Correlation analysis between the occurrence of adverse events and infrastructure development in an active war theater

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Here we report a correlation analysis aimed at determining the relationships between the occurrence of adverse events and infrastructure development in an active war theater. The total budget and total aid number of 14 project types at years t=0 (the current year), t-1 (the previous year), and t-2 (two years ago), as well as the number of adverse events (killed, wounded, and hijacked) in the previous month, and the urban and rural population density for males and females, were used to correlate the number of adverse events in year t+1. Thus, the data included a total of 89 independent variables and 4 dependent variables reflecting adverse events. All data used in this study reflect incidents and infrastructure development projects that took place between 2002 and 2010 in Afghanistan.

Based on the correlation analysis findings, we conclude that most independent variables are significantly related to the dependent variables ($p<0.05$). The results demonstrate that past projects and population density variables are more related with dependent variables. The correlation analysis conducted in this study may serve as a starting point for the eventual development of prediction models.

Practitioner Summary: Analyzing and better understanding the relationships between the occurrence of adverse events and infrastructure development may provide useful information about strategies and tactics to be employed for similar scenarios in an active war theater in the future. The correlation analysis conducted in this study may serve as a starting point for the eventual development of prediction models.

Keywords: Economic infrastructure development, adverse events, active war theatre, correlation analysis

1. From war to nation-building

Afghanistan lies in the Central Asia and divided into 34 provinces and these provinces are subdivided into 400 districts (Figure 1). The Afghanistan geography does not land itself to trade, military, and operations. Therefore, this situation makes it difficult to secure the population and to improve their economic situation.

On September 11, 2001, four passenger airliners were hijacked and the planes were crashed into the World Trade Center and the Pentagon. Approximately three thousand innocent people from 90 countries died in the attacks. Although Afghanistan is the main country for al-Qaeda, all nineteen hijackers were from other nations. After one week later, U.S. government signed the Authorization for Use of Military Force (AUMF) against those responsible for attacking the U.S. on 9/11. The U.S. military attacks began on October 7, 2001 against Taliban forces. On November 14, 2001, the UN Security Council approved a resolution for authorizing a temporary administration and asking for member states to send peacekeeping forces to encourage steadiness and aid delivery. In the following year, the first major ground assault and the largest operation Anaconda was launched against al-Qaeda and Taliban fighters. Approximately two thousand U.S. and one thousand Afghan troops joined in this operation.

In April 2002, to make Afghanistan as a better place, the U.S. Congress approved over $38 billion in humanitarian and reconstruction assistance to Afghanistan from 2001 to 2009. In Early 2002, the Afghan government built their army called Afghan National Army (ANA) with a target of 70,000 troops with the help of U.S. Moreover, the International Security Assistance Force (ISAF) defended the Kabul region with 4,000 non-U.S. soldiers. The U.S. government had a limited aid for nation-building and around 8,000 U.S. and allied troops mostly based at north of Kabul for conducting counterterrorist operations across the country.

In 2002, the country was socioeconomically among the ten bottom countries and there was no human capital to build on, then the international community promised over $5 billion in aid and started the work of

helping to rebuild Afghanistan (Collins 2011). After 9/11 attacks, the U.S. government signed agreements with the energy-rich countries bordering Afghanistan. The main objectives of these agreements were to increase economic liberalization and attract investments from foreign capital. The total amount of U.S. assistance was categorized into four portions (Tarnoff 2010). The main portion since 2001 is approximately 56% of the total amount was given to the Afghan Security Forces Fund (ASFF). This portion includes the training of Afghanistan security forces and their equipment.

