.00). Furthermore, all the top-five suicide bombers attacked targets in large Israeli cities; while only 52.7% of the suicide bombers in the full sample attacked in these cities. The anecdotal evidence in Table 3 suggests that the best performing suicide bombers tend to be older and more educated, and are also more likely to attack targets in major cities. In our empirical analysis we use the age and education of suicide bombers as proxies for their skills. We assume that older suicide bombers have more general human capital than younger suicide bombers. General human capital is in particular important in the case of suicide bombers since on-the-job human capital accumulation and learning by doing are not feasible. We also assume that educated suicide bombers are either more able or have acquired specific human capital compared to those who are not educated.

B. Ex-Ante Assignment of Suicide Bombers to Targets

We begin the regression analysis with a test of a simple assignment model, which predicts that higher ability suicide bombers are assigned to more important targets. In Models 1-2 we estimate the following regression:

$$Target\ Index_i = F(age_i, academic_i, \mathbf{X_i'}) + \epsilon_i, \tag{1}$$

where $\mathbf{X_i}$ is a vector of control variables that includes terror organization indicator variables, a dummy variable for attacks with more than one suicide bomber, and a dummy variable for military targets (not reported). The coefficients on *age* and *academic* should be positive and significant if older and educated suicide bombers are assigned to more important targets.

Model 1 in Table 4 estimates a probit regression (marginal effects are reported). As Table 4 shows *age* and the Target Index are correlated, but there is no relationship between *academic* and the Target Index. The coefficient on *age* equals 0.04 and is statistically significant at the 1 percent

level, while the coefficient on *academic* is not statistically different from zero. The marginal effect of one year of age is large and represents an increase of 4 percentage points in the probability that a suicide bomber will be assigned to a target in a large city. To get better understanding of the economic magnitude, note that a 25 year old suicide bomber has a 28 percentage points higher probability to be assigned to a target in a large city (representing an increase of 53.1% relative to the unconditional mean), than the assignment of an 18 year old suicide bomber. The marginal effect of an academic degree is not found to be a statistically significant determinant of target assignment. Similarly, using a logit regression in Model 2 we find that *age* is positively correlated with the Target Index, while *academic* is not statistically significant. Thus, age (and not education) appears to be an important characteristic that Palestinian terror organizations use for assigning suicide bombers to targets in large Israeli cities.

In Models 3-4 in Table 4 our dependent variable is whether a suicide bomber is assigned to a civil or military target. We estimate the following regression:

$$Military\ Target_i = F(age_i, academic_i, \mathbf{X_i'}) + \epsilon_i, \tag{2}$$

where $\mathbf{X_i}$ is a vector of control variables that includes terror organization indicator variables, and a dummy variable for attacks with more than one suicide bomber (not reported).

Model 3 in Table 4 estimates a probit regression (marginal effects are reported). As Model 3 demonstrates, there is a strong negative relationship between *academic* and the military targets. Educated suicide bombers are 13 percentage points less likely to be assigned to military targets, representing a decrease of 45.3% relative to the unconditional mean. The coefficient on *age* however is not statistically significant. Likewise, in Model 4 we use a logit regression and find similar results. Thus, academic education (and not age) appears to be an important characteristic that Palestinian terror organizations use for assigning suicide bombers to civil targets.

In Models 5-6 in Table 4 our dependent variable is the distance between the suicide bomber's locality or terror cell headquarters and the location of the target. If the likelihood of being captured is increasing in the distance to the target, and depends on individual ability to avoid detection, then more able suicide bombers might be sent to distant targets. On the other hand, if the likelihood of being captured depends mainly on other factors such as the guiding driver skills, and is independent of the suicide bomber's skills, then a more able suicide bomber might be saved for closer targets. We therefore do not hypothesize about the expected effect of target's distance on assignment. To

estimate the relationship between target's distance and the ability of the suicide bomber we use the following baseline regression:

$$Target\,Distance_i = a + b \times age_i + c \times academic_i + \mathbf{X_i'\Gamma} + \epsilon_i \tag{3}$$

where $\mathbf{X_i}$ is a vector of control variables that includes terror organization indicator variables, a dummy variable for attacks with more than one suicide bomber, and a dummy variable for military targets (not reported). We use two different measures of the distance to the target: the logarithm of the distance (Model 5) between the suicide bomber's locality and the target, and the logarithm of the distance (Model 6) between the terror cell headquarters and the target.[8] As Table 4 demonstrates we do not find evidence supporting that Palestinian terror organizations assign older or more educated suicide bombers to neither targets that are further away, nor to those that are closer to the hometown of the suicide bomber or the headquarters of its terror cell.

