THE ECONOMIC CAUSES OF TERROR: EVIDENCE FROM RAINFALL VARIATION AND TERRORIST ATTACKS IN PAKISTAN*

SHAN AMAN RANA

ABSTRACT. How do rainfall induced rural employment shocks affect terrorist violence? There can be two opposite effects i.e. labour supply and terror finance. A positive rainfall shock to the agrarian sector raises the relative wages across agrarian and terror sector and potentially reduces terrorist labour and violence. This is the opportunity cost or labour supply effect. Alternatively, in the societal context of Pakistan - with employment elastic religious charitable donations and information asymmetry in the religious charity market captured to some extent by militants - a positive rainfall shock to the agrarian sector potentially increases terror financing and production. This is the terror financing effect. Exploiting the fact that Pakistan is a predominantly poorly irrigated, agricultural economy, I use district level panel data from 1997-2010 on rainfall shocks as an instrument for rural employment to identify the net effect of rural employment shocks on terrorist violence in Pakistan. Results suggest that a one percentage point increase in rain induced- rural employment results in an increase in the probability of a terrorist attack by 8.09 percentage points and an increase in the number of terrorist attacks by 0.5697. Results remain robust and consistent with finance rather than the labour supply as the relative dominant channel through which rural employment affects terror production in districts of Pakistan.

Keywords: Conflict in Pakistan, religious violence, extremism, suicide-bombing, opportunity costs, terror financing, terrorist recruitment.

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Email: S.Aman-Rana@lse.ac.uk

Affiliation: London School of Economics & Political Science

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"There are two things a brother must always have for Jihad, the self and money[1]*" An Al-Qaeda operative*

1. Introduction

Conflicts are development in reverse (World Bank (2003)). The long term burden of disease and disability outweighs the actual number of deaths during fighting (Ghobarah et al (2003)). While during 1945-1999 the median duration of inter-state war has been approximately 3 months with 3.33 million war related deaths, the average death toll of intra-state wars is approximately five times that number, with a median duration of six years (Fearon et al. (2003)).

Of all the different modes of conflict, contemporaneously the most complex would have to be the phenomenon of terrorism. Religious ideology, grievances, historical political agendas, economic conditions and many other factors affect the production of terror. Estimates suggest that there have been 1730 terrorist attacks from 1981-2008 with over 25,000 casualties across the globe[2].

Despite the salience of terrorism as a policy issue, there is surprisingly quite a small literature on it. Most conflict studies have been on civil wars or insurgencies. While civil wars entail active participation of the state and effective resistance by both sides (Small and Singer (1982, p.210)), terrorism remains distinct in the collective existence of the following: non-identifiably of the party against whom terrorists can act; the intention to coerce and intimidate not just the government but non-combatants as well through possible attacks on their person or property; the use of an attack to convey a message to a larger audience than the immediate victims; violence that falls outside the context of legitimate warfare activities and international humanitarian law, particularly the prohibition against deliberately targeting civilians or non-combatants (Beres (1995)).

In addition, endogeneity remains a major concern in the few studies that do focus on terrorism. Most of them are either on a cross-country level or make little attempt at exploiting exogenous variation to identify a causal effect. Apart from obvious omitted variable concerns, cross country studies potentially suffer from sample selection bias as 69.8 percent of terrorist attacks are associated with just twenty-one countries (Gassebner et al. (2011)).

While many factors affect the production of terrorism, the main question that this paper attempts to investigate is whether economic conditions like rural employment shocks have a role to play. I use exogenous, sub-national, district level variation in rainfall shocks as an instrument for rural-agrarian employment to test its effect on terrorist attacks in Pakistan[3].

Interestingly, within the religious societal context of Pakistan, the structural relationship between exogenous rural-agriculture labour market shocks and terrorist attacks is derived from two potential mechanisms i.e. a labour supply and a terror finance effect. Thus, the overall effect of a rural employment shock on terrorist violence will depend on the relative importance of one mechanism over another.

[1] US Government intelligence reporting, 2004

[2] http://cpost.uchicago.edu

[3] There are 100 districts and 7 Tribal Agencies in Pakistan. Details of Pakistan's administrative structure are explained in the data section. Map of districts of Pakistan is at appendix 1.

A positive rainfall shock to the agrarian sector raises the relative wages across agrarian and terror sector and potentially reduces terrorist labour and violence[4]. This is the opportunity cost or labour supply effect[5]. Alternatively, in the societal context of Pakistan - with potentially employment elastic religious charitable donations, information asymmetry in the religious charity market and a somewhat militant captured market for religious charitable donations - a positive rainfall shock to the agrarian sector potentially increases terror financing and production by relaxing the terrorist organisation's budget constraint. This is the terror financing effect.

The Quranic levy of 'Zakat' might be uninteresting if district level religious charitable donations were (a) employment inelastic owing to a majority of Pakistanis being (i) non-religious in their belief or (ii) non-Muslims; or (b) religious charity or 'Zakat' collection had no way of flowing towards terrorist organizations. None of these appear to hold in the context of Pakistan. The Pakistani state is a constitutional theocracy comprising of 97 percent Muslims[6]. Pew Research Centre in 2002 showed that 91 percent of Pakistani population viewed religion to be a very important factor in their lives. 77 percent of Pakistanis say their approach to religion is to observe religious code[7]. In the hierarchy of religious code, 'Zakat' is the second most important worship ritual in Islam[8]. In addition, rural household level employment and 'Zakat' data compiled from HIES for 1998, 2001, 2005, 2007 and 2010 suggests that as an average rural household member becomes employed the 'Zakat' paid to the private sector goes up by approximately Rs. 45[9], which is 15 times that paid to the government 'Zakat' department.

The employment elasticity of 'Zakat' will be irrelevant if there was no way of it leaking out to the terrorist sector. Within Pakistan there is evidence to suggest that a fraction of 'Zakat', voluntarily or involuntarily, ends up in the coffers of terrorist organizations. First, evidence suggests that the Pakistani middle class hold militants in higher regard than poor Pakistanis (Blair et al. (2013)). Second, there is evidence within Pakistan that proscribed terrorist organizations frequently change their identity and set up religious charities that are not ostensibly linked to them to raise funds via 'Zakat'[10] . There is evidence to suggest that frequent identity change leaves most Pakistanis ill-informed about the parent organization of the religious charity to whom they give their 'Zakat'[11]. Information on the real identity of terrorist charities is also not easily available; a situation that makes any shock to rural

[4]There is evidence that terrorism is not based solely on ideological leanings in Pakistan and terror sector pays wages to labour employed. According to Stern (2000) "One mid-level manager of Lashkar-i-Taiba...earns Rs.15,000 a month. Top leaders of militant groups earn much more...Operatives receive smaller salaries but win bonuses for successful missions". According to excerpts of a US Diplomatic cable appearing on the website Wikileaks in November 2008, it was reported, "the current average rate is approximately Rs 500,000 (USD 6,500) per son, for martyrdom".

[5]The labour supply or opportunity cost channel posits that expected utility maximizing individuals allocate time across legal and illegal activities by comparing the opportunity cost of time across sectors (Becker (1968)). It assumes that participation is full-time and labour supply is a binding constraint on the illegal sector (Berman et al. (2011)).

[6]The 1998 Population Census shows that 96.28 percent of the population is Muslim in Pakistan. The provincial break up is as follows: 99.44 percent KPK, 99.6 percent FATA, 97.21 percent Punjab, 91.31 percent Sindh and 98.75 percent Balochistan In 1981 Census the picture was approximately the same.

[7]Gilani Research Foundation Survey by Gallup Pakistan in 2012.

[8]Ghamidi, J.A., (2010), 'The Islamic Shari'ah of Worship Rituals,' Al-Mawrid publication

[9]To put it in perspective: 1USD =104.86 Pakistani Rupee

[10]Rana, M.A., 'Under the garb of charity,' Dawn Newspaper, 02-12-2012.

[11]Zia-ur-Reman, 'Pakistani policies cripple militant fund-raising,' Central Asia Online, 20-08-2012

employment potentially relevant for terror financing. The terrorist organization Jaish-e-Muhammad (JeM), which now operates under the name Tehreek-e-Khuddam-ul-Islam, is one example. JeM's charity wing Al Rehmat Trust, not openly linked to JeM, is reported to have raised Rs.600 million in charity in 2005 alone[12]. Al Rasheed Trust, secretly linked to Jaish-e-Muhammad and Taliban indicates that the Trust's predominant source of funding is 'Zakat'[13]. It raised Rs.950 million in 2005[14]. In the same year, Al Asar Trust, which shows no links to its parent terrorist organization Harkatul Mujahideen raised Rs.280 million[15]. Falah-i-insaniyat Foundation Jamaat-ud-Dawa(JuD)'s latest clandestine charity wing, claims to have raised billions through private donations[16].

Basing this study on Pakistan aids identification. Coupled with clandestine militant charities is the fact that 62 percent of Pakistanis live in rural areas, 80 percent of whom are in one way or the other linked to agriculture[17]. Agriculture is the largest employer, absorbing 45 percent of the country's total labour force[18]. Water in any agricultural economy is a potential determinant of productivity. If there is access to irrigation water, it dilutes the importance of rainfall in the agro-production function. In Pakistan, however, due to the political economy of irrigation water disbursement and a poor irrigation system, rainfall remains a potentially significant determinant of agricultural productivity and can potentially be used as an instrument for rural employment. In addition, there is also ample exploitable variation in terrorist activity within Pakistan. From 1997-2010, within a district-year in Pakistan, on average, there have been approximately 2 terrorist attacks or an attack 25 percent of the time, with substantial deviation around that mean.

This study compiles data from a number of different sources to construct a district level panel data set from 1997-2010 on annual rainfall and terrorist attacks in Pakistan and a district level pseudo panel for rural employment.

Results suggest that a one percentage point increase in rural employment results in an increase in the probability of a terrorist attack by 8.09 percentage points and an an increase in the number of terrorist attacks by 0.5697. This implies that changes in rural employment at a within district and year level potentially accounts for approximately 33 percentage points of the mean probability of terrorist attacks of 0.248. If the mean number of terrorist attacks is 1.74 this also means that a one percentage point increase in rural employment can account for approximately 33 percentage points of the mean number of attacks. Results remain robust and consistent with finance rather than the labour supply as the relative dominant channel through which rural employment effects terror production in districts of Pakistan. I attempt to rule out potential endogeneity concerns by exploiting the panel data structure of the data, including additional covariates drawn mainly from the Development Statistics of the provinces of Pakistan and by using different sample compositions. Results remain robust in all specifications.

This study contributes to the literature on terrorism as it is potentially, to the best of my knowledge, the first to explicitly discuss the financial effect of rural employment shocks on terrorism using sub-national variation in data. In addition, the literature mainly discusses

[12]Rana, M.A., 'Under the garb of charity,' Dawn Newspaper, 02-12-2012.
[13]South Asia Terrorism Portal, 'Al-Rashid Trust,' Terrorist Outfits in Pakisan.
[14]Rana, M.A., 'Under the garb of charity,' Dawn Newspaper, 02-12-2012.
[15]ibid.
[16]ibid.
[17]1998 Population Census and the Economic survey of Pakistan p.13
[18]Economic survey of Pakistan 2009-10, p.13

the causal channels of civil wars and insurgencies; terrorism as a distinct form of violence is not extensively investigated. Using an instrument for rural employment aids identification, as a simple OLS estimation of agrarian-labour market shocks and terrorist activity potentially suffers from measurement error, reverse causality and a host of omitted variables. The policy implications of such an investigation can be substantial.

The paper proceeds as follows: Section 2 provides a discussion of the existing literature. Section 3 discusses the specific context of Pakistan in terms of terrorism and rural-agrarian labour market. Section 4 provides the theoretical framework, which is followed by the empirical strategy, key identifying assumptions and details of data used in section 5. Section 6 presents the main results and that is followed by section 7 which deals with identification concerns and robustness checks. Section 8 concludes.

2. Literature Review

I discuss and present evidence on the two potential mechanisms through which rural employment affects terrorist attacks in districts of Pakistan. As already discussed, while the labour supply or opportunity cost channel posits that rational individuals shift their labour supply to the terrorist sector if the opportunity cost of terrorism is low, the financial channel of terrorism discusses the budget constraint of terrorist organizations.

2.1. **Labour Supply or Opportunity Cost Channel.**

2.1.1. *Quantitative Effects.* Most empirical studies confirm the operation of an opportunity cost channel in the case of civil wars and insurgencies (Collier and Hoeffler (1998, 2002);Elbadawi et al. (2000, 2002); Fearon and Laitin (2003); Miguel et. al (2004); Dube and Vargas (2009); Berman et al. (2011)). The evidence on terrorism is contrary to that of civil wars. Piazza (2006), Krueger (2007) and Krueger and Laitin (2008) among others show that economic conditions are not directly correlated with the onslaught of terrorism. Berrebi (2007) uses biographies of 285 'martyrs' from 1987 to 2002 and finds that suicide bombers are less likely to come from poor families and are more likely to have completed high school and attended college than the general Palestinian population. Krueger and Malecˇkova (2003) focus on international terrorism using public opinion polls data and biographical evidence and find similar results. An attempt at a cleaner identification, albeit in a cross-country way, is by Abadie (2006). Abadie (2006) instruments income by geographic land-lock and finds that once the level of political freedom is controlled for, terrorist risk is not significantly higher for poorer countries.

Contrary evidence in the case of opportunity cost channel of terrorism shows that conclusions from the civil wars literature might not be directly applied to terrorism. Having said that, simple OLS, cross-country studies based on descriptive statistics and biographical accounts do not account for causal channel identification. These conclusions on opportunity cost need to be investigated further.

2.1.2. *Qualitative Effects.* There appears to be evidence in support of qualitative effects of income shocks on terrorism. 'Poor economic conditions may lead more able and better-educated individuals to participate in terror attacks, allowing terror organizations to send better-qualified terrorists to more complex, higher-impact terror missions,' (Benmelech et al. (2012): p.1). Such studies, however, only provide simple descriptive and correlational evidence.

2.2. **Financial or Religious Charity Channel of Terrorism.** To the best of my knowledge, terror financing and its effects on terrorist attacks have not been investigated in the Economics literature. In the particular context of Pakistan 'Zakat' appears to be the channel through which terror is potentially financed. According to excerpts of US Diplomatic cable appearing on the website Wikileaks in November 2008, it was reported, "a network (of terrorists are)....being strengthened through an influx of charity ('Zakat')".

'Zakat' is the second most important tenet in Islam and is mentioned in the Quran in over thirty verses:

> "Take zakāh from their wealth in order to purify them with it". (Quran (9:103))
>
> "give away what is due of them upon the harvest day" (Quran (6:141))

According to the Quran, 'Zakat' is a prerequisite for an individual to become a Muslim:

> "If they repent become diligent in the prayer and pay zakāh, they are your brethren in religion" (Quran (9:11)) .

Non-payment of this charity has been held in high contempt in the Quran:

> "And to those who hoard up gold and silver and spend it not in the way of Allah give them glad tidings of a dreadful punishment. The day when in Hell their treasures shall be heated, then their foreheads, sides, and backs branded with them: "These are the riches which you hoarded. Taste then what you were hoarding."(Quran (9:34-35)).

Interestingly, 'Zakat' is due not just to ones kin, orphans, needy, wayfarers and for the ransom of slaves but also to "those who ask" (Quran; 2:177), a phrase which is potentially exploited by many a militant charities.

'Zakat' is a fixed proportion of one's income and wealth ordained by God:

> "Zakat is due at the rate of 2.5 percent annually on income or wealth and "(i) 5 percent on all items which are produced by the interaction of both labour and capital, (ii) 10 percent on items which are produced such that the basic factor in producing them is either labour or capital and (iii) 20 percent in items which are produced neither as a result of capital nor labour but actually are a gift of God"[19]

As 'Zakat' becomes due after basic needs are fulfilled, a positive employment shock not only raises the amount of 'Zakat' due from the already employed population, but it also raises the percentage of people on whom 'Zakat' becomes a compulsory religious duty. It would be meaningless if Pakistani society was secular, non-religious or non-Muslim. However, none of these hold in Pakistan. Pakistan is constitutionally a theological state. According to the 1998 Population Census there are 96.28 percent Muslims in Pakistan and the religiosity of its populace, especially the relatively better off, has been on the rise. A number of studies have shown that Pakistanis followed a conservative thought pattern that may be construed by some as bordering on radicalism (Noor (2008)). Gallup World conducted a survey in 2006, 2007, and 2008 in 143 countries and Pakistan stands in the most religious country category. Pakistanis viewed religion as an important part of their daily lives. Zaidi (2010) argues along similar lines. In such circumstances compulsory religious tenets like 'Zakat' will potentially be followed by a majority of the population. The National Survey of Individual Giving by Agha Khan Development Network found that Pakistanis gave the equivalent of Rs

[19]Ghamidi, J.A., (2010), 'The Islamic Shari'ah of Worship Rituals,' Al-Mawrid publication

70 billion in donations during 1998 mostly directed towards religious organizations. Pakistani Muslims annually contribute billions of rupees or animal hides as part of 'Zakat' specifically on religious occasions[20].

While the State collects 'Zakat' under the 'Zakat' and 'Ushr' Ordinance 1980 and there are other benign charities in the field, as already discussed there is strong evidence to suggest that proscribed militant outfits set up religious charities and exploit asymmetric information about their true identity to collect 'Zakat' throughout Pakistan. A realization of potential terror financing via 'Zakat' is the main reason that the Interior Ministry of Pakistan in 2012 requires social welfare organizations collecting 'Zakat' to formally apply for state permission before any fund-raising activity. In 2012, the Anti-Terrorism (Amendment) Bill, was approved, which specifically focuses on terror financing via all channels including religious charity. In light of such strong anecdotal evidence on financial channel of terrorism, an empirical investigation has potentially significant policy implications.

3. Terrorism & The Labour Market-The Specific Context of Pakistan

3.1. **Terrorist Attacks in Pakistan.** Pakistan has experienced terrorism of varied types, however, the latest most significant onslaught has been from Al-Qaeda and the Taliban. Since Pakistan's alliance with the US in 2001, terrorist attacks have been on the rise. There is ample exploitable within district variation in terrorist activity. From 1997-2010 Dera Bugti experienced 37 attacks, while D.I.Khan 24, Mardan 9, Hangu 21, Karachi 118, Khyber 56 and Kohat 21.