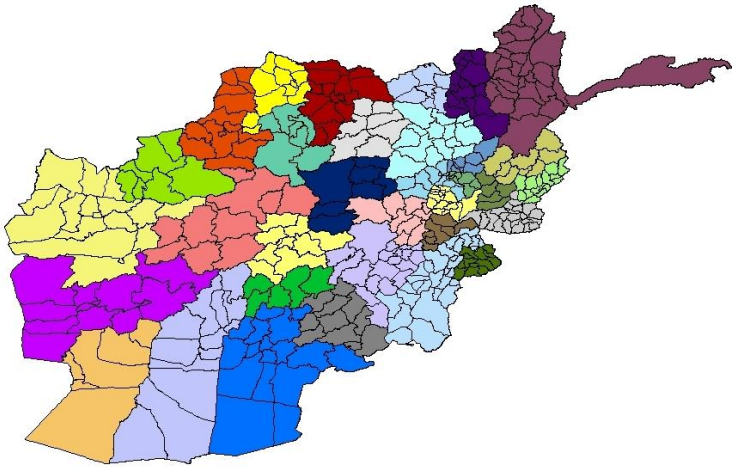


Figure 1. A map of the districts which are color grouped by province

The second largest amount is composed of economic, social, and political development efforts and it is approximately 31% of total amount. A third portion of assistance, humanitarian aid, mainly implemented through United States Agency for International Development (USAID) and international organizations, constitutes about 4% of total aid since 2001. The last portion of the aid program is counter-narcotics and is approximately 9% of total aid since 2001.

The impact of these infrastructure developments remains scarcely explored and the relationship between infrastructure development and 'terror' is not clear cut (Child 2014). Böhnke, Koehler & Zürcher (2010) conducted a survey for the north-eastern region of Afghanistan between 2005 and 2009. They tested the effect of aid in conflict zones and concluded that participants that felt already secure were more likely to feel positively about aid. However, nation-building was not so successful from 2001 through August 2009, when the second presidential election occurred. In this period, there was a negative relationship between the number of military forces and safety in Afghanistan, as the number of terrorism events tripled between 2002 and 2007 and endured through the summer of 2009 (Kamrany 2009). Wheeler and Stolkowski (2011) conducted a quantitative study by using district-level data over the period 2002-2010. They concluded that the influence of projects was so small on the number of security incidents for most cases. However, these economic and reconstruction efforts are part of the irregular warfare missions which are followed by today's military. To support these efforts, the U.S. military has encouraged various programs to understand the effect of social and cultural factors on human behavior especially to the domain of human, social, cultural, and behavioral (HSCB) modeling (Çakıt 2013).

2. Human Social Culture Behavior (HSCB) modeling

Irregular warfare is defined by the Department of Defense as "a violent struggle among state and non-state actors for legitimacy and influence over the relevant population(s)". This type of warfare includes a disproportional force to convince and hassle where opposite forces are not huge and effective in their region (Clancy and Crossett 2007). The success of irregular warfare operations mostly depends on the safety of the civilian population, since the civilian population is the center of irregular warfare (Çakıt et al. 2014). The military has made some adjustments to its force structure to recognize the challenges based on irregular warfare. Bhattacharjee (2007) outlined in the article "Pentagon Asks Academics for Help in Understanding its

Enemies," a program called Human Social Culture Behavior (HSCB) modeling used for understanding different types of cultures while operating overseas (Drapeau and Mignone 2007). The principal aim of HSCB modeling was to better organize and control the human terrain during nonconventional warfare and other missions (HSCB Modeling Program 2009). HSCB models have received significant attention in current and future operation requirements (Cakit and Karwowski, 2015).