In summary, we find that Palestinian terror organizations assign older and more educated suicide bombers to targets in larger cities and to civil targets. However, age and education are not correlated with distance between the target and the bomber or the terror cell location.

C. The Productivity of Suicide Bombers

We now turn to measure the relation between the ex-post outcomes of suicide attacks and the characteristics of suicide bombers. We test whether older and more educated suicide bomber are more productive when assigned to more important targets. The strategy for estimating this prediction is to use the number of people that were killed or injured (the output of the production of terror) as dependent variables. The baseline regression for this type of analysis is:

$$\begin{aligned} Killed_i(Injured_i) &= a + b \times age_i + c \times academic_i + d \times Target_i \\ &+ e \times (age_i \times Target_i) + f \times (academic_i \times Target_i) + \mathbf{V_i'\Gamma} + \epsilon_i \end{aligned} \tag{4}$$

where $\mathbf{V_i}$ is a vector of control variables that includes terror organization indicator variables, a dummy variable for attacks with more than one suicide bomber, suicide attack type indicators, and

[8] We were able to match latitude-longitude coordinates to the targets and to the suicide bomber's hometown locality or to the terrorist cell headquarters location. We computed the distance between any two locations using Haversine's Formula (see Sinnott (1984) for further details about the about this procedure). The distance is measured in kilometers.

a dummy variable for military targets (not reported).[9] Our measure of target importance in this regression is the population-based city size measure, but our results hold with the civil/military target measure as well. We exclude caught suicide bombers from the analysis in regression 4 in order to focus on suicide bombers who actually reach their targets, and thus we have 106 suicide bombers in Table 5. We analyze the determinants of caught suicide bombers in section IV. The interaction terms in the regression measure the cross-partial derivatives of the production function of suicide bombing with respect to age or education and target impact:

$$\frac{\partial^2 Killed(Injured)}{\partial Target \partial age}, \frac{\partial^2 Killed(Injured)}{\partial Target \partial academic}, \tag{5}$$

and should be positive if older and more educated suicide bombers perform better in more important targets. We employ different versions of regression 4 by estimating the coefficients on $age \times Target$ and $academic \times Target$ separately or alternatively by including both interaction terms in the same regression.

Table 5 presents the results for the productivity of suicide bombers. The table shows that older and educated suicide bombers are more effective when assigned to more important targets. The first column in Table 5 shows that the coefficient of $age \times Target$ is indeed positive and significant. According to Table 5 the coefficient e is 0.69 and is statistically different from zero at the seven percent level. In order to gauge the marginal effect of age, taking into account the interaction between age and $Target$, consider moving from a small city target (Target Index of 0) to a large city target (Target Index of 1) for a 25 years old suicide bomber. The increase in the number of people killed when moving from a Target Index of 0 to a Target Index of 1 for a 25 years old suicide bomber is: $-12.72 \times 1 + 0.69 \times (25 \times 1) - (-12.72 \times 0 + 0.69 \times (25 \times 0)) = 4.53$. The marginal effect of targets on younger suicide bombers is close to zero, moving from a Target Index of 0 to a Target Index of 1 for an 18 years old suicide bomber decreases the number of people killed by 0.3, indicating that very young suicide bombers perform better when they are assigned to targets in smaller cities. Interestingly, the coefficient of age is negative but not statistically significant when an interaction term is included, indicating that conditional on Target Index=0 age has no impact on the number of people killed or injured.

In the third and fourth columns of Table 5 we interact education (instead of age) with the Target Index. The positive and significant coefficient of $academic \times Target$ in column 3 suggests

[9] There are 9 suicide attack types in our sample; explosives belt, bag, bus attack, car, bike, boat, diver, tanker, and wagon. The most common were: explosives belt, bag, car, and bus.

that there are returns to education in the production of suicide attacks. An educated suicide bomber kills 5.9 more people when he attacks a large city target (Target Index of 1) compared to an uneducated suicide bomber. Interestingly, educated suicide bombers perform worse when they attack less important targets.