3.2. **Significance of Rural-Agricultural Sector in the Economy of Pakistan.** Since Pakistan is still a predominantly rural society and agriculture is by far the dominant economic activity for the bulk of the rural population, fluctuations in weather constitute important economic shocks. According to the 1998 Population Census approximately 80 percent of the rural population is linked in one way or the other to agriculture (see appendix A2 for rural areas and appendix A3 for cropped areas of Pakistan). To substantiate the significance of agriculture in the economy, I reproduce an excerpt from The Economic Survey of Pakistan 2010:

> "Agriculture is the second largest sector....and the largest employer, absorbing 45 percent of the country's total labour force. Nearly 62 percent of the country's population resides in rural areas, and is directly or indirectly linked with agriculture for their livelihood...Agriculture sector's strong linkages with the rest of the economy are not fully captured in the statistics. While on the one hand, the sector is a primary supplier of raw materials to downstream industry... on the other, it is a large market for industrial products[21]".

In addition, "Use of casual labour had been on the increase, 45% of farms reported use of casual labour in 1980 as compared to 30% during 1972. The percentage had further increased to 50% in 1990....The percentage of farms reporting permanent hired labour decreased from 7% in 1972..to 2% in 1990[22]". The trend has continued into the next two decades. Thus, the rural-agrarian employment effects of a negative rainfall shock will be felt almost immediately

[20]Zia-ur-Reman, 'During Ramadan, Pakistani militants collect money for terrorism,' Central Asia Online, 20-07-2012

[21]Economic survey of Pakistan 2009-2010, p.13

[22]Pakistan Bureau of Statistics,(2012), 'Emerging trends in Agricultural practices in Pakistan,'

by the casual labour for whom the rainfall elasticity of labour demand is potentially higher. This lends support to basing this study on rural employment in Pakistan.

3.3. **Significance of Rainfall in the Rural-Agricultural Sector of Pakistan.** In the presence of a well-planned irrigation system and a well thought out water management policy the link from rainfall to rural-agriculture employment might have been minimal. However, in Pakistan, at present, the state of the existing irrigation system is very poor. According to the Indus River System Authority actual surface water availability and area weighted recorded rainfall has been less than the average[23]. Critical investments in water infrastructure have not being made and inadequate water storage further exacerbates the problem; Pakistan has just 9 percent storage capacity of the world's average [24].This is worsened by an inefficient water management system. Efficiency of water utilization is less than 0.1 kg/m^3 as compared to 0.39 kg/m^3 in India[25].The canal irrigation system, concentrated mainly in Punjab and Sindh has been inadequate to meet the water requirements of even the traditional cropping patterns[26] (see appendix A4 for irrigated areas in Pakistan). During the 'Green Revolution' era of the 1960s, tubewells were widely encouraged as a means of irrigation, however, these private tubewells remained limited to Punjab and were mainly installed by large landholders owning more than 25 acres[27].Owing to public officials' involvement in water supply regulation, there is a lack of equal access to water. The marginal farmers, usually the tail-enders on a water course, are always at a disadvantage in getting water in adequate quantity and at the time most needed[28].

In these circumstances, erratic and highly variable rainfall, both in spatial and temporal terms, has a significant negative effect on agricultural productivity. Rainfall remains one of the main reasons for the high volatility in the agricultural sector growth rate ranging from 6.5 per cent in 2004-05 to 1.0 per cent in 2007-08[29]. Rainfall shortage not only has direct effects but also works its way through its contributions to Upper Indus Basin Flow and an adverse shock can lead to a reduction in overall availability of irrigation water. Therefore, given the political economy of irrigation policy in irrigated areas like Punjab and Sindh and the dependence on rain and uncertainty about water in rain-fed areas, rainfall remains a significant determinant of agricultural and hence rural productivity.

4. Theoretical Framework

The theoretical framework aims to capture the structural relationship between agrarian labour market shocks and terrorist attacks. This relationship is potentially based on two competing mechanisms:

(1) Positive rural-agrarian productivity shocks ⇒Increase in agrarian wages ⇒Increase in opportunity cost of terrorism ⇒ Reduction in aggregate labour participation in the terror sector ⇒Reduction in terrorist attacks

[23]Economic survey of Pakistan 2009-2010, p.35.
[24]ibid.
[25]ibid.
[26]Khan, M. H. 1998 'Public Policy and the Rural Economy of Pakistan', Vanguard Books, Lahore, pp.68-71
[27]ibid.
[28]ibid.
[29]Economic survey of Pakistan 2009-2010, p.35.

(2) Positive rural-agrarian productivity shocks⇒Increase in agrarian wages ⇒ Increased aggregate participation in the agrarian sector ⇒Increase in compulsory religious charitable donations or 'Zakat' ⇒ Increase in terror financing via militant charities collecting 'Zakat' ⇒Increase in terrorist attacks

The critical assumptions are: first, the supply of labour to terrorism is not inelastic to changes in relative wages between the agrarian and terrorist sector; second, the enforcement of 'Zakat' is ensured in a deeply religious society; third, it is assumed that a proportion of religious charity flows towards terrorist organizations through their charity organizations.

4.1. **The Model.** Consider a continuum of deeply religious Muslim population, living in a rural economy with two production sectors i.e. agriculture and terror, which produce a homogenous agricultural output Y and terrorist attacks Q respectively. Individuals believe in or have reverence for the rites and rituals ordained by Islam. This includes the rite of 'Zakat' which is a compulsory charity of a fixed proportion of total income, as ordained in the Quran. A fixed proportion of population N^l are identical land owners and N are identical labourers. A fraction of N is hired by land owners to work in agriculture (H), the rest enter the terror sector[30] (T) i.e. $N = H + T$. N labourers work on identically sized farms to produce Y.

4.1.1. *Agrarian Labour Demand.* Suppose agricultural production is Cobb-Douglas with constant returns to scale as follows:

$Y = f(\bar{K}, H) = A\bar{K}^{\alpha}H^{1-\alpha}$where $\alpha \in [0, 1]$;

Y is agricultural output; $\bar{K}$ denotes a fixed land input; H is rural-agricultural labour. A is total factor productivity, is determined by rainfall shocks, with mean ϖ and variance σ^2. Land-owners choose labour to maximize profits from agricultural production:

$\max_H\ \pi = p_yY - w_hH - r\bar{K}$

subject to the technology constraint:

$Y = f(\bar{K}, H) = A\bar{K}^{\alpha}H^{1-\alpha}$

where w_h is real agricultural wage, r is the fixed opportunity cost of using land in agriculture and p_y is the price of agricultural produce in the agrarian market. Let $p_y = 1$ for simplicity and real wage $w_h \in [0, 1]$.
Optimal labour demand equates value of marginal product of labour with wages:

$p_y(\frac{\partial f}{\partial H})$=$w_h$ or $(1)(1-\alpha)A(\frac{\bar{K}}{H})^{\alpha} = w_h$

Individual labour demand is:

$H_{n^l}(A, w_h, \bar{K}) = \bar{K}[\frac{(1-\alpha)A}{w_h}]^{\frac{1}{\alpha}} \Rightarrow$

Agrarian market demand curve: $H_{demanded} = \sum_{\forall n^l \in N^l} H_{n^l}(A, w_h, \bar{K})$.

As all land owners are identical, this implies that the agrarian market demand curve is $H_{demanded} = N^l(H_n(A, w_h, \bar{K}))$.

[30]In this study terrorist labour is a broad term and includes even those who may not be employed directly to produce attacks but in support of jobs which eventually increase the likelihood of an attack.

As $\alpha \in [0,1]$, $\frac{\partial H_{demanded}}{\partial A} > 0$ i.e. a positive rainfall shock increases agrarian market labour demand.

4.1.2. *Agrarian & Terrorist Sector Labour Market Participation.* This part of the model is based in part on the insurgent labour market participation decision in Iyengar (2011). The labour market decision that an individual faces is along the extensive margin i.e. whether he should participate in the agrarian or the terrorist sector. Under a participation decision, there is only the substitution effect of a wage change to consider. Therefore, an increase in w_h will sometimes raise, but never have a negative effect on the labour force participation decision.

N identical labourers value consumption (C) and leisure(l). Z is the total time available to each labourer. For simplicity, assume leisure (l) is fixed and $Z - l$ is one unit of time. This one unit may be allocated either to rural-agricultural sector H or the terrorist sector T.

The returns to participating in the agrarian sector is the real agricultural wage w_h. The returns to the n^{th} labourer from participating in the terrorist sector is β_n where β_n includes fixed pecuniary returns and net psychological returns (positive or negative depending on preferences) from participation in the terrorist activity. Assume that $\beta_n \sim i.i.dU[0,1]$and $Pr(\beta_n \leqslant \beta) = \beta$

It follows then that the n^{th} individual will participate in terrorist activity if the returns to terrorist activity are greater than w_h.

The marginal participation condition is $w_h^* = \beta^*$. $\beta^*$is the value of β_n for the pivotal worker where $\beta^* = w_h^*$. If due to a positive rainfall shock w_h^* rises the identity of the pivotal worker shifts and there is a new β^* which is equal to the new higher wage. For all wage between zero and the maximum wage of one $w_h^* \in (0,1)$, those with a β_n greater than w_h^* or β^* allocate their one unit of labour to the terrorist sector and those whose β_n is less than w_h^* or β^* allocate their one unit of labour to the agrarian sector. The percentage of population participating in the terrorist sector will be those individuals whose β_n will be at least the same as the agrarian wages w_h i.e.$\{Pr(\beta_n \geqslant w_h)\}\forall n = (1 - w_h)$. Therefore, the percentage of population participating in the agrarian sector is: $\{Pr(\beta_n \leqslant w_h)\}\forall n = (w_h)$. The aggregate terrorist sector labour supply is: $T = N[1 - w_h]$. The aggregate agrarian labour supply is: $H_{supplied} = N[w_h]$.

Figure 1 shows that when positive rainfall shocks lead to an outward shift of the labour demand curve, it traces movements along the labour supply curve. When $w_h^* = 0$ all of the labour force allocates its one unit of labour to the terrorist sector. At the maximum wage $w_h^* = 1$, all of the labour force allocates its one unit of labour to the agrarian sector and the total labour supply to agriculture is N. For all $w_h^* \in (0,1)$, those with a $\beta_n > \beta^* = w_h^*$ allocate their one unit of labour to the terrorist sector and those with a $\beta_n < \beta^* = w_h^*$ allocate their one unit of labour to the agrarian sector.

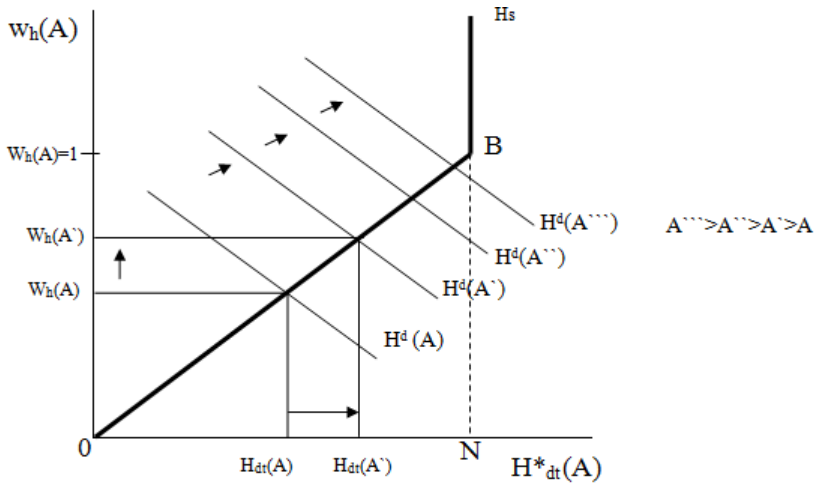

Figure 1. Agrarian Labour Force Participation Decision

Rainfall Shocks (A) to Aggregate Labour Demand ($H^d(A)$) capture movements along the Aggregate Labour Supply Curve (H^s) i.e. the proportion of people participating in the agrarian market

4.1.3. *Equilibrium in the Agrarian Sector.* Setting agrarian labour demand equal to labour supply we get the equilibrium agrarian wage:

$$w_h^*(A) = [\tfrac{N^l}{N}\bar{K}]^{\frac{\alpha}{1+\alpha}}[(1-\alpha)A]^{\frac{1}{1+\alpha}}.$$

Using the expression for equilibrium wages in agrarian employment we get equilibrium employment:

$$H^*(A) = [N^l\bar{K}]^{\frac{\alpha}{1+\alpha}}[N(1-\alpha)A]^{\frac{1}{1+\alpha}}$$

As $T^*_{supplied} = N[1 - w_h^*(A)]$.

it further gives equilibrium aggregate terrorist labour supply:

$$T^*_{supplied} = N - \{[N^l\bar{K}]^{\frac{\alpha}{1+\alpha}}[N(1-\alpha)A]^{\frac{1}{1+\alpha}}\} \text{ or}$$

$$T^*_{supplied} = N - H^*(A).$$

Equilibrium agrarian profits are (proofs at appendix A5):

$$\pi^*(A) = \{[N^l]^{\frac{1-\alpha(\alpha-1)}{1+\alpha}}[\bar{K}]^{\frac{2\alpha}{1+\alpha}}[N]^{\frac{1-\alpha}{1+\alpha}}(1-\alpha)^{\frac{2-\alpha^2}{1+\alpha}}[A]^{\frac{2}{1+\alpha}}\}\{1-[N^l(1-\alpha)]^{1+\alpha}\} - r\bar{K}.$$

Therefore, when a positive productivity shock hits the agrarian economy, labour demand and agrarian wages go up

$$\tfrac{\partial w_h^*(A)}{\partial A} = \tfrac{1}{1+\alpha}(1-\alpha)^{\frac{1}{1+\alpha}}(\tfrac{N^lK}{NA})^{\frac{\alpha}{1+\alpha}} > 0 \ \forall\alpha \in [0,1) \ .$$

This causes aggregate labour supply to rise and equilibrium agrarian employment rises:

$$\tfrac{\partial H^*(A)}{\partial A} = \tfrac{1}{1+\alpha}(N(1-\alpha))^{\frac{1}{1+\alpha}}(\tfrac{N^lK}{A})^{\frac{\alpha}{1+\alpha}} > 0 \ \forall\alpha \in [0,1).$$

On the other hand, with a positive productivity shock A, aggregate labour supplied to terror falls:

$$\tfrac{\partial T^*_{supplied}}{\partial A} = -\{\tfrac{1}{1+\alpha}(N(1-\alpha))^{\frac{1}{1+\alpha}}(\tfrac{N^lK}{A})^{\frac{\alpha}{1+\alpha}}\} < 0 \ \forall\alpha \in [0,1).$$

4.1.4. *Religious Charitable Donations.* As this is a deeply religious Muslim, rural economy an additional variable would be that of 'Zakat' or religious charitable donations. A fixed proportion s of total equilibrium income i.e. $\{N[w_h^*(A)][H^*(A)] + N^l[\pi^*(A)]\}$ is ordained by religion to be donated in the name of God.

D denotes aggregate charitable donations:

$$D^*(s, A) = (s)\{N[w_h^*(A)][H^*(A)] + N^l[\pi^*(A)]\}$$

which is split as follows:

$$D = D_b + D_t$$

where D_b is donation to faith-based, benign organizations, both private and public; D_t is donation that goes to charitable militant organizations. Benign donations finance a universal public good, whereas militant charities channel funds to terrorist organizations for terror production. The leakage rate p_t, is an exogenous proportion of total charity that flows to militant organizations. p_b is the proportion of total charity that is allocated to benign charities.

In equilibrium, donations supplied to terrorist charities are[31] (proof at appendix A5):

$$D_t^*(s, p_t, A) = p_t(s)\{N[w_h^*(A)][H^*(A)] + N^l[\pi^*(A)]\} \Rightarrow$$

$$D_t^*(s, p_t, A) = p_t(s)\{(N^l\bar{K})^{(\frac{2\alpha}{1+\alpha})}[(N)(1-\alpha)A]^{\frac{2}{1+\alpha}}\}\Lambda - p_t(s)N^l r\bar{K}$$

where

$$\Lambda = \{1 + N^{l(\frac{2-\alpha^2}{1+\alpha})}N^{\frac{(1-\alpha)}{2}}(1-\alpha)^{(-\frac{\alpha^2}{1+\alpha})}(1 - [N^l(1-\alpha)]^{(1+\alpha)})\}$$

Conditional on the leakage rate, on a positive rainfall shock, donations supplied to militant charities increase:

$$\Rightarrow \frac{\partial D_t^*(s,p_t,A)}{\partial A} = (\frac{2}{1+\alpha})A^{\frac{1-\alpha}{1+\alpha}}p_t(s)\{(N^l\bar{K})^{(\frac{2\alpha}{1+\alpha})}[(N)(1-\alpha)]^{\frac{2}{1+\alpha}}\}\Lambda$$

$$\Rightarrow \frac{\partial D_t^*(s,p_t,A)}{\partial A} > 0;\ \forall\alpha \in [0,1);\ N^l \in [0,1]$$

4.1.5. *Terror Production*[32]. Assume that there is a representative terrorist organization. Terrorist organizations wish to maximize attacks[33]. Attacks are a Cobb-Douglas function with constant returns to scale[34], denoted by

$$Q(D_t, T) = (D_t)^\gamma(T)^{(1-\gamma)}.$$

$Pr(Q(D_t, T))$ is the probability of a terrorist attack;

where $\gamma \in [0, 1]$; $D_t(s, p_t, A)$ are religious charitable donations, T is terrorist sector labour. The parameters γ and $1 - \gamma$ represent the elasticity of equilibrium terrorist attacks with

[31]Equilibrium total consumption will be $C^*(A) = (1-s)\{N[w_h^*(A)][H^*(A)] + N^l[\pi^*(A)]\}$.

[32]The way terrorists hire and train new recruits and sort them into either suicide bombers or planners or information bearers is a black box and needs deeper probe. Without further empirical research on the terrorist sector production function and labour demand curve, I only consider a reduced form version of the production function of terror.