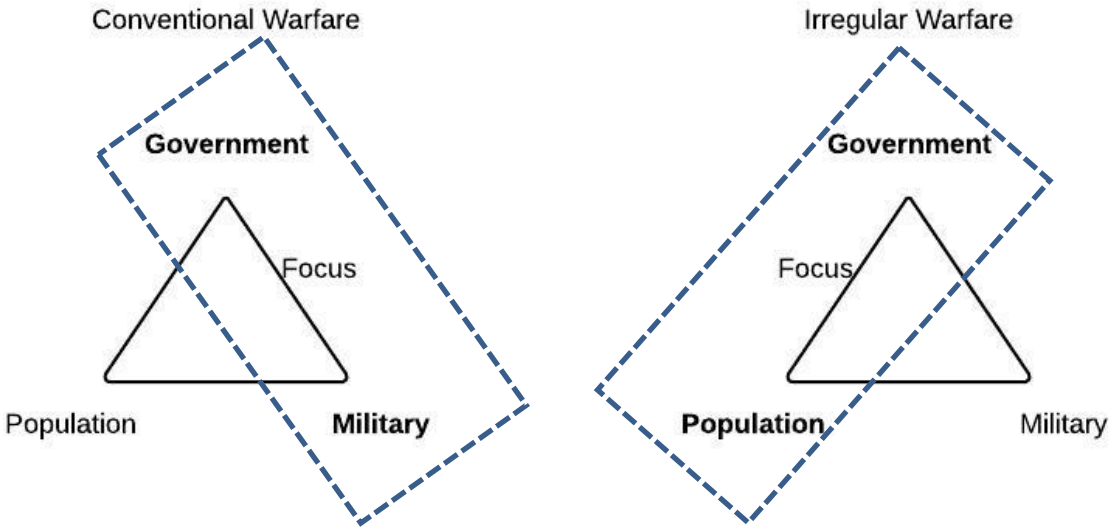


Figure 2. Contrasting Conventional and Irregular Warfare

Since HSCB models can be defined as a complex system, computational modeling and simulation techniques can deal with this complexity. Computational social scientists are researching how observations of human behavior might be used to develop scientifically based models of HSCB events (Schmorrow and Nicholson 2011). HSCB models are formed in order to understand the behavior and structure of organizational units at the macro level (economies, politics, socio-cultural regions) and the micro level (terrorist networks, tribes, military units) (Stanton 2007).

There are different kinds of modeling approaches to the data that are being used in this field and so far none have widely been accepted. Several studies have employed spatial and temporal analysis to analyze only terrorism events (LaFree et al. 2012; Siebeneck et al. 2009; Brown, Dalton, and Hoyle 2004; Johnson and Braithwaite 2009; Webb and Cutter 2004). Some authors highlighted several aspects of terrorist incidents by predicting patterns. Reed et al. (2013) aimed at demonstrating a proof of concept that a statistical understanding of terrorists' behaviors could be used to predict patterns in future behaviors. Minu, Lineesh, and John (2010) analyzed the time series of the number of terrorist attacks in the world measured on a monthly basis from 1968 to 2007. They concluded that wavelet neural networks provide the best model for analyzing terrorist attack time series, as opposed to other existing methods.

Although spatial and temporal analysis to analyze only terrorism events have been well studied, there is a dearth of information and assessments of the relationship between adverse events and infrastructure development projects. Therefore, the objective of this study was to conduct a study based on correlation analysis for understanding the relationship between infrastructure development and occurrence of adverse events.

3. Methodology

3.1 The dataset

Two different kinds of Afghanistan datasets provided by the HSCB program management (2001-2010) were utilized in this research, including: 1) The adverse event dataset, which includes information regarding the date of event, incident type, number of people killed, wounded, and hijacked, province, city, district, description of the event, and simple event summary. 2) The infrastructure aid dataset, which includes information regarding the population density, province, city, district, project types, and allocated budget information for different sectors. Provided adverse event datasets including information collected through

news feeds, blogs, reports, and through various databases. Collected dataset was processed by text processing techniques and analytics to generate suitable set of data to be used in the content of HSCB project.

In this research, the total budget of 14 project types considered at years t=0 (i.e., the current year), t-1 (the previous year), and t-2 (two years ago) (totally 42 independent variables), the total aid number of 14 project types considered at years t=0 (i.e., the current year), t-1 (the previous year), and t-2 (two years ago) (totally 42 independent variables), the number of adverse events (killed, wounded, and hijacked) in the previous month, and the urban and rural population density for males and females were used to estimate the number of adverse events in year t+1. Thus, the data included a total of 89 inputs and 4 outputs reflecting adverse events (Table 1).

Table 1. The variables used in ANN model construction.