We find no statistical significant returns to age or education when the production of suicide bombing is measured using the number of people injured in an attack.[10] Finally, in the last two columns of Table 5 we employ the full specification of Equation 4 including both interaction terms. Consistent with our previous results we find that both $age \times Target$ and $academic \times Target$ are positive and significant for the number of people killed.

IV. Evidence from Caught Suicide Bombers

In this section we supplement our analysis with empirical evidence on the relation between human capital and the likelihood that a Palestinian suicide bomber will fail in his mission or that he will be caught by Israeli security forces or civilians during his attack. Becker (2005) hypothesizes that younger and less educated suicide bombers are more likely to fail in their missions. He writes:

> *Any terrorist organization has available a supply of potential suicide bombers or other terrorists who have different levels of education and economic opportunities. To make my point in a simple way, suppose all potential bombers gain the same utility from destroying members of a hated group, such as Israelis, through successful attacks that are likely also to kill the bombers. Suppose too, they suffer to the same extent if they fail in their missions - they may be captured without hurting anyone, or they may only kill themselves.*
>
> *Recruits with good economic opportunities would only be willing to undertake suicide missions that have a relatively high likelihood of destroying some enemies too. For they would not be willing to go on missions that have little chance of succeeding since they would then prefer safer terrorist activities, or doing well economically while working peacefully. In this case, relatively highly educated terrorists will be sent on missions that are more likely to succeed in destroying their enemies as well as themselves. As a result, the education and other determinants of the economic opportunities of successful*

[10] We believe that this is probably due to the different types and levels of injuries, as well as reporting requirements that mask the analysis.

bombers will exceed the opportunities of bombers who fail (and who may be captured). [T]he education of captured bombers would be less than the education of all bombers since low educated individuals, such as the many teenagers sent on suicide efforts to Israel, would go on missions with smaller chances of succeeding. [11]

In order to test the hypothesis that less educated and younger suicide bombers are more likely to fail in their missions, we identify caught suicide bombers using the ISA reports. We classify attackers as caught suicide bombers if they: i) have failed to detonate their explosive devices, ii) looked suspicious and were apprehended, or killed by civilians, policemen or soldiers, iii) panicked and blew themselves up before they reach the target or died during capture, or iv) chickened out. There are 42 suicide bombers in the sample that are classified as caught suicide bombers, out of them 18 (42.9%) were caught alive, and 24 (57.1%) were killed.

A. Univariate Analysis

Table 6 splits the sample into two subsamples of caught and uncaught suicide bombers, and reports summary statistics for their age and education. The table demonstrates that there are differences in age and educational attainment between caught and uncaught suicide bombers. According to Panel A the average age of a caught suicide bomber is 18.8, while uncaught suicide bombers are on average 3.2 years older, and the difference is statistically significant (two-sample t-test for equal means is significant at the 1 percent level). Likewise, the median caught suicide bomber is 19 years old, three years younger than the median uncaught suicide bomber.

Panel B of Table 6 compares educational attainment between caught and uncaught suicide bombers. While 23% of the uncaught suicide bombers went beyond high school education, only 7% of the caught suicide bombers had an academic education. The difference in educational attainment between caught and uncaught suicide bombers is sizeable (16 percentage points, significant at the 3 percent level), and represent a 88.9% decrease in the likelihood of being educated compared to the mean.

B. Multivariate Analysis

Table 7 presents probit and logit estimates (marginal effects are reported, p-values in parenthesis) of the determinants of the probability that a suicide bomber will be caught either before or during

[11] See The Becker-Posner Blog (a blog by Gary Becker and Richard Posner, May 29, 2005 http://www.becker-posner-blog.com/archives/2005/05/).

his attack. All the regressions include an intercept (coefficient is not reported for brevity), and standard errors are calculated using clustering by attack location. The regressions results are consistent with the univariate analysis in Table 6. An additional year of age is associated with a decrease of between 4 and 5 percentage points in the probability of being caught, a reduction of between 14.1% and 17.6% relative to the sample mean. Likewise, suicide bombers who went beyond high school education are between 15 and 16 percentage points less likely to be caught, which is a between 52.9 and 56.4 percent decrease from the 28.4 percent frequency of caught suicide bombers in the sample. The last two regressions include additional control variables; dummy variables for the Hamas, PIJ and the Fatah, a dummy variable that equals to one if more than one bomber participated in an attack, and zero otherwise, and a dummy variable for military targets. Our results confirm Becker's (2005) predictions that caught or failed suicide bombers should be younger and less educated, and are in general consistent with our model that emphasize the importance of human capital in suicide bombing.