[33]The key insight does not change if terrorist organizations maximize intensity of attacks i.e. number of attacks per capita instead of number of attacks.

[34]There can be many other factors $W = (w_1, w_2.....w_k)$ that enter the terrorist production function and which are not the explicit focus of discussion in this paper. W, might include, inter alia, the attitude of the state or people towards terrorist organizations or peace agreements between the government and terrorists etc.

respect to changes in $D_t^*(s, p_t, A)$ and $T^*(A)$, respectively. Assume terrorist organizations are able and willing to absorb into the production of terror all donations offered and all labour supplied to them.
This implies equilibrium donations and terrorist labour is:

$$D_t^*(s, p_t, A) = p_t(s)\{N[w_h^*(A)][H^*(A)] + N^l[\pi^*(A)]\}.$$

$$T^*(A) = T^*_{supplied}(A).$$

This implies in equilibrium the number of terrorist attacks are:

$$Q^*(s, p_t, A) = [D_t^*(s, p_t, A)]^\gamma [T^*(A)]^{(1-\gamma)}$$

and equilibrium probability of a terrorist attack is:

$$Pr(Q^*(s, p_t, A)) = q(D_t^*(s, p_t, A), T^*(A))$$

The overall effect of an exogenous rainfall shock on terrorist attacks is:

$$\frac{\partial Q^*(s,p_t,A)}{\partial A} = \frac{\partial Q^*(s,p_t,A)}{\partial T^*(A)}\frac{\partial T^*(A)}{\partial A} + \frac{\partial Q^*(s,p_t,A)}{\partial D_t^*(s,p_t,A)}\frac{\partial D_t^*(s,p_t,A)}{\partial A}$$

The net effect of a positive rainfall shock on terrorist attacks i.e. $\frac{\partial Q^*(s,p_t,A)}{\partial A}$ is ex-ante ambiguous and depends on the relative strength of the labour supply and charitable donation channels of terrorism. The marginal productivity of both donations and terrorist labour is positive. However, a positive rainfall shock in the agrarian market leads to opposite effects on equilibrium donations and labour employed. A positive rainfall shock translates into an increase in total income and equilibrium donations, while at the same time it leads to an increase in opportunity cost of terrorism, agrarian sector labour and a fall in the equilibrium terrorist labour employed.

The relative strength of either channel depends on the size of the parameters α,γ, s and p_t. As s is fixed and ordained by religion, and generally in the long run α is also more or less constant, the sign of $\frac{\partial Q^*(s,p_t,A)}{\partial A}$ will essentially depend on γ and p_t. This implies the following propositions:

Proposition 1. *For a given value of parameters γ, α, a donation rate s and a positive rainfall shock, there exists leakage rates $\underline{p_t}$ and $\overline{p_t}$ such that: (i) for $p_t < \underline{p_t}$, the labour supply channel dominates the finance channel and a positive rain shock decreases terror, i.e. $\frac{\partial Q^*(s,p_t,A)}{\partial A} < 0$; (ii) for $p_t > \overline{p_t}$, the finance channel dominates the labour supply channel and a positive rain shock increases terror, i.e. $\frac{\partial Q^*(s,p_t,A)}{\partial A} > 0$; (iii) for $p_t \in \{\overline{p_t}, \underline{p_t}\}$ a positive rain shock leads to ambiguous affects on terror, i.e. $\frac{\partial Q^*(s,p_t,A)}{\partial A} > 0$ or $\frac{\partial Q^*(s,p_t,A)}{\partial A} < 0$.*

p_t is the proportion of total donations that flow to militant charities and determines the magnitude of the partial effect of a positive rainfall shock on charitable donations[35]. For a given labour supply effect, parameters γ, α, a donation rate s, with a $p_t < \underline{p_t}$, a positive rainfall shock leads to a low magnitude of donations to militants and thus, a small increase in terrorist attacks via the financial channel. Therefore, the labour supply channel will dominate

[35] As $\frac{\partial D_t^*(s,p_t,A)}{\partial A} = (\frac{2}{1+\alpha})A^{\frac{1-\alpha}{1+\alpha}}p_t(s)\{(N^l\bar{K})^{(\frac{2\alpha}{1+\alpha})}[(N)(1-\alpha)]^{\frac{2}{1+\alpha}}\}\Lambda$; where
$\Lambda = \{1 + N^{l(\frac{2-\alpha^2}{1+\alpha})}N^{\frac{(1-\alpha)}{2}}(1-\alpha)^{(-\frac{\alpha^2}{1+\alpha})}(1-[N^l(1-\alpha)]^{(1+\alpha)})\}$

the finance channel resulting in $\frac{\partial Q^*(s,p_t,A)}{\partial A} < 0$ i.e. a positive rainfall shock will lead to a net decrease in terrorist activity.

If $p_t > \overline{p_t}$, then the magnitude of the partial effect of a positive rainfall shock on donations to terrorists is quite high. Therefore, donations induced terrorist attacks rise substantially. For a given labour supply effect, the finance effect will be considerable, resulting in $\frac{\partial Q^*(s,p_t,A)}{\partial A} > 0$ i.e. a positive rainfall shock will lead to a net increase in terrorist activity.

For $p_t \in \{\overline{p_t}, \underline{p_t}\}$,the net effect will be ambiguous and depends on the other parameters γ, α or donation rate s.

Proposition 2. *For a given positive rainfall shock, parameter α, a donation rate s and leakage rate p_t : (i) if $\gamma \to 1$ the elasticity of terrorist attacks to donations is high so that the finance channel dominates the labour supply channel and a positive rain shock leads to an increase in terror, i.e. $\frac{\partial Q^*(s,p_t,A)}{\partial A} > 0$; (ii) if $\gamma \to 0$ the elasticity of terrorist attacks to labour is high so that the labour supply channel dominates the finance channel and a positive rain shock leads to a decrease in terror, i.e. $\frac{\partial Q^*(s,p_t,A)}{\partial A} < 0$.*

The parameters γ and $1-\gamma$ represent the elasticity of equilibrium terrorist attacks with respect to changes in $D_t^*(s,p_t,A)$ and $T^*(A)$, respectively. For a given positive rainfall shock, parameter α, a donation rate s and leakage rate p_t, if $\gamma \to 1$ the donation elasticity of equilibrium terrorist attacks will be substantially high, while the labour supply elasticity of terrorist attacks will be low. More specifically, with a positive rainfall shock, an increase in total income and donations to militant charities, terror production increases considerably due to the high elasticity. On the other hand, with a rainfall shock induced increase in w_h^*, terrorist labour supply falls. However, due to low labour supply elasticity of terror, terrorist attcks don't fall by much[36]. Therefore, on a positive rainfall shock, the finance channel dominates the labour supply channel and $\frac{\partial Q^*(s,p_t,A)}{\partial A} > 0$. By the same logic, if $\gamma \to 0$, on a positive rainfall shock, the labour supply channel dominates the finance channel and $\frac{\partial Q^*(s,p_t,A)}{\partial A} < 0$.

Therefore, the relationship between rural employment and terrorist attacks operates through two competing channels. As data on the fundamental determinants of terrorist attacks i.e. terror financing and terrorist recruits is not available, empirically the effect of rural employement on terrorist attacks attempts to identify the net effect of rural employment through the labour supply and financial channel of terrorism. An isolated acceptance or rejection of the two competing channels of terrorism will not be possible.

5. Empirical Strategy

5.1. **From Theory to Empirics.** Structural parameters of the two competing underlying mechanisms, like the leakage rate p_t or the donation or labour supply elasticity of terrorist attacks i.e. γ or $1-\gamma$ would have been recovered if individual labour employed in the terrorist sector and donations to terrorist organizations was observable. As a first step, putting endogeneity concerns aside for the moment, we could then run a simple OLS regression of

[36] It can easily be seen that $\frac{\partial Q^*(s,p_t,A)}{\partial T^*(A)} = (1-\gamma)(\frac{D^*}{T^*})^{\gamma}$ and $\frac{\partial Q^*(s,p_t,A)}{\partial D_t^*(s,p_t,A)} = \gamma(\frac{T^*}{D^*})^{(1-\gamma)}$. This implies that: $lim_{\gamma\to 1}\frac{\partial Q^*(s,p_t,A)}{\partial T^*(A)} \to 0$ and $lim_{\gamma\to 1}\frac{\partial Q^*(s,p_t,A)}{\partial D_t^*(s,p_t,A)} \to 1$. In addition, $lim_{\gamma\to 0}\frac{\partial Q^*(s,p_t,A)}{\partial T^*(A)} \to 1$ and $lim_{\gamma\to 0}\frac{\partial Q^*(s,p_t,A)}{\partial D_t^*(s,p_t,A)} \to 0$.

terrorist attacks on religious charitable donation and terrorist labour and estimate parameters as follows:

$Q^*_{dt} = \beta_0 + \beta_1 D^{*t}_{dt} + \beta_2 T^*_{dt} + \mu_{dt}$.....(1)

Where:

Q^*_{dt}**:** are terrorist attacks in a district d and year t.

D^{*t}_{dt}**:** are religious charitable donations or 'Zakat' that flows to terrorist organizations in district d and year t.

T^*_{dt}**:** is terrorist labour employed in district d and year t

μ_{dt}**:** is the error term.

β_1 would capture the effect a unit change in religious donations has on terrorist attacks in a district d and year t. β_2 would capture the effect a unit change in terrorists employed has on terrorist attacks in a district d and year t. Identifying assumptions for $\beta_1$and β_2 would be: $E(\mu_{dt}, D^{*t}_{dt}) = 0$ and $E(\mu_{dt}, T^*_{dt}) = 0$. Similar equations could have been estimated using the underlying relationship between rainfall, donations and terrorist labour supply.

Apart from non-random placement of D^{*t}_{dt} and T^*_{dt}, the main concern is that terrorist labour supply data and donation data is not observed. Therefore, what is estimated is the reduced form effect of rural employment on terrorist attacks working through the competing labour supply and financial mechanism. Rural-agrarian employment H^*_{dt} in district d and year t in Pakistan is linked to religious donations D^{*t}_{dt} and terrorist labour supply T^*_{dt} as follows:

$D^{*t}_{dt} = \upsilon + \upsilon_1 H^*_{dt} + \varepsilon_{dt}$.....(2)

$T^*_{dt} = \lambda_0 + \lambda_1 H^*_{dt} + \eta_{dt}$.....(3)

From Section 4 we can conclude that the expected sign of the estimated coefficient in eq(2) is $\upsilon_1 > 0$ and that of the coefficient in eq(3) is $\lambda_1 < 0$ i.e. as rural employment goes up, district level donations should go up while, owing to a high opportunity cost of terrorism in a tight labour market, terrorist labour supply should fall. Using Equations (2) and (3) in (1) we get the relationship that this paper attempts to identify:

$Q^*_{dt} = Q(H^*_{dt})$.....(4)

Where the relationship in (4) captures the effect of rural employment shocks H^*_{dt} on terrorist attacks Q^*_{dt} via the donation and labour supply channel of terrorist attacks. In order to circumvent endogeneity concerns, discussed later, and to identify a causal effect of rural employment shocks on terrorist attacks, I use rainfall shocks as a source of exogenous variation to rural employment.

5.2. **Data.** Pakistan is administratively divided into four main provinces i.e. Punjab, Sindh, Khyber Pakhtunkhawa (KPK), and Balochistan comprising of 98 percent of the population. Provinces are administratively sub-divided into divisions which are further sub-divided into districts. Apart from the four provinces there are the Federally Administered Tribal Areas (FATA), Provincially Administered Tribal Areas (PATA), Islamabad and the disputed territories of Gilgit-Baltistan and Azad Jammu and Kashmir (see appendix A1 for a detailed map of districts of Pakistan). FATA is not well-integrated into Pakistan. It is ruled under Frontier Crimes Regulations. Pakistani courts and police have no jurisdiction in FATA.

It may be pertinent to mention that from 1997-2010 many districts have been split to form new districts[37] . I merge districts back into their parent district to create a balanced panel of 100 districts in 4 provinces from 1997-2010, which gives a total sample size of 1400 observations[38]. For discrete control variables like number of hospitals or schools, I sum the values of both districts. However, for continuous variables like rural employment expressed as a rate, I use the ratio of each district's area as a percentage of total area as reported by Survey of Pakistan, to create adjusted values. Using the ratio of population across the parent and new district might have been a better way especially for continuous variable like rural employment. However the last population census was held in 1998 and most of these districts were created post 2003.

5.2.1. *Data on Rainfall Shocks.* Data on annual district level rainfall in Pakistan is compiled from the Pakistan Meteorological Department's (PMD) gauge station data from 1997-2010[39]. The merits of using gauge data over satellite based rainfall estimates are discussed in detail in Cheema et al. (2012) and are not repeated here. The main advantage of gauge data lies in its precision. Satellite rainfall data deviate from actual rainfall to the scale of approximately 10 percent for annual periods (ibid.).

There are at present 98 PMD gauge stations in Pakistan (See appendix A8). Daily rainfall data on 89 of these stations, from the date of each station's establishment, was collected from PMD. The daily rain estimates were then aggregated to months and annual averages. These stations were established in different years over the country's history and do not follow district boundaries. In addition, these rainfall estimates will pertain to a single geographical point where that station is located. They might not capture rainfall variation across an entire land mass of a district. In order to arrive at representative district level rainfall estimates from 1997-2010, isohyetal method is used (estimation details and panel graphs of rainfall at appendix A7 (i) and (ii)). Data on 30 year average rainfall from 1970-2000, called 'Normals', was collected from PMD. 'Normals' data is on 55 PMD Stations which have been in existence since 1970. For the rest of the stations I use deviation from 20 year average rainfall generated using the same isohyetal method.

Table-1 describes the relationship between rainfall deviations from 'normals' data and its lags. Column 1 shows that rainfall shocks in a district in time period t are positively correlated with rainfall in time period t-1, negatively related to rainfall in time t-2 and not correlated with rainfall in t-3 and t-4. In the same way it can be seen that rainfall in time period t-1 is uncorrelated with rainfall in time t-2, negatively associated with rainfall in t-3, while it is positively associated with rainfall in t-4. Rainfall in time period t-2 is correlated negatively with rainfall in time period t-4. Rainfall in time period t-3 is uncorrelated with rainfall in t-4.

[37]Nankana was created from Sheikhupura district in Punjab in 2005. Chiniot was created from Jhang in 2009. Jacobabad, Larkana and Dadu districts in Sindh were bifurcated to form Kashmore Kamber/Shahdat Kot and Jamshoro in 2004. From Hyderabad district were created Matiari, Tando Allah Yar, Tando Muhammad Khan and Hyderabad in 2005. Harnai in Balochistan was created from Sibi in 2007, Washuk from Kharan in 2007 and Sherani from Zhob in 2006. Nushki is treated as part of Chagi district. Lower and Upper Dir in KPK were created from Dir in 2001.

[38]This is especially relevant for rural employment which is a pseudo panel of district level rural employment created from repeated cross sections of Labour Force Surveys of Pakistan. In this way, the membership of district cohorts remains fixed throughout the entire period of observation and conditional on population estimates and migration each individual observed in the survey belongs to exactly one cohort (Baltagi (2005)).

[39]I would like to thank Mr. Asif Khan, PhD Candidate, Department of Engineering, University of Cambridge for using the isohyetal method and compiling rainfall estimates.

TABLE 1. Rainfal Deviation from Normals - Correlations

	Rain (t)	Rain (t-1)	Rain (t-2)	Rain (t-3)	Rain (t-4)
Rain (t)	1.00				
Rain (t-1)	0.0779***	1.00			
	(0.0070)				
Rain (t-2)	-0.0649**	0.0268	1.00		
	(0.0402)	(0.3980)			
Rain (t-3)	0.0271	-0.1191***	-0.0271	1.00	
	(0.4446)	(0.0007)	(0.4443)		
Rain (t-4)	-0.0047	0.1048**	-0.1964***	-0.0667	1.00
	(0.9086)	(0.0102)	(0.0000)	(0.1025)	

p-value in parenthesis

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Data on annual district level rainfall in Pakistan is compiled from the Pakistan Meteorological Department's (PMD) gauge station data from 1997-2010. In order to arrive at representative district level rainfall estimates from 1997-2010, isohyetal method is used. The dataset includes 100 districts from four provinces of Pakistan i.e. Punjab, Balochistan, Khyber-Pakhtunkhawa (KPK), Sindh from 1997-2010.

It can be seen that on average rainfall in a district in Pakistan is not predictably correlated over the years. Rainfall shocks are nearly as good as randomly assigned to districts over years. In this case, expectations about future rainfall might not be a significant determinant of behaviour.

5.2.2. *Data on Terrorist Attacks.* District level panel dataset from 1997-2010 on terrorist attacks is compiled from the University of Maryland's Global Terrorism Database (GTD). Data in the GTD is drawn entirely from publicly available, open-source materials, including electronic news archives, existing datasets, secondary source materials such as books, journals and legal documents. Transparency in data collection methodology is a huge advantage of the GTD.

GTD defines terrorism as:

> "the threatened or actual use of illegal force and violence by a non-state actor to attain a political, economic, religious, or social goal through fear, coercion, or intimidation". In addition the incident must be intentional, must entail some level of violence or threat of violence, the perpetrators must be sub-national actors. At least two of the following three criteria must also be present: (1) The act must be aimed at attaining a political, economic, religious, or social goal; (2) There must be evidence of an intention to coerce, intimidate, or convey some other message to a larger audience (or audiences) than the immediate victims; (3) The action must be outside the context of legitimate warfare activities[40].

GTD provides incident-wise information on terrorist attacks across the globe from 1970-2010. I matched incident-wise locality information to districts in Pakistan to compile data on the number of terrorist attacks. I then aggregated the number of terrorist attacks upto a month

[40]Data Collection Methodology, Global Terrorism Database (GTD).

and a year for each of the district-year from 1997-2010, which gives the continuous variable of number of terrorist attacks. The dummy variable of terrorist attack takes a value of one for each district from 1997-2010 if there is even a single terrorist attacks within the geographical bounds of a district, and zero otherwise.