Input variable (89 Inputs)	Output variable (4 Outputs)
$P_{t,t-1,t-2}$ Agriculture	y_t Number of Adverse Events (Killed, Wounded, Hijacked, and Total number of terrorism events)
$P_{t,t-1,t-2}$ Capacity building	
$P_{t,t-1,t-2}$ Commerce and industry	
$P_{t,t-1,t-2}$ Community development	
$P_{t,t-1,t-2}$ Education	
$P_{t,t-1,t-2}$ Emergency assistance	
$P_{t,t-1,t-2}$ Energy	
$P_{t,t-1,t-2}$ Environment	
$P_{t,t-1,t-2}$ Gender	
$P_{t,t-1,t-2}$ Governance	
$P_{t,t-1,t-2}$ Health	
$P_{t,t-1,t-2}$ Security	
$P_{t,t-1,t-2}$ Transport	
$P_{t,t-1,t-2}$ Water and sanitation	
$A_{t,t-1,t-2}$ Agriculture	
$A_{t,t-1,t-2}$ Capacity building	
$A_{t,t-1,t-2}$ Commerce and industry	
$A_{t,t-1,t-2}$ Community development	
$A_{t,t-1,t-2}$ Education	
$A_{t,t-1,t-2}$ Emergency assistance	
$A_{t,t-1,t-2}$ Energy	
$A_{t,t-1,t-2}$ Environment	
$A_{t,t-1,t-2}$ Gender	
$A_{t,t-1,t-2}$ Governance	
$A_{t,t-1,t-2}$ Health	
$A_{t,t-1,t-2}$ Security	
$A_{t,t-1,t-2}$ Transport	
$A_{t,t-1,t-2}$ Water and sanitation	
Y_{t-1} Adverse event number at month t-1	
U_f Urban female population density	
U_m Urban male population density	
R_f Rural female population density	
R_m Rural male population density	

*$P_{t,t-1,t-2}$: Project budget amount at year t, t-1, and t-2 ($)
*$A_{t,t-1,t-2}$: Aid Number at year t, t-1, and t-2
t: years between 2004 and 2010
t-1: years between 2003 and 2009
t-2: years between 2002 and 2008

4. Results and discussion

Correlation analysis was conducted using training data (between 2004 and 2009) to see the statistically significant relationships between independent and dependent variables. Correlation analysis is used to describe the negative or positive relationship between two variables. For each independent variable, the p-value was tabulated. Based on the correlation analysis results, we can conclude that most independent variables are significantly related to the dependent variables ($p<0.05$)

For the number of people killed: 26 of 28 project budgets and the number of projects in year (t-2); 21/28 project budgets and number of projects in year (t-1); 18/28 project budgets and number of projects in year (t); and urban and rural population density and number of people killed in previous month (t-1), were found to be significantly related. For the number of people wounded: 25/28 project budgets; the number of projects in year (t-2); 21/28 project budgets and number of projects in year (t-1); 19/28 project budgets and number of projects in year (t); urban population density; and number of people wounded in the previous month (t-1), were found to be significantly related. For number of people hijacked: 13/28 project budgets and number of projects in year (t-2); 9/28 project budgets and number of projects in year (t-1); 6/28 project budgets and number of projects in year (t); rural population density and number of people hijacked in previous month (t-1), were found to be significantly related. For the total number of adverse events: 27/28 project budgets and number of projects in year (t-2); 22/28 project budgets and number of projects in year (t-1); 19/28 project budgets and number of projects in year (t); and urban and rural population density and total number of adverse events in previous month (t-1), were found to be significantly related (Table 2).

Table 2. Number of projects that significantly correlated with dependent variables based on time period

Dependent variable	**Number of projects starting at year (t-2)**	**Number of projects starting at year (t-1)**	**Number of projects starting at year (t)**
Number of people killed	26	21	18
Number of people wounded	25	21	19
Number of people hijacked	13	9	6
Total number of adverse events	27	22	19
TOTAL	**91**	**73**	**62**

5. Conclusion

For the purpose of allocating resources and development of regions, the results can be summarized by determining the relationship between adverse events and infrastructure development in an active war theatre. Analyzing and better understanding the relationships between the occurrence of adverse events and infrastructure development may provide useful information about strategies and tactics to be employed for similar scenarios in an active war theater in the future. The correlation analysis conducted in this study may serve as a starting point for the eventual development of prediction models.

Acknowledgements

This study was supported in part by Grant No. 1052339, Complex Systems Engineering for Rapid Computational Socio-Cultural Network Analysis, from the Office of Naval Research. The authors acknowledge the helpful guidance of ONR program management, and the contributions of the technical team.

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