C. The Education of Suicide Bombers

Our results also shed more light on the link between education and terrorism. While suicide bombers are on average more educated than the general Palestinian population, our estimate of higher education among suicide bombers is lower than the figures reported by Berrebi (2003) and Krueger and Malečková (2003). Berrebi (2003) finds that 55% of the suicide bombers for whom he was able to find information on education had or were perusing academic education. Berrebi's figure is more than three times our estimate of 18%.[12]

It is possible that a selection bias drives the differences in the estimates of education among suicide bombers. In order to obtain data on suicide bombers, Berrebi (2003) collects biographical data on successful terrorist attack against Israelis from 1949 to May 2002. Berrebi (2003) identifies terror attacks using data from the Israeli Foreign Ministry and the National Insurance Institute of Israel. His data does not include suicide bombers who were caught or failed in their mission, or suicide bombers that did not succeed in killing others.[13] However, the evidence in this paper shows that failed and caught suicide bombers are less educated than those who do not fail in

[12]The evidence on the effects of education on suicide rates in general is mixed. Durkheim (1952) argues that education encourages inquiry and is likely to be associated with higher suicide rates. However, many modern empirical studies found that suicide rates of students were below those of demographically matched cohorts (Helliwell 2004).

[13]See Berrebi (2003) footnote 36.

their missions. Krueger and Malečková (2003) argue along these lines that terror organizations may prefer to select those who have better education since a high level of education attainment is probably a signal of commitment, as well as of ability to carry an attack. Similarly, Becker (2005) argues that: "the sample of bombers or other terrorists must be representative of all terrorists - not mainly either failures or successes - before reliable conclusions can be drawn about the relation between economic opportunities and the recruitment of terrorists." Since failed suicide bombers are less likely to be educated, previous estimates of academic education along the lines of Berrebi (2003) are probably biased upward.

Another potential explanation is that Berrebi (2003) uses data on suicide bombing attacks between 1993 and 2002, and it is possible that the characteristics of suicide bombers have changed during the period 2001-2005. According to the ISA there were 38 suicide bombing attacks that were carried out by 43 individual suicide bombers between 1993 and September 2000, while there were 151 suicide bombing attacks by 168 suicide bombers from September 2000 to August 2005. If there is excess demand for suicide bombers (as might have been the case in the al-Aqsa intifada), terror organizations might become less selective in recruiting potential suicide bombers.

V. Conclusion

This paper provides the first detailed analysis of the relationship between suicide bombers characteristics and their performance in suicide bombing attacks. We find evidence that Palestinian terror organizations match older and more educated suicide bombers to more important Israeli targets. We also find that older and more educated suicide bombers kill more people in their suicide attacks when assigned to important targets. Furthermore, we also find that older and educated suicide bombers are less likely to fail or to be caught when they attack. Our evidence suggests that, as predicted by economic theory, suicide bombers plausibly maximize an expected payoff from their attacks. The evidence confirms the prediction that older and more educated suicide bombers are more effective when assigned to more important targets, and that older and educated suicide bombers are more likely to launch successful attacks without being caught.

Our paper also contributes to the debate on the relation between education, poverty and terrorism. We revise the existing estimate of the proportion of suicide bombers who either have an academic degree or are enrolled as students in academic institutions. While our estimate is still

significantly higher than the average educational attainment in the Palestinian society it is lower than previous estimates of educational attainment of suicide bombers. We argue that sample selection may bias the estimates of education among suicide bombers since less educated bombers are significantly more likely to fail in their mission.