5.2.3. *Data on Agrarian Labour Market Measure.* District level panel data on agriculture labour market of Pakistan is not available. I, therefore, use original rural household level employment data of the Labour Force Survey of Pakistan. The main reason for using rural rather than agricultural employment is that while agricultural employment only includes skilled agriculture workers or self cultivating subsistence farmers, rural employment also accounts for unskilled agricultural labour like cleaners and helpers etc. Therefore, agricultural employment data under-reports actual agricultural employment. The other reason for using rural rather than agricultural employment is that from 1997-2005 agriculturally employed are not necessarily currently employed and include all those that just had agriculture as their main occupation.

The Labour Force Survey does not follow households though time and is a random sample of repeated cross section of households in ten waves during the sample years of 1997-2010 i.e. 1997, 1999, 2001, 2003, 2005, 2006, 2007, 2008, 2009 and 2010. In order to compile a district level rural employment measure, I use district level sample means of household rural employment from 1997-2010[41].

Following standard arguments these can be considered consistent estimates of population district level rural employment if number of households in each district d i.e. $N_d \to \infty \forall d$. What dimension of district wise household sample is large enough for the asymptotic result to hold? Verbeek (2008) provides a list of empirical papers and the sample sizes used that allow consistent estimation in the presence of repeated cross sectional data on both dependent and independent variables. In this study, as will be discussed later, the Labour Force Survey has a sample size of 36400 households[42]. With 100 districts, the average N_d turns out to be 364, which falls within the range used by most empirical papers. However, despite this, as district level sample means of rural employment can still be a noisy signal of population rural employment we cannot rule out endogeneity concerns stemming from measurement error in rural employment. I discuss these in Section 7.1.

Apart from rural employment, data on real rural wage and crop production at a district-year level were also compiled. Owing to non-availability of district-wise inflation data, real rural wage is not treated as the main variable of interest. Crop production was dropped as it only indirectly captures the underlying labour market relationships.

Details of Rural Employment Data Compilation:

The universe for Labour Force Survey consists of 98 percent of total population of Pakistan and includes all urban and rural areas of the four provinces as defined in the 1998 Population Census. FATA and military restricted areas are excluded. A stratified two-stage sample design is adopted for the survey. Villages/mouzas/dehs the lowest denomination or a block in the 1998 Population Census are considered as Primary Sampling Units (PSUs) for rural

[41]Labour Force Survey was not conducted for 1998, 2000, 2002. For these years I use linear interpolation method that fills in for the missing values using an average of the last and the next year. Around 30.5 percent of the values are missing for rural employment from 1997-2010. For the remaining (3 percent) missing values I substitute district level mean of each variable.

[42]Data Collection Methodology, Labour Force Survey, various years.

areas. The listed households of sample PSUs are taken as Secondary Sampling Units (SSUs). A random sample of 16 households from each rural PSU is selected and surveyed. In rural areas each administrative district in the Punjab, Sindh and KPK is considered an independent stratum whereas in Balochistan, each administrative division constitutes a stratum. For Balochistan I ascribe data for a division to each district within that division. An entire sample of 36400 households (SSUs) is drawn from 2576 Primary Sampling Units (PSUs) out of which 1372 are rural[43] (see appendix A9 (i) and (ii) for details of LFS coding scheme and pseudo panel graphs of district rural employment).

To get an idea of what rural employment rate stands for in such a context, I reproduce LFS definitions:

- "Employment comprises all persons ten years of age and above who worked at least one hour during the reference period and were either "paid employee" or "self employed". Persons employed on permanent/regular footings have not worked for any reason during the reference period are also treated as employed, regardless of the duration of the absence or whether workers continued to receive a salary during the absence."Pakistan LFS 2010, p.6. Similar to the US Labour Department, reference period here is a week before the survey. The survey is carried out in four quarters throughout the year.
- "Self-employment job is a job where the remuneration is directly dependent upon the profits, or the potential profits, derived from the goods and services produced." Pakistan LFS 2010, p.6
- "Currently Active Population or labour force comprises all persons ten years of age and above who fulfil the requirements for including among employed or unemployed during the reference period i.e. one week preceding the date of interview." Pakistan LFS 2010, p.6

The weighted percentage of rural population, 10 years of age and over, that responded in the affirmative to the following LFS question was used to compile rural employment rate data from 1997-20[44]:

> "Did you do any work for pay, profit, or family gain during last week, at least for one hour on any day?"

It is worth pointing out the difference of this method of employment rate measurement from the general methodology employed for instance by the Bureau of Labour Statistics, United States Labour Department. First, the age of entry into currently active population begins at 16 in the US statistics. Second, while in most countries employment rate is a percentage of the civilian labour force i.e. employed and unemployed people, in this particular case, rural employment rate is not just a percentage of the civilian labour force but also includes people who are 10 years and above and who are not in the labour force in rural areas i.e.

$$RuralEmploymentRate = [\frac{T.EmployedPopulation}{CurrentlyActivePopulation(E+U)+NLF(10yrs\&above)}]\text{in rural areas}$$

Certain data related concerns need to be highlighted. If at any time employed people in rural areas stop looking for work then they switch from being employed to being categorized

[43]Data Collection Methodology, Labour Force Survey, various years.

[44]Each query was weighted according to the population weights of each primary sampling unit. These are based on the population list of villages from the 1998 Population Census. This aims to make the sample representative at the village level in each district.

as not in labour force (NLF). Employment rate falls inducing measurement error. This issue is addressed in the identification concerns section.

Another obvious concern is seasonal variation in rural employment. Rural employment rate can simply capture seasonality if LFS is carried out in the harvesting and sowing season when there is a higher demand for labour. However, seasonality does not pose a challenge in this context. First, LFS is carried out in all districts simultaneously in four distinct quarters. The survey time period for households remains the same across years. The first quarter starts in July and lasts till October in which 10,000 of the total 36,400 households are surveyed each year. Second, using annual data smoothes the peaks and troughs of employment that are induced by seasonality. There are two cropping seasons. "Kharif" and "Rabi". The sowing season of "Kharif" begins in April-June and harvesting during October-December; sowing of "Rabi" begins in October-December and ends in April-May[45]. Therefore, high labour demand in one quarter is followed by a lower one in the next quarter with the cycle repeating itself after 6 months.

TABLE 2. Descriptive Statistics

	Mean	Min	Max	Std Dev	N
Rainfall	37.14	0	193	31.535	1498
Rainfall Deviations from PMD Normals	-2.06	-107	85	13.092	1498
Terrorist Attacks Dummy	0.248	0	1	0.432	1498
No. of Terrorist Attacks	1.735	0	118	7.392	1498
Rural Employment	38.979	12.00	75.1	9.143	1400

Note:The dataset includes 100 districts from four provinces of Pakistan i.e. Punjab, Balochistan, Khyber-Pakhtunkhawa (KPK), Sindh and 7 Tribal Agencies from the Federally Administered Tribal Areas (FATA) from 1997-2010. Labour Force Survey is not carried out in FATA and so rural employment is reported excluding FATA.

The average district in a year has a mean rainfall of 37.14 mm with a standard deviation of 31.535. This suggests that there is sufficient exploitable variation in rainfall. If we look at rainfall deviation from 'Normals' we can see that rainfall has been on average 2.06 mm below the 'Normals'. The standard deviation is 13.1 points. The probability of a terrorist attack on average is 0.248. This shows that an average district in a year in Pakistan experiences a terrorist attack 24.8 percent. The mean number of terrorist attacks in a district-year is approximately 2. The variation in terrorist attacks is potentially sufficient to base this study on Pakistan. An average district has 38.979 percentage points rural employment rate in a year. The variation around that mean is 9.143 percent which again suggest the existence of exploitable variation.

5.3. **OLS Estimation & the need for an IV.** Using OLS I estimate:

$Q^*_{dt} = \varphi_t + \varphi_1 \overline{H}^*_{dt} + \varphi_2 F_{dt} + \tau_{dt}$

Where:

Q^*_{dt}**:** are terrorist attacks in a district d and year t.

[45]Economic Survey of Pakistan 2010 , p.15

$\overline{H}^{*}_{dt}$**:** is district level sample mean at time t from repeated cross sections of rural household employement data from Labour Force Survey i.e.

in the population $\overline{H}^{pop}_{dt} = E(H_{idt}|d)$

or in the sample $\overline{H}_{dt} = \frac{1}{N_d} \sum_{i \in N_d} (H_{idt}|d)$ where $i = \{1, 2, ...N\}$ are households, $d = \{1, 2, ...D\}$ are districts & $t = \{1, 2, ...T\}$ is the time period used in the study with N_d as the population within each district[46].

F_{dt}**:** captures other control variables varying in district t and time t and which might result in a failure of the identifying assumptions (discussed below). They are essentially observed factors that affect charitable donation D^{*t}_{dt}, terrorist labour T^{*}_{dt} or have a direct affect on Q^{*}_{dt}. One example is road access. Consider the case where owing to government policy road access increases. Road access is correlated with violence (Fearon and Laitin (2003)) and also determines terrorist labour recruited (T_{dt}) through inducing changes in access to agrarian markets and relative wages between the terror and agrarian sector. F_{dt} attempts to control for all such observable factors.

φ_t**:** are time fixed effects and captures time trends assumed to be the same for all districts but varying over time. These include macro level policy changes etc.

τ_{dt}**:** is the error term.

φ_1 is the coefficient of interest in an OLS framework and shows what effect a unit change in H^{*}_{dt}, via a unit change in terrorist labour T^{*}_{dt} and religious charitable donations D^{*t}_{dt}, has on terrorist attacks (Q^{*}_{dt}).

5.3.1. *Endogeneity Concerns.* For expositional purposes, partially out the effect of F_{dt}, and assuming $E(\tau_{dt}, F_{dt}) = 0$, the main identifying assumption for φ_1 to capture the causal effect of rural employment on terrorist attacks is :

$E(\tau_{dt}, H_{dt}) = 0$

where:

$\tau_{dt} = \gamma_d + \mu_{dt}$.

τ_{dt}, therefore, includes unobserved, time-invariant heterogeneity γ_d and μ_{dt};

where μ_{dt} according to theory consists of three main factors:

(i) unobserved factors that affect terrorist labour T^{*}_{dt};

(ii) unobserved factors that affect religious donations to terrorist organizations D^{*t}_{dt};

(iii) unobserved factors that affect terrorist attacks Q^{*}_{dt}.

In other words, rural-agrarian employment should potentially be unrelated to district level unobserved heterogeneity, other unobserved factors that affect charitable donations, terrorist labour or unobserved factors that have a direct effect on terrorist attacks. Even if a fixed effects specification is employed, the identifying assumption will potentially be violated and $E(\tau_{dt}, H_{dt}) \neq 0$. Below I discuss some of these.

Omitted Variables Bias:

There can be a host of unobserved factors that can result in endogeneity. One example can be that of proximity to terrorist organizations. It is a potential determining factor of

[46]Where the sample mean is a consistent estimate of the true population mean if $plim_{N_d \to \infty} \overline{H}_{dt} \to \overline{H}^{pop}_{dt}$

terrorist recruitment T^*_{dt}. Having a terrorist organization nearby means that it offers a viable substitute for agrarian employment, in case relative wages between agriculture and terrorist sector fall. It increases the ease of labour supply shift to terror. It also affects the agrarian labour market as increased presence of terrorists potentially implies security concerns and fear of expropriation. This implies a lower investment in legal sectors like agriculture and a lower rural-agrarian employment (H^*_{dt}).

In addition, if with a tighter rural-agrarian labour market, the cost of information for counter-terrorist forces goes up and terror production rises, there would be a direct relationship between unobserved factors that affect Q^*_{dt} and H^*_{dt}, leading to inconsistent results.

Or consider the case where militant charities choose to relocate themselves in areas with a tight labour market so that they could maximize D^{*t}_{dt} and terrorist attacks. This would lead to a correlation between unobserved factors that affect D^{*t}_{dt} and H^*_{dt}.

In the presence of such unobserved factors, a simple OLS of rural-agrarian employment and terrorist attacks will result in inconsistent estimates of φ_1.

Measurement Error:

Apart from omitted variables concern, φ_1 will not capture the causal effect if there is measurement error in the rural-agrarian employment. As rural employment is a pseudo panel generated from district level sample means these can be a noisy signal of true population rural employment at the district level. Another source of measurement error in rural employment H^*_{dt} stems from the fact that it is meant to capture effects on terrorist attacks through either labour supply or financial channel. It is possible that rural-agrarian employment data captures these with error i.e.

$H_{dt} = H^*_{dt} + \nu_{dt}$:
where:

ν_{dt} is classical measurement error including all sources of measurment errors lumped together with $\nu_{dt} \sim N(0, \sigma^2_\nu)$,

$E(\nu_{dt}, H^*_{dt}) = 0$ and $E(\nu_{dt}, \tau_{dt}) = 0$.

With measurement error, using OLS I would in fact be estimating:

$$Q^*_{dt} = \varphi_t + \varphi_1 H_{dt} + \varphi_2 F_{dt} + \Pi_{dt} \quad \text{where}$$

$$\Pi_{dt} = (\tau_{dt} - \varphi_1 \nu_{dt}).$$

In the presence of standard attenuation bias, even if we assume $E(\tau_{dt}, H_{dt}) = 0$, $E(\Pi_{dt}, H_{dt}) \neq 0$ due to $E(\nu_{dt}, H_{dt}) \neq 0$ which leads to inconsistent estimation of φ_1.

Measurement error poses an additional concern. If the unobserved heterogeneity are fixed effects i.e. $E(\gamma_d \mid H_{dt}) \neq E(\gamma_d)$, then under measurement error, using a fixed effects specification to control for district fixed effects, will lead to inconsistent estimates. Apart from standard attenuation bias, there will be an additional fixed effects bias, the direction of which is unknown ex-ante.

Reverse Causation:

An additional identification concern in an OLS framework will be potential reverse causation, especially within the context of Pakistan. Although terror attacks might be a function of equilibrium rural-agrarian employment, it is equally plausible that terrorist attacks lead to deterioration in economic opportunities in the agrarian sector and a fall in rural-agrarian

employment. There is ample evidence within Pakistan that terrorist attacks have had a devastating impact on the economic conditions of the country.

> "Pakistan's economy is under pressure of the War on Terror. (It) has...cost the country..erosions of investment climate, nose diving of production and growing unemployment and above all brought economic activity to a virtual standstill in many part of the country[47]".

Therefore, in an OLS framework it is possible to have $H^*_{dt} = \rho_t + \rho_1 Q^*_{dt} + \rho_2 F_{dt} + \varsigma_{dt}$. Even if we assume $E(\tau_{dt}, \varsigma_{dt}) = 0$, $E(\tau_{dt}, F_{dt}) = 0$ it can be shown that φ_1 will be inconsistent with $E(\tau_{dt}, H_{dt}) = \frac{\rho_1}{1-\rho_1\varphi_1} Var(\tau_{dt})$.

5.4. **Instrumental Variables Estimation & Key Identifying Assumptions.** In order to circumvent endogeneity concerns and to identify a causal effect of rural employment shocks on terrorist attacks, I use rainfall shocks as a source of exogenous variation to rural employment[48] in the structural equation

$Q_{dt} = a_d + a_t + a_1 \overline{H}_{dt} + \upsilon_{dt}$

Where in the population $\overline{H}_{dt} = E(H_{idt}|d)$

or in the sample $\overline{H}_{dt} = \frac{1}{N_d} \sum_{i \in N_d} (H_{idt}|d)$ where $i = \{1, 2, ...N\}$, $d = \{1, 2, ...D\}$ & $t = \{1, 2, ...T\}$

I include district fixed effects due to potential unobserved heterogeneity correlated with rainfall i.e. $E(\Psi_d \mid rainfall_d) \neq E(\Psi_d)$. It is possible that areas with historically less rainfall volatility or better irrigation systems might also be the ones with better institutions mitigating the effects of employment shocks on terrorism. It might also be that areas with more volatile rainfall also have much harsher geographic conditions and so the populace is temperamentally more inclined to violence. District fixed effects control for it.

Apart from that, as $Q_{dt}$is a true panel, there will not be measurement error concerns associated with a_d and $\overline{H}_{dt}$ typical of repeated cross sections (Moffitt (1993), Deaton (1985) and Browning et al. (1985)). Despite that using an instrument for rural employment aids in overcoming this concern (Moffitt(1993)).

One can potentially justify the use of rainfall shocks as an instrument for rural employment in predominantly agricultural economies with little irrigation, like Pakistan.

Referring back to Figure 1 in Section 4, another motivation for using rainfall deviations as an instrument for rural-agrarian employment is that it helps to disentangle agrarian labour supply from labour demand shocks. Rain induced shifts in labour demand, allows the use of variation in rural employment along the aggregate labour supply curve. This is important if it is to be argued that the empirical strategy rests on the structural relationship as outlined in section 4.

Ensuring that the relationship works through the mechanism discussed in the theoretical framework section is also one of the main reasons that I do not simply run a reduced form of

[47]Special Section 1, Economic Survey of Pakistan, 2010-11.

[48]The validity of using rainfall as an instrument has been challenged by Sarsons (2011) using rain-fed and dam-fed districts in India. She investigates riot incidents in districts of India as the main variable of interest measuring violence. There appears to be no detailed discussion of identification checks. The very basic classification of upstream and downstream districts is questionable. There is also the issue of treating all kinds of conflicts are perfect substitutes.

terrorist attacks and rainfall shocks i.e. $Q_{dt} = b_d + b_t + b_1 A_{dt} + \sigma_{dt}$, even though potentially the identifying assumption for $b_1 : E(\sigma_{dt} \mid A_{dt}, b_d) = 0$ holds[49].

I therefore, estimate a two stage least squares using rainfall shocks as an instrument for rural-agrarian employment, using data on 100 districts d in four provinces of Pakistan from $t = 1997 - 2010$:

$H_{dt} = \vartheta_d + \vartheta_t + \vartheta_1 A_{dt} + \Omega_{dt}$: (First Stage)
$Q_{dt} = \alpha_d + \alpha_t + \alpha_1 \widehat{H_{dt}} + \phi_{dt}$: (Second Stage)
Where:
$\widehat{H_{dt}} = \hat{\vartheta}_d + \hat{\vartheta}_t + \hat{\vartheta}_1 A_{dt}$ & under consistent estimation:

$\phi_{dt} = [\upsilon_{dt} + \alpha_1 (H_{dt} - \widehat{H_{dt}})] = \upsilon_{dt} + \alpha_1 \Omega_{dt}$

Where υ_{dt} consists of three main factors:

(i) unobserved factors that affect terrorist labour T^*_{dt};

(ii) unobserved factors that affect religious donations to terrorist organizations D^{*t}_{dt};

(iii) unobserved factors that affect terrorist attacks Q^*_{dt}.

and in the data :

Q_{dt}**:** are terrorist attacks both as a dummy variable which takes on the value of one if there has been a terrorist attack in a district d year t and zero otherwise and a continuous variable, number of attacks in a district d and year t.