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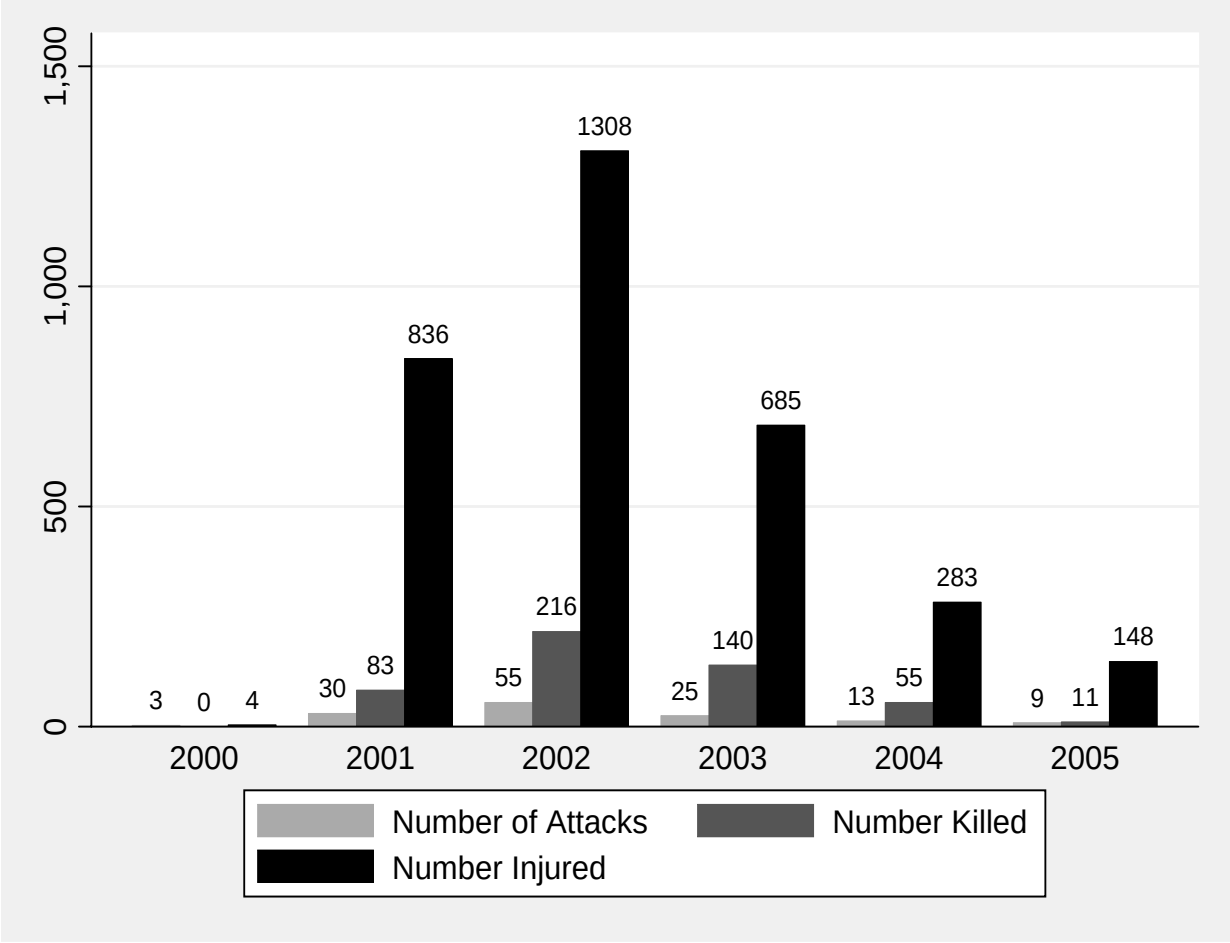

Figure 1

Number of suicide-bombing attacks, and number of people killed and injured in suicide-bombing attacks for each of the years during the period September 2000-August 2005.