H_{dt}**:** is rural-agrarian employment in district d and year t i.e. the percentage of people in a district who are employed.

A_{dt}**:** is the single instrument used to instrument for rural employment and captures rainfall deviation from the 20-30 year average rainfall in district d year t.

ϑ_d, α_d**:** are district fixed effects in the first and second stage. They capture time-invariant district level unobserved heterogeneity, for example, geography, religious or ethno-linguistic fractionalization[50], culture, quality of institutions etc.

ϑ_t, α_t**:** captures year fixed effects in the first and second stage respectively. These control for any macroeconomic trends, for example, national policy or country level business cycles that are same for all districts but vary over years.

ϑ_1**:** in the first stage captures how a $1mm$ above average rainfall shock (A_{dt}) in district d and time t will lead to a change in the percentage of rural-agrarian employment (H_{dt}).

α_1**:** in the second stage is the main coefficient of interest and captures what effect a one percentage point, rainfall-induced, change in rural employment has on terrorist attacks.

Ω_{dt}, ϕ_{dt}: are error terms in the first and the second stage.

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[49]Substituting the first stage into the structural equation $Q_{dt} = a_d + a_t + a_1 H_{dt} + \upsilon_{dt}$, we can arrive at a reduced form:

$Q_{dt} = a_d + a_t + a_1(\vartheta_d + \vartheta_t + \vartheta_1 A_{dt} + \Omega_{dt}) + \upsilon_{dt}$:
$Q_{dt} = \Theta_d + \Theta_t + \Theta_1 A_{dt} + \Upsilon_{dt}$:
where: $\Theta_d = a_d + a_1\vartheta_d$; $\Theta_t = a_t + a_1\vartheta_t$; $\Theta_1 = a_1\vartheta_1$; $\Upsilon_{dt} = a_1\Omega_{dt} + \upsilon_{dt}$ where $\upsilon_{dt} = \beta_2 \varsigma_{dt} + \beta_1 \omega_{dt} + \varepsilon_{dt}$
Under fixed effects, consistently estimating the coefficient of interest $\Theta_1$requires $E(\Upsilon_{dt} \mid A_{dt}, F_{dt}, \Theta_d) = 0$

[50]Ethno-linguistic fractionalization is potentially a slow moving variable in Pakistan. According to the 1998 Population Census the ethno-linguistic fractionalization in Pakistan is as follows: 73.9 percent speak Pushto in KPK, 99.1 percent speak Pushto in FATA, 79.74 percent speak Punjabi and Urdu in Punjab, 80.78 percent speak Urdu and Sindhi in Sindh and 84.4 percent speak Pushto and Balochi in Balochistan. In 1981 the picture was approximately the same.

Within the context of Pakistan, using the aforementioned instrumental variables estimation, I find that there is a positive relationship between exogenous rainfall shocks induced rural employment and terrorist attacks i.e. $\alpha_1 > 0$. Referring back to the mechanism through which rural employment effects terrorist attacks, results suggest that relatively finance is more of a significant determinant of terrorism than labour supply. The results remain robust in various specifications including additional controls and changes in composition of the sample.

5.4.1. *Key Identifying Assumptions.* The identifying assumption for α_1 to capture the causal effect are:

(1) *Instrumental Relevance or Rank Condition*: The rank condition states that the matrix $E(H'_{dt}A_{dt})$ is of full column rank i.e. if H_{dt} is $NT \times K$ and A_{dt} is $NT \times L$ then the rank of $E(H'_{dt}A_{dt})$ is $K = 1$. In other words, the instrument is relevant, $E(H_{dt}, A_{dt}) \neq 0$ or $\vartheta_1 \neq 0$ and that there is sufficient correlation between the rainfall shocks and rural-agrarian employment in district d and year t in Pakistan.

(2) *Order Condition:* The necessary (not sufficient) order condition is $L \geq K$. In this context, as the model is exactly identified i.e. $L = K = 1$, the order condition is trivially satisfied.

(3) As I control for district and year fixed effects, identification rests on the usage of within district-year variation in data i.e. rain shocks causes within-district and within-year rural employment and subsequent terrorist attacks changes. As α_1 potentially captures local average treatment effect (LATE) the following must hold:
   (a) *Independence:* Conditional on fixed effects, the rainfall instrument A_{dt} is as good as randomly assigned $[\{Q_{dt}(H_{dt}, A_{dt}); \forall H_{dt}, A_{dt}\}, H_{dt}] \perp A_{dt} \mid \alpha_d$ i.e. all expectations involving functions of $[\{Q_{dt}(H_{dt}, A_{dt}); \forall H_{dt}, A_{dt}\}, H_{dt}]$ conditional on α_d, do not depend on A_{dt}.
   (b) *Exclusion Restriction*: While the independence assumption claims random assignment of rainfall, the exclusion restriction assumes that the unique channel for the causal effect of rainfall on terrorist attacks is rural employment. In the presence of potential fixed effects the exclusion restriction will be stronger than uncorrelatedness. It will require strict exogeneity i.e.$E(\phi_{dt} \mid A_{dt}, \alpha_d) = 0, t = 1997 - 2010$ or $\{A_{dt} : t = 1997, ...2010\}$ is strictly exogenous, conditional on the unobserved effect α_d, where with fixed effects $E(\alpha_d \mid A_d)$ is allowed to be any function of A_d. This implies that the exclusion restriction holds if, conditional on fixed effects, within district-year rainfall shocks are mean independent of:
      (i) Unobserved factors that directly affect rural-agricultural employment (H_{dt}) and terrorist attacks (Q_{dt});
      (ii) Unobserved factors that affect both terrorist labour employed (T^*_{dt}) and terrorist attacks (Q_{dt});
      (iii) Unobserved factors that affect both religious charitable donations (D^{*t}_{dt}) terrorist attacks (Q_{dt});
      (iv) Unobserved factors that directly affect terrorist attacks (Q_{dt}).

   In other words, conditional on fixed effects, ϕ_{dt} is uncorrelated with *any* function of A_{dt} and in particular ϕ_{dt} is uncorrelated with each of A_{dt} in all time periods: past, present and future.

(4) *Monotonicity:* The relationship between rainfall and rural employment is positive in the data. Monotonicity in this context requires that with a rainfall deviation of $1mm$

above its 20-30 year average, rural-agrarian employment should be at least as big as that without this increase i.e. with probability 1, with a rainfall shock A_{dt} in a district d and time t $H_{dt} - H_{dt-1} \geqslant 0$ for each district (Imbens & Angrist (1994)).

(5) *Mean Independence of Measurement Error i.e.* $E(\nu_{dt} \mid A_{dt,}, \alpha_d) = 0$: Conditional on fixed effects, measurement error ν_{dt} (discussed in Section 5.3.1) is assumed to be mean independent of rainfall shocks in district d and year t.

In Section 7 I attempt to address identification concerns resulting from a violation of any of the aforementioned identifying assumptions in detail. The assumption in a fixed effects scenario is that the causal channels works at a within district-year level. Despite low inter-district migration rates (appendix A6) and positively correlated cross-district rainfall shocks (appendix A7(i), figure A1), this is a strong identifying assumption of the study. I carry out a robustness check of this additional assumption in Section 7.3.

5.5. **Relationship between Rainfall, Rural Employment, 'Zakat' and Terrorist Attacks.** It would have been most useful to have district wise granular household level data on 'Zakat' paid to religious private organizations, relatives, other NGOs or government. Analysing the relationship of particular types of 'Zakat' paid out with rural employment, rainfall shocks and violence would have added richness to the analysis and could have been used to isolate the mechanism in a more direct way. However, in the absence of such a granular dataset, in order to shed some light on the claimed underlying relationship between rural employment, rainfall, terrorist attacks and 'Zakat', I compiled rural household 'Zakat' data (both public and private sector) from the Household Integrated Economic Survey (HIES), which is a repeated cross section for five waves i.e. 1998, 2001, 2005, 2007 and 2010[51].

Details of Rural 'Zakat' *Data Compilation:*

The universe of HIES Survey consists of all urban and rural areas of all four provinces as defined by the Provincial Governments. Military restricted areas are excluded from the scope of the survey. With regard to the rural areas, the lists of villages/mouzas/dehs according to population Census, 1998 are used as sampling frame. There are 50,588 mouzas/villages/dehs in the rural sub-universe of the survey[52]. In the rural areas, the population of each district in Punjab, Sindh and N.W.F.P Provinces has been grouped together to constitute a stratum. For Balochistan province each of administrative Division has been taken as a stratum. For Balochistan I ascribe data for a division to each district within that division. Mouzas/dehs/villages in rural domain have been taken as Primary Sampling Units (PSUs).Households within each sample Primary Sampling Unit (PSU) have been considered as Secondary Sampling Unit (SSU). 16 and 12 households have been selected from each sample village and enumeration block respectively by random systematic sampling scheme with a random start[53].

The 1998 HIES had a sample size of 2268 households as secondary sampling units (SSU). In 2001 the sample size was increased to 16,400 rural households. The 2004-05 HIES was

[51]In 1998-99, HIES was integrated into the Pakistan Integrated Household Survey (PIHS). After this HIES was conducted as an Integrated Survey with PIHS in 2001-02. In 2004, 2005, 2007 and 2010 HIES was conducted as an integrated part of PSLM. 'Zakat' related data is not available for 2004.

[52]Pakistan Bureau of Statistics various HIES/PSLM/PIHS reports. Accessed at: http://www.pbs.gov.pk/content/pakistan-social-and-living-standards-measurement

[53]Pakistan Bureau of Statistics various HIES/PSLM/PIHS reports. Accessed at: http://www.pbs.gov.pk/content/pakistan-social-and-living-standards-measurement

conducted as part of first round of PSLM Survey covering 14708 households. The 2007 HIES has been carried out covering 15453 households. The 2010 HIES was conducted covering 16341 households[54].
The weighted response to the following HIES questions was used to compile data on rural 'Zakat' paid out (to the public and private sector) for the years 1998, 2001, 2005, 2007 and 2010[55]**:**

Part B: 'Zakat' Paid

1. "During the last 1 Year, did any member of the HH pay out to others , in cash or in kind?

Amount paid (in 'Zakat' & usher cash or in kind)[56]

a) Paid to public Sector (Federal/Provincial/District/Semi government)

b) Paid to private sector (Relatives/non-relatives, NGO/Trust etc)[57]"

If yes, give amount(Rs) in Q-2 otherwise tick non box."

2. "Total Amount paid in the Last 1 Year (Rs.)"

Certain data related concerns need to be highlighted. First of all this is stated 'Zakat' and might in fact vary from actual 'Zakat'. For instance, some households sometimes don't reveal the amount of 'Zakat' actually given as they find it to be a mark impiety. On the other hand, some households might actually overstate the amount of 'Zakat' paid out. Apart from a desire to over or understate the amount of 'Zakat' there is also a natural recall bias that needs to be kept in mind[58].

Appendix Table 11 gives the descriptive statistics of rural household 'Zakat' paid and received. Mean total 'Zakat' recieved in a given year by rural households is less than mean total 'Zakat' paid out suggesting potential inefficiency in the system or some 'Zakat' leaking out of the system. In addition, mean household 'Zakat' received by households from public sector is greater than 'Zakat' received from private sector. This trend is reversed in 'Zakat' paid out. A mean household 'Zakat' of Rs. 5 is paid to public sector versus a mean household 'Zakat' of Rs. 195 to the private sector.

What would have been interesting to test the underlying relationships espoused by the paper would have been an estimation of the following structural equation:

$Q_{dt} = \lambda_d + \lambda_t + \lambda_1 \overline{H}_{dt} + \lambda_2 Zakat + \Omega_{dt}$:

For expositional purposes, I refer back to Eq (1), (2) and (3) in Section 5.1. i.e.

$Q^*_{dt} = \beta_0 + \beta_1 D^{*t}_{dt} + \beta_2 T^*_{dt} + \mu_{dt}$.....(1)

[54]ibid.

[55]Prior to 1998-99, the data of HIES surveys was collected by male enumerators. From the year 1998-99 onwards the income and consumption data of the HIES was collected by adopting team approach comprising of both male and female enumerators. However, 'Zakat' questions are only asked of male interviewees by male interviewers in 1998, 2001, 2005 and 2007.

[56]Note: if any income in cash or kind paid then written against each source

[57]In 2001, the public-private sector bifurcation is not available. In addition, 2001 'Zakat' paid also includes nazrana/'Zakat'/usher.

[58]Another data related concern is that the reference period used is the past one year. A household surveyed in the beginning of the year will be reporting their 'Zakat' in the past year. The data becomes close to accurate as the survey progresses through the year.

$D^{*t}_{dt} = \upsilon + \upsilon_1 H^*_{dt} + \varepsilon_{dt}$.....(2)

$T^*_{dt} = \lambda_0 + \lambda_1 H^*_{dt} + \eta_{dt}$.....(3)

Where:

Q^*_{dt}**:** are terrorist attacks in a district d and year t.

D^{*t}_{dt}**:** are religious charitable donations or 'Zakat' that flows to terrorist organizations in district d and year t.

T^*_{dt}**:** is terrorist labour employed in district d and year t

$\mu_{dt}, \varepsilon_{dt}, \eta_{dt}$**:** are the error terms, which include unoberved heterogeneity.

Using Eq (3) in (1) we get

$Q^*_{dt} = [\beta_0 + \beta_2\lambda_0] + \beta_1 D^{*t}_{dt} + \beta_2\lambda_1 H^*_{dt} + [\beta_2\eta_{dt} + \mu_{dt}]$.....(5)

'Zakat'paid to the private sector Z^*_{dt} from the HIES data could have been used as a proxy for D^{*t}_{dt} in Eq (5), under the standard assumptions[59].

Assuming a linear relationship between Z^*_{dt} and D^{*t}_{dt}:

$D^{*t}_{dt} = \alpha_0 + \alpha_1 Z^*_{dt} + \xi_{dt}$.....(6)

Using (6) in (5) above I would have estimated:

$Q^*_{dt} = [\beta_0 + \beta_2\lambda_0 + \beta_1\alpha_0] + \beta_1\alpha_1 Z^*_{dt} + \beta_2\lambda_1 H^*_{dt} + [\beta_2\eta_{dt} + \mu_{dt} + \beta_1\xi_{dt}]$.....(7)

Including district and time fixed effects:

$Q_{dt} = \phi_d + \phi_t + \phi_1 H^*_{dt} + \phi_2 Z^*_{dt} + \omega_{dt}$.....(7)

Where the main identifying assumption would be

$E(\omega_{dt}|Z^*_{dt}, H^*_{dt}, \phi_d) = 0$ or

$E(\beta_2\eta_{dt} + \mu_{dt} + \beta_1\xi_{dt} \mid Z^*_{dt}, H^*_{dt}, \phi_d) = 0$

The expected sign of the coefficients are: $\phi_1 < 0$ and $\phi_2 > 0$. In the absence of exogenous variation in 'Zakat' paid to the private sector Z^*_{dt} any estimation that includes Z^*_{dt} will suffer from endogeneity. In addititon there is the added constraint that 'Zakat' data is only available in the HIES for five years. This potentially means a very small sample size of approximately 500 district-year observations. Such a small sample size suggests that any attempt at an instrumental variables specification too will suffer from finite sample bias.

Despite these limitatons, in order to get a sense of the underlying relationship between rural household 'Zakat' and rural household employment, I present simple correlational results. To this end I compiled data on both rural household 'Zakat' and rural household level employment from HIES for 1998, 2001, 2005, 2007 and 2010 to see whether the relationship is in fact positive. The definition of employment and question used to compile rural household level employment data is the same as Labour Force Survey.

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(1) $E(Q^*_{dt} \mid D^{*t}_{dt}, H^*_{dt}, Z^*_{dt}) = E(Q^*_{dt} \mid D^{*t}_{dt}, H^*_{dt})$ or that Z^*_{dt} is redundant (ignorable) in Eq (5) or is irrelevant for explaining Q^*_{dt}, in a conditional mean sense, once D^{*t}_{dt}, H^*_{dt} have been controlled for.

(2) The correlation between D^{*t}_{dt} and each H^*_{dt} is zero once Z^*_{dt} is partialled out or in a linear projection: $L(D^{*t}_{dt} \mid 1, H^*_{dt}, Z^*_{dt}) = L(D^{*t}_{dt} \mid 1, Z^*_{dt})\ \forall d$

Table 3 shows the correlation of rural household employment and rural household 'Zakat' paid out for 5 years in the four provinces of Pakistan. The results suggest that as a rural household member becomes employed 'Zakat' paid to the private sector goes up by approximately Rs. 45. The magnitude of the effect falls to approximately Rs.3 when 'Zakat' paid to the government 'Zakat' department is considered. Therefore, on average, the private sector within Pakistan receives 15 times the amount of 'Zakat' that the government would receive on employment of a household member. Table 3, specification (3) suggests that at the margin, employment is correlated with an increase in total household 'Zakat' of approximately Rs. 57.

TABLE 3. Household Level OLS Regressions of Rural Employment and Rural Zakat

	Zakat Paid Pvt.	Zakat Paid Govt.	Zakat Paid Total
	(1)	(2)	(3)
Rural Employment	44.899**	3.278*	56.95***
	(23.47)	(2.04)	(19.52)
Observations	124,072	124,072	203,969
Time Fixed Effects	Yes	Yes	Yes

Clustered standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Rural employment is a dummy variable that turns on one if a 10 year and above member of the household is employed within the reference period and zero otherwise. Data is compiled from HIES for 1998, 2001, 2005, 2007 and 2010 of the four provinces of Pakistan i.e. Punjab, Balochistan, Khyber-Pakhtunkhawa (KPK), Sindh. Rural household Zakat is stated zakat compiled from Household Integrated Economic Survey (HIES) of four provinces of Pakistan i.e. Punjab, Balochistan, Khyber-Pakhtunkhawa (KPK), Sindh for 1998, 2001, 2005, 2007 and 2010. Error terms are assumed to be correlated over time within a district. All specifications include time dummies.