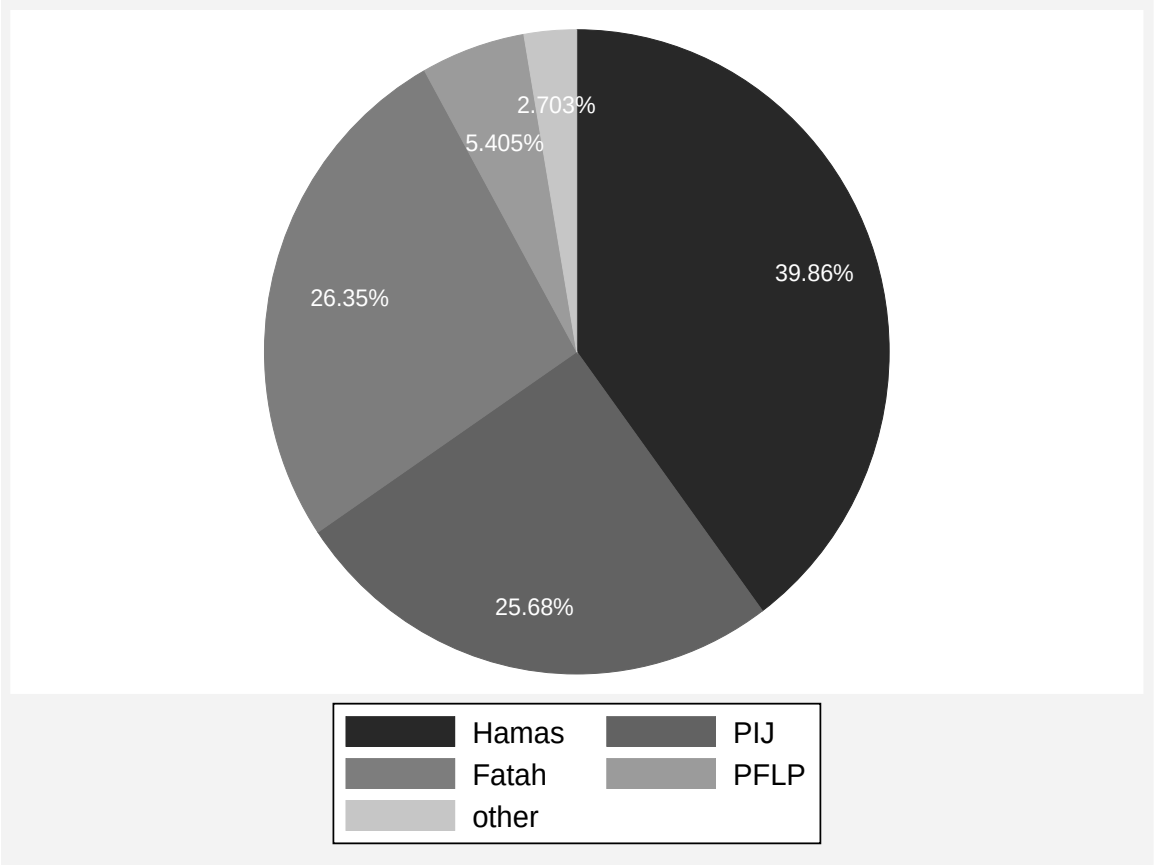

Figure 2
Suicide-bombing attacks by terror organizations.

Table 1:
Characteristics of Suicide Attacks

		Number killed			Number injured		
	Number of Attacks	Mean	Max	Std	Mean	Max	Std
Full sample	135	3.7	29	6.1	24.2	170	32.6
2000	3	0.0	0.0	0.0	1.3	3	1.5
2001	30	2.8	22	5.5	27.9	170	40.4
2002	55	3.9	29	6.2	23.8	144	27.6
2003	25	5.6	23	7.8	27.4	115	36.7
2004	13	4.2	16	5.3	21.8	100	30.2
2005	9	1.2	5	2.2	16.4	88	31.8

Notes: This table reports the number of attacks, and summary statistics for the number of people killed and injured in suicide attacks, for each of the years in the sample and for the full sample.