HIES is only nationally and provincially representative at the 95% level of confidence with 5% to 7% margin of error[60], however, just to get an idea of how 'Zakat' varied with rainfall and terrorist attacks, district level 'Zakat' estimates were also compiled. District level estimates are compiled by taking a weighted sum of the total household 'Zakat' in the district[61]. In this case too as Q_{dt} is a true panel, there will not be measurement error concerns associated with a_d and $\overline{H}_{dt}$ typical of repeated cross sections (Moffitt (1993), Deaton (1985) and Browning et al. (1985)).

Table 4 shows that rainfall shocks are positively correlated with 'Zakat' paid to the private sector. The relation strengthens when within district-year variation is used in a fixed effects scenario. Using variation across districts in a simple OLS setting specifications (2) and (3) suggest that there is no correlation of 'Zakat' paid to private sector and terrorist attacks; a result, which in the presence of standard attenuation bias is close to the simple OLS results of rural employment and terrorist attacks. The fixed effect results, with measurement error in 'Zakat', are not very informative. Results suggest that using a within-district variation the

[60]Pakistan Bureau of Statistics various HIES/PSLM/PIHS reports.

[61] Each query was weighted according to the population weights of each primary sampling unit. These are based on the population list of villages from the 1998 Population Census.

relationship between 'Zakat' paid and terrorist attacks is significant and positive. Although the magnitude of the effect is not large. The mean amount of 'Zakat' paid to the private sector explains around 0.03 percentage points variation in mean terrorist attacks both as a dummy variable and as number of terrorist attacks.

TABLE 4. District Level OLS and FE Regressions of Zakat, Rainfall Shocks and Terrorist Attacks

	Zakat Paid Pvt. (OLS) (1)	Terrorist Attacks Dummy (OLS) (2)	No. of Terrorist Attacks (OLS) (3)	Zakat Paid Pvt. (FE) (4)	Terrorist Attacks Dummy (FE) 5	No. of Terrorist Attacks (FE) (6)
Rainfall Deviations from Normals	977.56*** (302.18)			1602.43*** (397.8207)		
Zakat Paid Pvt.		2.02e-07 (2.02e-07)	1.13e-06 (1.40e-06)		4.06e-07* (2.33e-07)	2.95e-06* (1.75e-06)
Observations	494	494	494	494	494	494
District Fixed Effects	No	No	No	Yes	Yes	Yes
Time Fixed Effects	No	No	No	Yes	Yes	Yes

Clustered standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Rural Zakat pvt. is stated zakat paid to the private sector per 1000 households. Data is compiled from Household Integrated Economic Survey (HIES) of four provinces of Pakistan i.e. Punjab, Balochistan, Khyber-Pakhtunkhawa (KPK), Sindh for 1998, 2001, 2005, 2007 and 2010. Data is compiled by taking a weighted sum of household zakat at a district level and then normalizing by population estimates. Terrorist Attacks dummy takes on a value of one if there is a terrorist attack within a district in a year and zero otherwise in the four provinces of Pakistan i.e. Punjab, Balochistan, Khyber-Pakhtunkhawa (KPK), Sindh for 1998, 2001, 2005, 2007 and 2010. The continuous variable, number of terrorist attacks, captures the number of attacks in a district within a year in the four provinces of Pakistan i.e. Punjab, Balochistan, Khyber-Pakhtunkhawa (KPK), Sindh for 1998, 2001, 2005, 2007 and 2010. Terrorism data is compiled from Global Terrorism Database of the University of Maryland. Error terms are assumed to be correlated over time within a district.

In view of obvious endogeneity concerns, I reiterate that caution should be exercised in reading too much in these results. However, despite these cavaets, in the absence of district level - country wide exogenous 'Zakat' variation these provides a useful insight.

6. RESULTS

6.1. **OLS Estimation**[62]**.** Specification 1 and 2 in Table 5 use the underlying relationships outlined in Section 5.3. OLS results suggest that there is no relation between rural employment rate changes and the binary and a continuous variable of terrorist attacks. As discussed, the lack of a significant effect can be due to potential measurement error in rural employment. In both specifications, I include time trends. I also include additional covariates which can potentially cause endogeneity in an OLS framework. For instance, a district with greater amount of additional agricultural inputs will have a greater agricultural productivity and hence a higher rural employment. Such a high investment district offers terrorists a soft target which sends a bigger signal of terror.

The coefficient potentially does not capture the causal effect of a percentage change in rural-agrarian employment on terrorist attacks due to other omitted variables, reverse causality

[62]See Appendix Table 12 for a fixed effects specification with controls. The coefficient remains insignificant. Owing to the presence of measurement error in rural employment the fixed effects specification is not informative and so not given much weight.

or measurement error. I next discuss the instrumental variables estimation strategy that attempts to overcome these concerns.

TABLE 5. OLS Regression of Rural Employment and Terrorist Attacks with controls

	Terrorist Attacks Dummy (1) OLS	No. of Terrorist Attacks (2) OLS
Rural Employment	0.0008	0.0164
	(0.0019)	(0.0245)
Observations	1344	1344
Districts	96	96
Time Fixed Effect	Yes	Yes

Clustered standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
The legal labour market measure is rural employment in districts of Pakistan as a percentage of total unemployed and employed population. Terrorist Attacks dummy takes on a value of one if there is a terrorist attack within a district in a year and zero otherwise. The continuous variable, number of terrorist attacks, captures the number of attacks in a district within a year. The original dataset includes 100 districts of four provinces of Pakistan i.e. Punjab, KPK, Sindh and Balochistan from 1997-2010. Error terms are assumed to be correlated over time within a district. All specifications include district level quantity of fish produced, total registered factories, mineral production, forest area and livestock slaughtered, rural inter-district migration rate, population estimates, rural population married estimates, fertilizer consumed, agricultural electricity consumers, irrigated and cropped area and total low quality road kilometers.

6.2. **Instrumental Variables Estimation.** Table 6 shows results using an instrumental variables specification as outlined in Section 5.4. The model is exactly identified. I instrument for rural employment using rainfall deviation from 20-30 year PMD 'Normals'. Results in the first stage suggest that a 1 mm above PMD 'Normals' rainfall leads to a 0.05 percentage point increase in rural employment. Mean rainfall deviation from 1997-2010 has been -2.06 and the rural-agriculture sector is rain dependent, fraught with drought and water shortage. There have been droughts in Pakistan from 1998-2002, 2004-05 and middle of 2009 to 2010[63]. Thus, it appears logical that a positive rainfall deviation leads to an increase in rural-agricultural employment.

The Angrist-Pischke (AP) F-test of excluded instrument or equivalently the Kleibergen-Paap (KP) Wald rk F Stat is 13.04 with a p-value of 0.0005. Staiger and Stocks (1997) recommend declaring instruments to be weak if the first stage F-Statistic is less than 10. Stock and Yogo (2005) provide a formal testing interpretation of the Staiger-Stock (1997) rule of thumb and validate it for use in the case of one instrument. The F-Stat of 13.04, therefore, suggests that there is evidence against a weak instrument problem.

The second stage in Table 6 shows that a one percentage point increase in rural employment results in an increase in the probability of a terrorist attack of 8.09 percentage points and an an increase in the number of terrorist attacks by 0.5697. This implies that changes in rural employment at a within district and year level potentially accounts for approximately 33 percentage points of the mean terrorist attacks probability of 0.248. If the mean number of terrorist attacks is 1.74 then this means that a one percentage point increase in rural employment can account for approximately 33 percentage points of the mean number of

[63]'History of drought in Pakistan', Pakistan Weather Portal, 2011

attacks. The positive and significant result in the IV estimation, with an insignificant OLS, suggests the presence of an attenuation bias in the rural employment measure.

I also report Anderson and Rubin (1949) Wald test which is robust to the presence of weak instruments and seem to have the correct size under a wide variety of violations of the standard assumptions of IV regression (Stock and Yogo (2005)). The Wald test rejects the hypothesis that the coefficient of interest does not enter the reduced form regression. Results are consistent with finance rather than the labour supply as the relative dominant channel through which rural employment effects terror production.

If exogeneity of rural employment holds then OLS is not only consistently estimated but is also more efficient than the instrumental variables estimated coefficient. I carry out the robust to non i.i.d. standard errors, version of the Durbin-Wu-Hausman test of endogeneity of rural employment. I reject the null that the OLS estimator is consistent and efficient. The Chi-sq (1) p-value is nearly zero and 0.0089 using the dummy variable of attacks and the continuous variable of terrorist attacks respectively. Therefore, the loss of efficiency from using an instrumental variables estimation strategy is a worthwhile cost for consistency.

TABLE 6. IV Regressions of Rural Employment and Terrorist Attacks without controls

	Terrorist Attack Dummy	No. of Terrorist Attacks
Panel B: Second Stage	(1)	(2)
Rural Employment	0.0809***	0.5697**
	(0.0289)	(0.2514)
Anderson-Rubin	17.54	6.27
Wald Test	(p-value 0.0001)	(p-value 0.0139)
	Rural Employment	Rural Employment
Panel A: First Stage	(1)	(2)
Rainfall Deviation	0.04557***	0.04557***
from PMD Normals	(0.0126)	(0.0126)
AP/KP F-Stat	13.04	13.04
Wald Test	(p-value 0.0005)	(p-value 0.0005)
Observations	1400	1400
Districts	100	100
District Fixed Effects	Yes	Yes
Time Fixed Effects	Yes	Yes
Endogeneity Test	17.438	6.834
of Rural Emp	(p-value 0.0000)	(p-value 0.0089)

Clustered standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
The legal labour market measure is rural employment in districts of Pakistan as a percentage of total unemployed and employed population. The model is just-identified and the single instrument is rainfall deviation from the PMD Normals or the 20-30 year average for each district from 1997-2010. Terrorist Attacks dummy takes on a value of one if there is a terrorist attack within a district in a year and zero otherwise. The continuous variable, number of terrorist attacks, captures the number of attacks in a district within a year. The original dataset includes 100 districts of four provinces of Pakistan i.e. Punjab, KPK, Sindh and Balochistan from 1997-2010. Error terms are taken to be correlated over time within a district. Panel A and B report first and second stage results respectively.

7. Identification Concerns & Robustness Checks

The validity of the instrumental variables estimation strategy rests on the identifying assumptions discussed in Section 5.4.1. I discuss potential identification concerns and attempt to substantiate these assumptions further. Details of all additional controls with their data

source, level of disaggregation and descriptive statistics is provided at appendix Table A1 and Table 10[64]. Overall I find that results remain robust, positive and consistent with finance rather than the labour supply as the relative dominant channel through which rural employment effects terror production in districts of Pakistan.

7.1. **Rural Employment- Measurement Error Concerns.**

TABLE 7. Measurement Error Concerns-IV Regressions of Rural Employment and Terrorist Attacks with additional controls

	Terrorist Atks Dummy	No. of Terrorist Atks	Terrorist Atks Dummy	No. of Terrorist Atks	Terrorist Atks Dummy	No. of Terrorist Atks
Panel B: Second Stage	(1)	(2)	(3)	(4)	(5)	(6)
Rural Employment	0.0809***	0.5697**	0.0806***	0.5659**	0.0768***	0.4590**
	(0.0289)	(0.2514)	(0.0305)	(0.2627)	(0.0321)	(0.2766)
Anderson-Rubin Wald Test	17.54 (p-value 0.0001)	6.27 (p-value 0.0139)	16.77 (p-value 0.0001)	5.86 (p-value 0.0174)	13.10 (p-value 0.0005)	3.24 (p-value 0.0750)
	Rural Emp	Rural Emp	Rural Emp	Rural Emp	Rural Emp	Rural Emp
Panel A: First Stage	(1)	(2)	(3)	(4)	(5)	(6)
Rainfall Deviation from PMD Normals	0.04557***	0.04557***	0.0443***	0.0443***	0.0406***	0.0406***
	(0.0126)	(0.0126)	(0.0132)	(0.0132)	(0.0132)	(0.0132)
AP/KP F-Stat	13.04 (p-value 0.0005)	13.04 (p-value 0.0005)	11.32 (p-value 0.0011)	11.32 (p-value 0.0011)	9.53 (p-value 0.0027)	9.53 (p-value 0.0027)
Observations	1400	1400	1344	1344	1344	1344
Districts	100	100	95	95	95	95
District Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Clustered standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
The legal labour market measure is rural employment in districts of Pakistan as a percentage of total unemployed and employed population. The model is just-identified and the single instrument is rainfall deviation from the PMD Normals or the 20-30 year average for each district from 1997-2010. Terrorist Attacks dummy takes on a value of one if there is a terrorist attack within a district in a year and zero otherwise. The continuous variable, number of terrorist attacks, captures the number of attacks in a district within a year. The original dataset includes 100 districts of four provinces of Pakistan i.e. Punjab, KPK, Sindh and Balochistan from 1997-2010. Error terms are assumed to be correlated over time within a district. Panel A and B report first and second stage results respectively. Specification (1) and (2) include no controls. Specification (3) and (4) includes district level quantity of fish produced, total registered factories, mineral production, forest area and livestock slaughtered. Specification (5) and (6) add rural inter-district migration rate, population estimates and the percentage of rural population married.

There are two sources of measurement error. First, rural employment rate is a noisy measure of the effect of labour supply and religious charitable donations on terrorism. Second, it measures actual district level rural employment with error. Although the use of an instrument aids identification, however, endogeneity would result if both sources of measurement error, lumped together in ν_{dt}, are not mean independent of within-district year rainfall shocks $E(\nu_{dt} \mid A_{dt}, \alpha_d) \neq 0$. Conditional on fixed effects, with mean independence, measurement error in all time periods and of all functional forms is to be independent of rainfall.

One case, where rural employment might not capture the two channels of labour supply and finance, is that of occupations other than rural-agrarian employment. For instance if a district experienced a negative rainfall shock in time t, it is possible that individuals subsequently

[64]Missing data on all the additional controls was linearly interpolated in the same way as the main variables.

switch from agriculture to not just terrorism but other occupations as well, resulting in a greater number of equilibrium competing occupations in district d in time period t+1. It will effect both the labour supply and religious donations to terrorism. I, therefore include occupations that are substitutes for agriculture i.e. district level quantity of fish produced, total registered factories, mineral production, forest area and livestock slaughtered in the main specification[65].
With additional controls I estimate:

$H_{dt} = \vartheta_d + \vartheta_t + \vartheta_1 A_{dt} + \vartheta_2 F_{dt} + \Omega_{dt}$ (First Stage)

$Q_{dt} = \alpha_d + \alpha_t + \alpha_1 \widehat{H_{dt}} + \alpha_2 F_{dt} + \phi_{dt}$ (Second Stage)

where F_{dt} includes these control variables. The main identifying assumption under measurement error is $E(\nu_{dt} \mid A_{dt,}, F_{dt}, \alpha_d) = 0$.

Table 7, specifications (3) and (4) report results including other occupations. Results remain robust and consistent with finance rather than the labour supply as the relative dominant channel through which rural employment effects terror production. A one percentage point increase in rural employment leads to an increase in the probability of a terrorist attack of 0.0806 and an increase in the number of terrorist attack by 0.5659. In the first stage, reported in panel A, specification (3) and (4), rainfall deviations enter significantly. The AP/KP F Stat report a value of 11.32 which suggests that there does not appear to be a weak instrument problem. The Anderson-Rubin Wald test rejects the hypothesis that the coefficient of interest does not enter the reduced form regression at a one and five percent significance level, which suggests confidence in the identification strategy.

Another concern can be rain induced fertility changes in the population. For instance, if with above average rainfall at a within district-year level, a greater proportion of the district's population self selects into producing children in time period t or t+1. This implies an increase in the proportion of people not looking for work (NLF). If those that leave the labour force were employed, it would induce measurement error that will not be mean independent of rainfall shocks at a within district-year level. Such a high frequency relationship between NLF changes and rainfall shocks seems less likely[66]. However, in order to control for measurement error from rain induced fertility changes I include district level population estimates and percentage of rural population married in specification (5) and (6) in Table 7.

Migration can be another concern. For instance, if a positive rainfall shock attracts a lot of migrants within the district, the rural employment or unemployment rate can go up, leading to measurement error in rural employment rate. This, however, appears to be less of a concern in the context of this study. First, inter-district migration rates of the rural population are low (see appendix A6). Second, rainfall patterns are positively correlated across districts at least within the four main provinces (see appendix A7 (i) Figure 1, for the isohyetal map of Pakistan). So if a district experiences a positive rainfall shock, it seems highly unlikely that a neighbouring district will experience a negative rainfall shock. However, one can still

[65]Occupations that might be substitutes for agricultural, potentially do not include high end occupations like managerial positions etc. due to large skill gap between these and agriculture. Labour Force Survey and Pakistan Mauza Statistics 2008 describe these as other occupations at the rural level in Pakistan.

[66]An advantage of using $RuralEmploymentRate = \frac{T.EmployedPopulation}{CurrentlyActivePopulation(E+U)+NLF(10yrs\&above)}$ is that any shift of individuals between unemployment and not in labour force (10 years and above) does not effect the rural employment rate. If at any time unemployed people stop looking for work then they switch from being unemployed to being categorized as not in labour force (NLF), unemployment falls, NLF goes up, however, the rural employment rate remains unchanged.

argue that on a relative scale districts might experience more of a positive rainfall shock than their neighbouring districts. I, therefore, include inter-district migration rate of the rural population in specification (5) and (6) in Table 7[67]

Table 7, specifications (5) and (6) suggest that a one percentage point increase in rural employment leads to an increase in the probability of a terrorist attack of 0.0768 and an increase in the number of terrorist attack of 0.4590. In the first stage, in panel A, rainfall deviations enter significantly and the AP/KP F Stat report a value of approximately 10 which suggests that there does not appear to be a weak instrument problem. The Anderson-Rubin Wald test rejects the hypothesis that the coefficient of interest does not enter the reduced form regression at a one percent significance level in the case of probability of terrorist attacks and a ten percent significance level in the case of number of terrorist attacks.