Table 2:
Targets and Outcomes

		Number killed per attack				Number injured per attack			
City	Number of Attacks	Mean	Median	Max	Std	Mean	Median	Max	Std
Population $\geq$ 50,000	78	6.2	3.0	29.0	7.3	42.6	34.5	170.0	40.0
Population $<$ 50,000	70	1.4	0.0	17.0	3.4	7.0	2.0	52.0	13.1
p-value (t-test on means)		0.00 ***				0.00 ***			
Correlation between target ranking and number killed: 0.38 ***									
Correlation between target ranking and number injured: 0.51 ***									
Civil	115	5.0	2.0	29.0	6.8	32.5	20.0	170.0	37.2
Military	33	0.3	0.0	4.0	0.85	2.4	2.0	17.0	3.5
p-value (t-test on means)		0.00 ***				0.00 ***			
Correlation between civil target target and number killed: 0.31 ***									
Correlation between civil target and number injured: 0.36 ***									

Notes: This table reports summary statistics for the number of people killed and injured in suicide attacks, stratified by target importance and civil vs. military targets, and correlation coefficients between the number of people killed and injured by target importance and civil vs. military targets. *** denotes significance at the 1 percent level.

Table 3:
Top Five Palestinian Suicide Bombers

Name	Age	Education	Organization	Attack Date	Attack Location	Number Killed	Number Injured
‘Abd al-Baasit ‘Awdeh	25	High School	Hamas	3/27/2002	Netanya	29	144
Raa’id ‘Abd al-Hamid ‘Abd al-Razzaaq Misk	29	Masters’ Candidate	Hamas	8/19/2003	Jerusalem	23	115
Sa‘eed Hasan Husayn al-Hutari	22	High School	Hamas	6/1/2001	Tel Aviv	21	83
Hanaadi Taysir ‘Abd al-Malik Jaraadaat	29	Law School Graduate	PIJ	10/4/2003	Haifa	21	48
Muhammad Hazzaa‘ ‘Abd al-Rahmaan al-Ghoul	22	Masters’ Candidate	Hamas	7/18/2002	Jerusalem	19	50
Top-five mean	25.8	0.60				22.8	88.0
Truncated Sample mean (a)	20.9	0.17				3.0	22.4
p-value (t-test on means)	0.02 ***	0.02 **				0.00 ***	0.00 ***

Notes: This table lists the top-five ‘stand-alone’ suicide bombers ranked based on the number of people killed in their attacks. The table reports name, age, education, terror organization affiliation, attack date, attack location, number of people killed, and number of people injured. p-value of t-tests on the means are reported for age, education, number of people killed, and number of people injured. (a) truncated sample mean excludes the top-five suicide bombers. **, *** denote significance at the 5 and 1 percent level, respectively.

Table 4:
ATTACK ASSIGNMENTS

	Dependent Variable = Target Impact or Distance					
Model	(1) Population $\geq$ 50,000	(2) Population $\geq$ 50,000	(3) Military Target	(4) Military Target	(5) log(Distance) (hometown)	(6) log(Distance) (headquarters)
Age	0.04 ***	0.05 ***	-0.01	-0.01	-0.05	-0.02
	(0.00)	(0.00)	(0.32)	(0.40)	(0.13)	(0.44)
Academic	-0.02 (a)	-0.02 (a)	-0.14 *** (a)	-0.13 *** (a)	-0.01	-0.22
	(-0.20)	(-0.19)	(0.01)	(0.01)	(0.95)	(0.59)
Adjusted R^2	0.30 (b)	0.30 (b)	0.35 (b)	0.35 (b)	0.16	0.32
Observations	148	148	148	148	134	122
Estimation	probit	logit	probit	logit	OLS	OLS

Notes: Regression results of target index (columns 1 and 2), military target (columns 3 and 4), the logarithm of the distance (column 5) between the suicide bomber's locality and the target, the logarithm of the distance (column 6) between the terror cell headquarters and the target, on the suicide bomber's age and an academic degree dummy variable. Additional regressors include terror organization indicator variables, and a dummy variable for attacks with more than one suicide bomber. Models 1-2 and 5-6 also include a dummy variable for military targets. Regressions are run under probit (columns 1 and 3), logit (columns 2 and 4),and OLS (columns 5 and 6), with robust standard errors that assume group-wise clustering at the attack location level. Marginal effects and their associated p-values (in parentheses) are reported along with R^2, and the number of observations. (a) dy/dx is for discrete change of dummy variable from 0 to 1. (b) indicates Pseudo R^2. *,**,and *** denote significance at the 10, 5, and 1 percent levels, respectively.

Table 5:
The Productivity of Suicide Bombers

Dependent Variable = Number of People Killed or Injured in the Attack						
	Killed	Injured	Killed	Injured	Killed	Injured
Age	-0.16	-0.03			-0.11	-0.03
	(0.56)	(0.98)			(0.62)	(0.98)
Academic			-4.72 **	-15.10	-4.68 **	-15.15
			(0.04)	(0.30)	(0.03)	(0.30)
Target	-12.72	-37.60	0.38	23.70 ***	-13.50 *	-40.21
	(0.11)	(0.37)	(0.84)	(0.00)	(0.09)	(0.36)
Age×Target	0.69 *	2.92			0.64 *	2.91
	(0.07)	(0.17)			(0.07)	(0.16)
Academic×Target			5.90 **	4.66	5.83 **	4.80
			(0.04)	(0.76)	(0.03)	(0.32)
Adjusted R^2	0.24	0.36	0.22	0.33	0.25	0.36
Observations	106	106	106	106	106	106

Notes: This table reports regression results of the number of people that were killed or injured in successful suicide attack (the output of the production of terror) on the suicide bomber's age, an academic degree dummy variable, a target index, and interactions between age and the target index, and academic degree and the target index. Additional regressors include terror organization indicator variables, a dummy variable for attacks with more than one suicide bomber, and a dummy variable for military targets. Regressions include fixed effects for suicide attack type. Coefficient estimates for the constant, additional regressors, and fixed effects are not reported for brevity. Regressions are run under OLS with robust standard errors that assume group-wise clustering at the attack location level. Coefficient estimates and their associated p-values (in parentheses) are reported along with adjusted R^2's, and the number of observations. *,**,and *** denote significance at the 10, 5, and 1 percent levels, respectively.

Table 6:
Characteristics of Caught vs. Uncaught Suicide Bombers

Panel A: Age

	Mean	Median	Min	Max	Std	Number
Full Sample	21.1	20.5	12	48	4.7	148
Caught	18.8	19	12	26	3.3	42
Uncaught	22.0	22	16	48	4.9	106

p-value of a two-sample t-test for equal means: 0.00***

Panel B: Education (education=1 for academic education.)

	Mean	Median	Min	Max	Std	Number
Full Sample	0.18	0	0	1	0.39	148
Caught	0.07	0	0	1	0.26	42
Uncaught	0.23	0	0	1	0.42	106

p-value of a two-sample t-test for equal means: 0.03**

Notes: This table compares age and education for suicide bombers that were caught with those that were not caught. Mean, median, minimum, maximum, standard deviation and number of observations are reported along with p-value of t-tests on the means. *,**,and *** denote significance at the 10, 5, and 1 percent levels, respectively.

Table 7:
The Determinants of Caught Suicide Bombers

Age	-0.05 ***	-0.04 ***	-0.04 ***	-0.04 ***
	(0.00)	(0.00)	(0.00)	(0.00)
Academic (a)	-0.16 ***	-0.15 ***	-0.16 **	-0.15 ***
	(0.01)	(0.01)	(0.02)	(0.01)
Multiple Bombers (a)			-0.18 **	-0.17 **
			(0.04)	(0.05)
Military Target (a)			0.04	0.04
			(0.73)	(0.75)
Hamas (a)			-0.12	-0.11
			(0.30)	(0.32)
PIJ (a)			-0.14	-0.12
			(0.14)	(0.19)
Fatah (a)			-0.10	-0.10
			(0.23)	(0.21)
Pseudo R^2	0.14	0.14	0.17	0.17
Estimation	probit	logit	probit	logit
Observations	148	148	148	148

Notes: Regression results of the probability that a suicide bomber will be caught either before or during his attack on the suicide bomber's age and an academic degree dummy variable. Additional regressors include terror organization indicator variables, a dummy variable for attacks with more than one suicide bomber, and a dummy variable for military targets. Regressions are run under probit (columns 1 and 3), and logit (columns 2 and 4) with robust standard errors that assume group-wise clustering at the attack location level. Marginal effects and their associated p-value (in parentheses) are reported along with Pseudo R^2's, and the number of observations. (a) dy/dx is for discrete change of dummy variable from 0 to 1. *,**,and *** denote significance at the 10, 5, and 1 percent levels, respectively.