7.2. **Additional Identification Concerns.**

TABLE 8. IV Regressions of Rural Employment and Terrorist Attacks with additional controls

	Terrorist Atks Dummy	No. of Terrorist Atks	Terrorist Atks Dummy	No. of Terrorist Atks	Terrorist Atks Dummy	No. of Terrorist Atks
Panel B: Second Stage	(1)	(2)	(3)	(4)	(5)	(6)
Rural Employment	0.0768***	0.4590**	0.0775***	0.5551**	0.0743***	0.5430**
	(0.0321)	(0.2766)	(0.0325)	(0.3096)	(0.0316)	(0.3044)
Anderson-Rubin	13.10	3.24	12.87	4.06	12.25	4.06
Wald Test	(p-value	(p-value	(p-value	(p-value	(p-value	(p-value
	0.0005)	0.0750)	0.0005)	0.0467)	0.0007)	0.0468)
	Rural Emp	Rural Emp	Rural Emp	Rural Emp	Rural Emp	Rural Emp
Panel A: First Stage	(1)	(2)	(3)	(4)	(5)	(6)
Rainfall Deviation	0.0406***	0.0406***	0.0423***	0.0423***	0.0429***	0.0429***
from PMD Normals	(0.0132)	(0.0132)	(0.0137)	(0.0137)	(0.0139)	(0.0139)
AP/KP F-Stat	9.53	9.53	9.58	9.58	9.49	9.49
	(p-value	(p-value	(p-value	(p-value	(p-value	(p-value
	0.0027)	0.0027)	0.0026)	0.0026)	0.0027)	0.0027)
Observations	1344	1344	1344	1344	1344	1344
Districts	95	95	95	95	95	95
District Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Clustered standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
The legal labour market measure is rural employment in districts of Pakistan as a percentage of total unemployed and employed population. The model is just-identified and the single instrument is rainfall deviation from the PMD Normals or the 20-30 year average for each district from 1997-2010. Terrorist Attacks dummy takes on a value of one if there is a terrorist attack within a district in a year and zero otherwise. The continuous variable, number of terrorist attacks, captures the number of attacks in a district within a year. The original dataset includes 100 districts of four provinces of Pakistan i.e. Punjab, KPK, Sindh and Balochistan from 1997-2010. Error terms are assumed to be correlated over time within a district. Panel A and B report first and second stage results respectively. Specifications (1) and (2) reproduce specifications (5) and (6) of the previous table and includes district level quantity of fish produced, total registered factories, mineral production, forest area, livestock slaughtered, rural inter-district migration rate, population estimates and population married estimates. Specifications (3) and (4) further includes fertilizer consumed, agricultural electricity consumers, irrigated and cropped area and specifications (5) and (6) adds total low quality roads.

[67]While there is very little evidence of urban to rural migration, rain induced rural urban migration can be a problem for identification. It is unfortunate that there is no data available on intra-district migration. In the absence of this data, identification rests on the assumption that within district rainfall is mean independent of intra-district migration within districts.

In practise, rural-agrarian employment is linked to not just rainfall but the availability of other inputs like fertilizers, agricultural electricity, irrigation and cropped area. It is quite possible that when there is a negative rain shock at a within district-year level, farmers invest in substitute agricultural inputs like irrigation to bolster production. In addition, it is also possible that terrorists choose to increase violence when investment increases, to send a greater terror signal. Therefore, excluding additional agricultural inputs can lead to an underestimation of the effect and a violation of the exclusion restriction.

Table 8 specifications (3) and (4) report results further including district level consumption of fertilizers, total number of agro-electricity consumers, total irrigated and cropped area. Results remain robust. In fact conditioning on these controls, the magnitude of the effect rises. This suggests that excluding additional agricultural inputs like irrigation was underestimating the true effect. Second stage results in panel B, specifications (3) and (4), suggest that a one percentage point increase in rural employment leads to an increase in the probability of terrorist attacks of 0.0775. The coefficient on the number of terrorist attacks rises to 0.5551. The first stage is significant and the AP/KP F Stat reports a value of approximately 10. The Anderson-Rubin Wald test now rejects the hypothesis that the coefficient of interest does not enter the reduced form at a five percent significance level for both the probability and number of terrorist attacks.

Another concern for identification can be that above average rainfall in fact makes it easier for terrorists to go undetected and therefore they can reach more areas of the district, leading to direct effect on terrorist attacks (Fearon and Laitin (2003)). In Table 8, specifications (5) and (6), I control for total kilometres of low quality roads to capture terrorists' geographical reach. Results remain robust and suggest that a one percentage point increase in rural employment leads to an increase in the probability of terrorist attacks of 0.0743 and an increase in the number of terrorist attacks to 0.5430. The first stage is significant and the AP/KP F Stat reports a value of slightly below 10. However, the Anderson-Rubin Wald test, which is robust to the presence of weak instruments and seem to have the correct size under a wide variety of violations of the standard assumptions of IV regression (Stock and Yogo (2005)), rejects the hypothesis that the coefficient of interest does not enter the reduced form at a five percent significance level in both specifications.

A potential violation of the exclusion restriction can stem from negative rainfall shock associated with heat waves that can potentially lead to a rise in tempers and violence (Miguel et al. (2004)). Such a relationship should lead to an underestimation of the true effect and therefore, is less of a concern.

7.3. **Reduced Form-Including Federally Administered Tribal Areas (FATA) .** A greater proportion of radicalized population will be more likely to join terrorist organizations. They would also give 'Zakat', specifically to militant organizations. For this study, radicalization that is not mean independent of rainfall shocks and terrorism at a within district-year level can confound results.

It is possible that with a negative rainfall-induced employment shock in time period t there is an increase in the number of people associated with militant charities or militant "clubs". It can be due to a need for social safety net (Chen (2005; 2010)). Association with militant clubs could result in an increase in radicalization of the population in time t+1 (Beckworth (2009)). In this case, unobserved radicalization will cause an underestimation of the true effect.

In the absence of a comprehensive data on radicalization, I am constrained to use a proxy. 'Madrassahs' have been linked to militancy, speedy radicalization and charity via provision of social safety net in Pakistan[68]. I, therefore, include the number of 'Madrassahs' as a proxy for radicalization under standard assumptions.

The inclusion of this variable, however, comes at a cost. Missing observations on number of 'Madrassahs' is quite high. With its inclusion, the sample size drops from 1344 to 924 observations in the original sample[69]. In order to overcome the sample size constraint I expand the empirical investigation to include FATA which has comprehensive data on 'madrassahs' or mosque schools in all its seven tribal agencies. The sample size rises to 1022. Including FATA also serves as a robustness check to the inclusion of another region. As Labour Force

TABLE 9. Reduced Form including Federally Administered Tribal Areas (FATA) with additional controls

	Terrorist Atks Dummy (1) District FE	No. of Terrorist Atks (2) District FE	Terrorist Atks Dummy (3) District FE	No. of Terrorist Atks (4) District FE	Terrorist Atks Dummy (5) Division Dummies	No. of Terrorist Atks (6) Division Dummies
Rainfall Deviation from PMD Normals	0.0035***	0.0382***	0.0037***	0.0458***	0.0012	0.0184
	(0.0009)	(0.0161)	(0.001)	(0.0184)	(0.0015)	(0.0183)
No. of Madrassahs/ Mosque Schools			9.94e-06	-0.0035		
			(0.0004)	(0.0034)		
Observations	1456	1456	1022	1022	1456	1456
Districts/Tribal Agencies	104	104	73	73	-	-
Divisions	-	-	-	-	28	28
District/ Tribal Agency FE	Yes	Yes	Yes	Yes	No	No
Division Dummies	No	No	No	No	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes

Clustered standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
As Labour Force Survey is not carried out in FATA, reduced form results are reported. All specifications use rainfall measured as the deviation of rainfall from the PMD Normals or the 20-30 year average for each district or tribal agency from 1997-2010. Terrorist attacks dummy takes on a value of one if there is a terrorist attacks within a district/tribal agency in a year and zero otherwise. The continuous variable, number of terrorist attacks, captures the number of attacks in a district/tribal agency within a year. The original dataset for all specifications included 100 districts from Punjab, Sindh, KPK and Balochistan and 7 tribal agencies in FATA from 1997-2010. Additional controls in all specifications include district level total registered factories, mineral production, forest area,total livestock slaughtered, population estimates, fertilizer consumed, agricultural electricity consumers, irrigated and cropped area and total low quality roads. In specifications (1)-(4) error terms are assumed to be correlated over time within a district. In specifications (5) and (6) error terms are assumed to be correlated over time within a division. For the purposes of specification (5) and (6) all agencies in FATA are treated as one division.

Survey is not conducted in the tribal belt, data on rural employment is unavailable for FATA. On the assumption that the exclusion restriction holds, I carry out a reduced form analysis. The reduced form is also robust to potential rural employment measurement error concerns.

Table 9 shows that the overall result remains robust. Table 9, specification (1) and (2) suggests that a 1 mm above 20-30 year average rainfall potentially results in an increase in the probability of a terrorist attack of 0.35 percentage points. The number of terrorist attacks

[68]9/11 Commission Report (Section 12.2)
[69]Results (not reported) remain robust and positive, when I use a reduced form including 'Madrassahs' in the original sample of the four main provinces.

increase by 0.0382. The magnitude of the effect is close to the structural IV regressions in Table 6.

Table 9, specification (3) and (4) includes number of 'madrassahs' or mosque schools. With the inclusion of 'madrassahs' owing to missing values there is a substantial drop in sample size. The result, however, remains robust and there is a little increase in magnitude from specification (1) and (2), which suggests that not accounting for radicalization resulted in an underestimation of the true effect. A 1 mm above average rainfall suggests an increased probability of terrorist attacks of 0.37 percentage points. The effect on the number of terrorist attacks is 0.0458.

Number of 'madrassahs' does not appear to be significantly correlated with terrorist attacks. Although the main result remains robust, the coefficient on number of madrassahs might not be very informative and needs a deeper investigation. Data on number of 'madrassahs' includes only those 'madrassahs' that have been registered with the state authorities. Intensive data gathering exercise is needed in this regard to comment on the exact nature of correlation between the number of 'madrassahs' and terrorist activity.

Another identification concern, already highlighted, is whether the causal channel operates at a within district-year level. It might be the case that a shock in one district leads to an attack in another district. In order to test the plausability of a within-district causal channel operation, I cluster districts at a divisional level. Just to be clear about what a division means, Pakistan is administratively divided into four main provinces i.e. Punjab, Sindh, Khyber Pakhtunkhawa (KPK), and Balochistan. Provinces are administratively sub-divided into divisions which are further sub-divided into districts. Therefore, divisions are one administrative tier above districts. Approximately 3-4 districts comprise a division.
I estimate:

$$Q_{dst} = \psi_s + \psi_t + \psi_1 A_{dst} + \psi_2 F_{dst} + \phi_{dst}$$

where all variables i.e. Q_{dst},A_{dst} and F_{dst} are at a district d, division s and time t variation. With the inclusion of division dummies, the above specification exploits across districts, within division-year variation.

If the identifying assumption of Section 5.4.1. holds i.e. the causal channels works at a within district-year level, then the above estimation ψ_1 should be insignificant. Table 9 specification (5) and (6) show the results. Specifications (5) and (6), table 9 suggests that there is no relationship between rainfall and terrorist attacks, using cross district -within division variation. Though promising, cross district effects across divisions can still be a challenge to the identification.

7.4. **The Structural Relationship between Rural Employment and Terrorist Attacks - Potential Concerns.** If there are other equally valid intervening structural relationships between rain-induced rural employment shocks and terrorist attacks then that can be another challenge for identification.

One of these can be the cost of information for counter-terrorist forces. The cost of obtaining counter-terrorist information rises as the rural labour market becomes tight on a positive rainfall shock. If the main constraint on terrorist organizations is the level of non-combatants' information sharing with the security forces (Kalyvas (2006); Berman, et al. (2008, 2011)) this can result in an increase in terrorist attacks. If data on cost or method of information collection by the security forces could be obtained then the robustness of the

result could have been tested. However, cost or method of information collection are unobserved. Though problematic for identification, the challenge from this channel, in the specific context of Pakistan, appears to be less of a concern.

Underlying this channel is the presumption that information is compiled by counter-terrorist forces in a civilized manner, through payments to informants. Although, the actual information gathering tactics used by security forces in Pakistan is classified information, there is evidence to suggest that within the institutional context of Pakistan, coercion rather than payment is potentially the information gathering tactic used. In fact, unfortunately, within Pakistan, security forces are known to abduct individuals if (apart from other reasons) it is felt that they have any information on or are linked to terrorists. There are a number of habeas corpus petitions of families of these 'missing persons' that are pending with the superior judiciary of Pakistan[70]. The cost of information channel appears to be less of a concern in a study based on a state which potentially does not engage in civilized means to extract information.

Another concern can be reduced presence of security establishment i.e. above average rainfall shocks can obstruct the establishment of checkpoints by the security establishments. This reduced security machinery in a district on the one hand can potentially reduce disruption of the economy, and on the other cause an increase in the production of violence (Hendawi (2008)). For this to cause identification concerns, security checkpoints have to be a fast changing. Within the context of Pakistan such a causal channel does not appear to hold. First, Pakistan is in a continuous state of red alert as the threat of terrorist attacks is quite high. Government buildings, offices, courts and even private schools have a continuous presence of security machinery, irrespective of rainfall shocks. In such a situation, the decision, to increase security, by the civilian and military high command is potentially slow moving and has little or no correlation with district level rainfall or income. Second, fresh military movement into areas, say for example in Swat in KPK in May 2009, is potentially the result of socio-political reasons and is potentially mean independent of rainfall shocks.

It can still be argued that with a positive rainfall shock areas that become prosperous are more prone to be hit by terrorists. Such threat perception can lead to changes in the security provided to a region. However, this should result in an underestimation of the true effect and so is less of a concern.

7.5. **Other Potential Concerns.** One concern can be if, following a positive rainfall shock, terrorists target their fund-raising activities only in those districts that have huge urban centres next to rural agriculture. Big cities offer economies of scale, logistical ease and a soft target of a dense population, which can be more attractive for terrorist. I estimate results, dropping districts with big urban areas i.e. Karachi, Lahore, Gujranwala, Faisalabad, Rawalpindi, Multan, Sialkot, Sargodha, Bahawalpur, Hyderabad, Sukkur, Peshawar and Quetta[71]. Results (not reported) remain robust and are consistent with finance rather than the labour supply as the relative dominant channel through which rural employment effects terror production in districts of Pakistan.

It has already been described that there are three competing actors seeking religious charitable donations i.e. State 'Zakat' institutions, benign private charities and militant organizations. The pie of total 'Zakat' can be divided amongst the three actors, depending on the intensity of their fund-raising activity. Rationality dictates that they would increase the

[70]Shah W.A., 'Agony of missing persons families far from over', Dawn Newspaper, 08-10-2012.

[71]These are classified as big urban area districts by the Labour Force Survey.

intensity of fund-raising activity if there is a positive rainfall shock. Therefore, intensity of their fund-raising activity will not be mean independent of rainfall shocks and terrorism at a within district-year level. In the context of this study, the challenge from rain-related, intensive fund-raising activity of State 'Zakat' institutions remains limited. There appears is no targeting of areas according to their rainfall and employment shocks by the State 'Zakat' department[72]. In fact, the biggest chunk of State 'Zakat' is automatically collected through direct deduction from the income of the salaried class[73]. Although the intensity of militant fund-raising remains unobserved, preliminary evidence suggests that it too is not correlated with rainfall shocks at a within district-year level. Despite faking identity, the militant charities still operate under fear of crack-down and government surveillance. Their intensity of fund-raising is mostly dictated by the ease with which they can operate. Even if they function discretely, it is potentially directed by State policy rather than rainfall shocks[74]. The bigger concern is from the intensity of fund-raising activities of private benign charities. In the absence of district level fund-raising activity data of private benign charities the challenge from this channel remains. Identification rests on the assumption that the intensity of benign fund-raising is mean independent of rainfall shocks and terrorism at a within district-year level.

Some other less important concerns include 'Zakat' to militant charities from the Middle East, particularly Saudi Arabia. Preliminary evidence on financial channel of terrorism suggests that it is one of the main actors providing religious charitable donations to militants. However, this is less of a concern as evidence suggests that the operation of international terror financing is potentially mean independent of rainfall shocks at a within district-year level in Pakistan.

If government tightens security and levies more checks and balances, the ability of the terrorist organizations to raise funds is diminished. For instance, post 9/11 many militant groups were banned in Pakistan or the State Bank of Pakistan (SBP) Anti-Money Laundering and Combating the Financing of Terrorism (AML/CFT) Regulations which further tightened regulations to check for terror financing[75]. Such regulations, if differentially implemented with a rainfall shock, can potentially prove to be an identification concern for the study. However, these do not pose a challenge in this context as such regulations are implemented country-wide, irrespective of rainfall shocks and so are potentially mean independent of rainfall shocks at a within district-year level.

8. Conclusion

Terrorism is distinct from other forms of conflict and deserves specific attention. Exploiting the fact that Pakistan is a predominantly poorly irrigated, agricultural economy, I used district level panel data from 1997-2010 on rainfall shocks as an instrument for rural employment to identify the net effect of rural employment shocks on terrorist violence in Pakistan. Results suggested that a one percentage point increase in rural employment results in an increase in the probability of a terrorist attack of 8.09 percentage points and an an increase in the number of terrorist attacks by 0.5697. Results remained robust and consistent with

[72]Chodhury, M.Z. , 'Zakat system's failure to deliver', Express Tribune, 23-07-2012

[73]http://www.zakat.gop.pk/

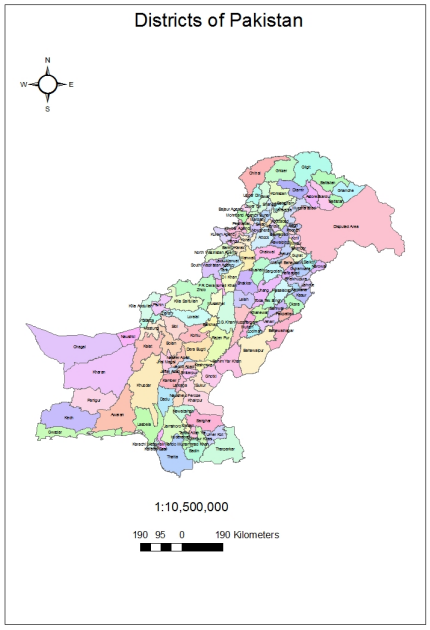
[74]Haider, Z., 'Pakistan to clamp down on Islamist militant charities', Reuters Pakistan, 20-08-2010.

[75]State Bank of Pakistan (2012), Anti-money Laundering and Combating the Financing of Terrorism (AML/CFT) Regulations for Banks & DFIs, Government of Pakistan

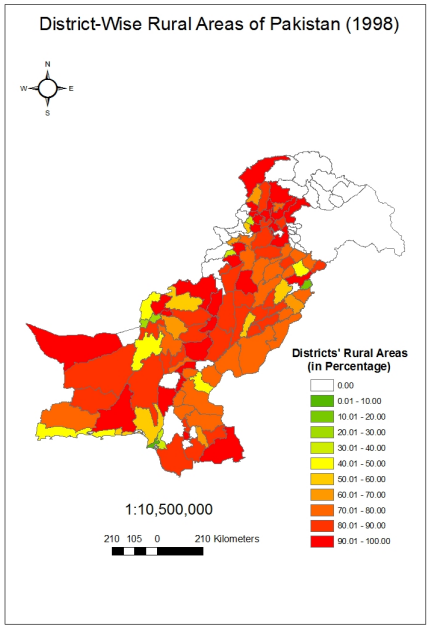
finance rather than the labour supply as the relative dominant channel through which rural employment effects terror production in districts of Pakistan. It might be worthwhile to point out that these results are along the extensive margin of rural employment decisions. Results based on the intensive margin might bring in new insights. It is also worth considering rural employment decisions of part time employed workers.

Thus, one policy implication would be that counter-terrorism attention should be focused on isolating and drying out terrorist financing. An improvement in the State 'Zakat' institutions will also divert funds away from private charities. State run advocacy campaigns which promote a more informed charitable giving behaviour and which also investigate and then highlight the parent militant organizations of religious charities in Pakistan can be a way forward. Another would be to create a licensing requirement for religious charities on the one hand. In a bid to reduce radicalisation clamping down on militant propaganda literature will also be helpful. Future research should design ingenious ways to collect data and estimate structural parameters.

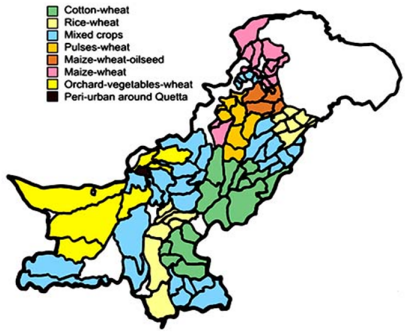
Appendix A1 Districts of Pakistan



Appendix A2 District Level Percentage of Rural Areas of Pakistan 1998 Census

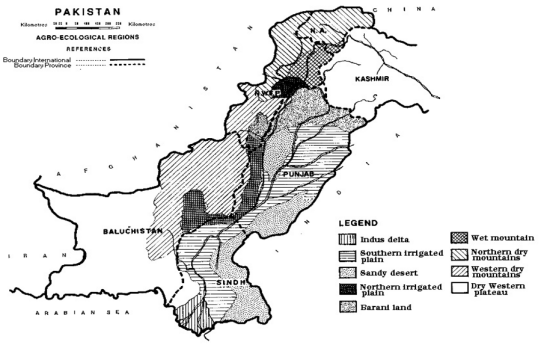


Appendix A3 Cropped Areas of Pakistan



Crop Producing Regions (scale = 1:7 000 000)

Appendix A4 Irrigated Areas of Pakistan



Source: Food and Agricultural Organization

Appendix A5

Proof of Agrarian Equilibrium Wages

$$Proof: w_h^*(A) = [\frac{N^l}{N}\bar{K}]^{\frac{\alpha}{1+\alpha}}[(1-\alpha)A]^{\frac{1}{1+\alpha}}$$

Setting $H_{demanded} = N^l\bar{K}[\frac{(1-\alpha)A}{w_h}]^{\frac{1}{\alpha}}$ equal to $H_{supplied} = N[w_h]$ so that the agrarian labour market clears.

$N[w_h] = N^l\bar{K}[\frac{(1-\alpha)A}{w_h}]^{\frac{1}{\alpha}}$

$w_h^{\frac{1+\alpha}{\alpha}} = [\frac{N^l\bar{K}}{N}][(1-\alpha)A]^{\frac{1}{\alpha}}$

$\Rightarrow w_h^*(A) = [\frac{N^l}{N}\bar{K}]^{\frac{\alpha}{1+\alpha}}[(1-\alpha)A]^{\frac{1}{1+\alpha}}$ (Q.E.D.)

Proof of Agrarian Equilibrium Employment

$$Proof: H^*(A) = [N^l\bar{K}]^{\frac{\alpha}{1+\alpha}}[N(1-\alpha)A]^{\frac{1}{1+\alpha}}$$

Using $w_h^*(A)$ in $H_{supplied} = N[w_h^*(A)]$ or $H_{demanded} = N^l\bar{K}[\frac{(1-\alpha)A}{w_h^*(A)}]^{\frac{1}{\alpha}}$

$\Rightarrow H^*(A) = N\{[\frac{N^l}{N}\bar{K}]^{\frac{\alpha}{1+\alpha}}[(1-\alpha)A]^{\frac{1}{1+\alpha}}\}$

$\Rightarrow H^*(A) = [N^l\bar{K}]^{\frac{\alpha}{1+\alpha}}[N(1-\alpha)A]^{\frac{1}{1+\alpha}}$(Q.E.D.)

Proof of Terrorist Labour Supply

$$Proof: T^*_{supplied} = N - \{[N^l\bar{K}]^{\frac{\alpha}{1+\alpha}}[N(1-\alpha)A]^{\frac{1}{1+\alpha}}\}$$

To arrive at an expression for $T^*_{supplied}(A)$ substitute $w_h^*(A)$ in $T_{supplied} = N[1 - w_h^*(A)]$

$T^*_{supplied} = N[1 - \{[\frac{N^l}{N}\bar{K}]^{\frac{\alpha}{1+\alpha}}[(1-\alpha)A]^{\frac{1}{1+\alpha}}\}]$

$T^*_{supplied} = N - \{[N^l\bar{K}]^{\frac{\alpha}{1+\alpha}}[N(1-\alpha)A]^{\frac{1}{1+\alpha}}\}$ or

$T^*_{supplied} = N - H^*(A)$ (Q.E.D.)

Proof of Agrarian Equilibrium Profits

$$Proof: \pi^*(A) = \{[N^l]^{\frac{1-\alpha(\alpha-1)}{1+\alpha}}[\bar{K}]^{\frac{2\alpha}{1+\alpha}}[N]^{\frac{1-\alpha}{1+\alpha}}(1-\alpha)^{\frac{2-\alpha^2}{1+\alpha}}[A]^{\frac{2}{1+\alpha}}\}\{1 - [N^l(1-\alpha)]^{1+\alpha}\} - r\bar{K}$$

$\pi^*(A) = p_yY - w_h^*(A)[H^*(A)] - r\bar{K} \Rightarrow$

$\pi^*(A) = (1)A\bar{K}^\alpha H^{*(1-\alpha)} - w_h^*(A)[H^*(A)] - r\bar{K}$

$\pi^*(A) = A\bar{K}^\alpha\{[N^l\bar{K}]^{\frac{\alpha}{1+\alpha}}[N(1-\alpha)A]^{\frac{1}{1+\alpha}}\}^{(1-\alpha)} - \{[\frac{N^l}{N}\bar{K}]^{\frac{\alpha}{1+\alpha}}[(1-\alpha)A]^{\frac{1}{1+\alpha}}\}\{[N^l\bar{K}]^{\frac{\alpha}{1+\alpha}}[N(1-\alpha)A]^{\frac{1}{1+\alpha}}\} - r\bar{K}$

$\pi^*(A) = A\bar{K}^\alpha\{[N^l\bar{K}]^{\frac{\alpha}{1+\alpha}}[N(1-\alpha)A]^{\frac{1}{1+\alpha}}\}^{(1-\alpha)} - \{[N^l\bar{K}]^{\frac{2\alpha}{1+\alpha}}[(1-\alpha)A]^{\frac{2}{1+\alpha}}N^{\frac{1-\alpha}{1+\alpha}}\} - r\bar{K}$

$\pi^*(A) = \{[N^l]^{\frac{\alpha(1-\alpha)}{1+\alpha}}[\bar{K}]^{\frac{2\alpha}{1+\alpha}}[N]^{\frac{1-\alpha}{1+\alpha}}(1-\alpha)^{\frac{1-\alpha}{1+\alpha}}[A]^{\frac{2}{1+\alpha}}\} - \{[N^l\bar{K}]^{\frac{2\alpha}{1+\alpha}}[(1-\alpha)A]^{\frac{2}{1+\alpha}}N^{\frac{1-\alpha}{1+\alpha}}\} - r\bar{K}$

$\pi^*(A) = \{[N^l]^{\frac{\alpha}{1+\alpha}}[\bar{K}]^{\frac{2\alpha}{1+\alpha}}[N]^{\frac{1-\alpha}{1+\alpha}}(1-\alpha)^{\frac{1}{1+\alpha}}[A]^{\frac{2}{1+\alpha}}\}\{[N^l(1-\alpha)]^{(1-\alpha)} - [N^l(1-\alpha)]^2\} - r\bar{K} \Rightarrow$

$\pi^*(A) = \{[N^l]^{\frac{1-\alpha(\alpha-1)}{1+\alpha}}[\bar{K}]^{\frac{2\alpha}{1+\alpha}}[N]^{\frac{1-\alpha}{1+\alpha}}(1-\alpha)^{\frac{2-\alpha^2}{1+\alpha}}[A]^{\frac{2}{1+\alpha}}\}\{1 - [N^l(1-\alpha)]^{1+\alpha}\} - r\bar{K}$ (Q.E.D.)

Proof of Charitable Donations to Terrorist Organizations

$$Proof: D_t^*(s, p_t, A) = p_t(s)\{(N^l\bar{K})^{(\frac{2\alpha}{1+\alpha})}[(N)(1-\alpha)A]^{\frac{2}{1+\alpha}}\}\Lambda - p_t(s)N^lr\bar{K}$$

Where $\Lambda = \{1 + N^{l(\frac{2-\alpha^2}{1+\alpha})}N^{\frac{(1-\alpha)}{2}}(1-\alpha)^{(-\frac{\alpha^2}{1+\alpha})}(1 - [N^l(1-\alpha)]^{(1+\alpha)})\}$

Using equilibrium values of $w_h^*(A) = [\frac{N^l}{N}\bar{K}]^{\frac{\alpha}{1+\alpha}}[(1-\alpha)A]^{\frac{1}{1+\alpha}}$

$H^*(A) = [N^l \bar{K}]^{\frac{\alpha}{1+\alpha}} [N(1-\alpha)A]^{\frac{1}{1+\alpha}}$

$\pi^*(A) = \{[N^l]^{\frac{1-\alpha(\alpha-1)}{1+\alpha}} [\bar{K}]^{\frac{2\alpha}{1+\alpha}} [N]^{\frac{1-\alpha}{1+\alpha}} (1-\alpha)^{\frac{2-\alpha^2}{1+\alpha}} [A]^{\frac{2}{1+\alpha}}\}\{1 - [N^l(1-\alpha)]^{1+\alpha}\} - r\bar{K}$

in the expression for $D_t^*(s, p_t, A) = p_t(s)\{N[w_h^*(A)][H^*(A)] + N^l[\pi^*(A)]\}$we get:

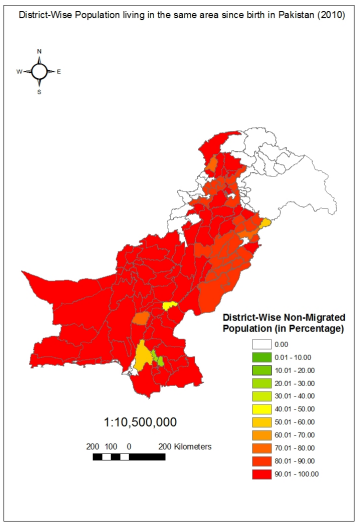
$D_t^*(s, p_t, A) = p_t(s)(\{[N^l \bar{K}]^{\frac{\alpha}{1+\alpha}} [N(1-\alpha)A]^{\frac{1}{1+\alpha}}\}^2 + \{\mathcal{F}\})$

Where $\mathcal{F} = \{N_l^{(\frac{2(1+\alpha)-\alpha^2}{1+\alpha})} [\bar{K}]^{\frac{2\alpha}{1+\alpha}} [A]^{\frac{2}{1+\alpha}} N^{(\frac{1-\alpha}{1+\alpha})} (1-\alpha)^{\frac{2-\alpha^2}{1+\alpha}} [1 - (N^l(1-\alpha))^{(1+\alpha)}]\} - N^l r\bar{K} \Rightarrow$

After simplifying $D_t^*(s, p_t, A) = p_t(s)\{(N^l \bar{K})^{(\frac{2\alpha}{1+\alpha})} [(N)(1-\alpha)A]^{\frac{2}{1+\alpha}}\}\Lambda - p_t(s)N^l r\bar{K}$

where $\Lambda = \{1 + N^{l(\frac{2-\alpha^2}{1+\alpha})} N^{\frac{(1-\alpha)}{2}} (1-\alpha)^{(-\frac{\alpha^2}{1+\alpha})} (1 - [N^l(1-\alpha)]^{(1+\alpha)})\}$ (Q.E.D.)

Appendix A6 Population Living in the same District since Birth (Percentage) 2010



Appendix A7 (i) Details of Rainfall Estimation Strategy

Rainfall data (1997-2010) has been obtained from PMD and average annual rainfall Isohyetal map is provided in Fig 1, which shows spatial distribution of rainfall throughout Pakistan. To devise a criterion for spatial interpolation of rainfall distribution for districts that do not have any gauge station or has some missing data, following procedure has been adopted. Gujrat has been selected as test case, where no gauge station is available. Its geographic location is provided in Fig 2. All periphery meteorological stations are shown in Fig 3, which shows all possible nearest stations from where one can spatially interpolate rainfall data for Gujrat. Isohyetal map for average annual rainfall over Gujrat is shown in Fig 4, which shows a number of Isohyets passing through the region, ranging from 95 to 120 mm. For simplification and quick selection of an appropriate average Isohyet for Gujrat, centroid of district area (shown by red asterisk) has been calculated using ArcGIS and provided in Fig-5. Centroid of region and Isohyets passing through Gujrat district area, are provided in Fig 6, which show nearest Isohyet with the centroid is 105mm (average annual rainfall over Gujrat). Hence in that year, the average annual rainfall over Gujrat is 105 mm.

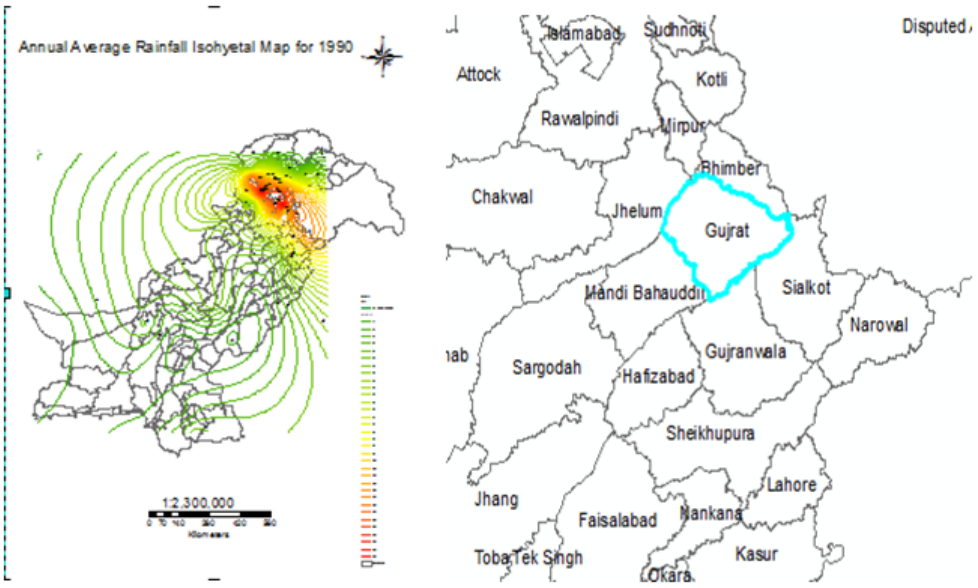


Figure A1. Average Rainfall Isohyetal Map; Figure A2. Geographic location of Gujrat

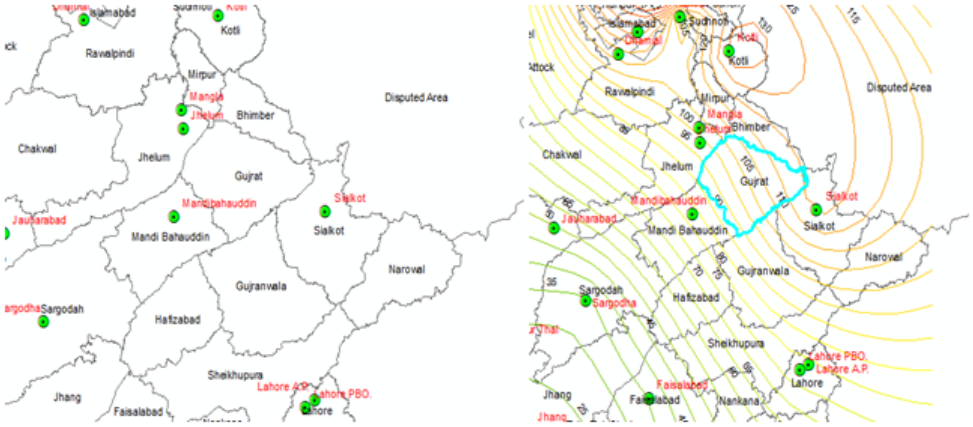


Figure A3: Peripheral Meteorological Stns; Figure A4: Isohyets passing through Gujrat

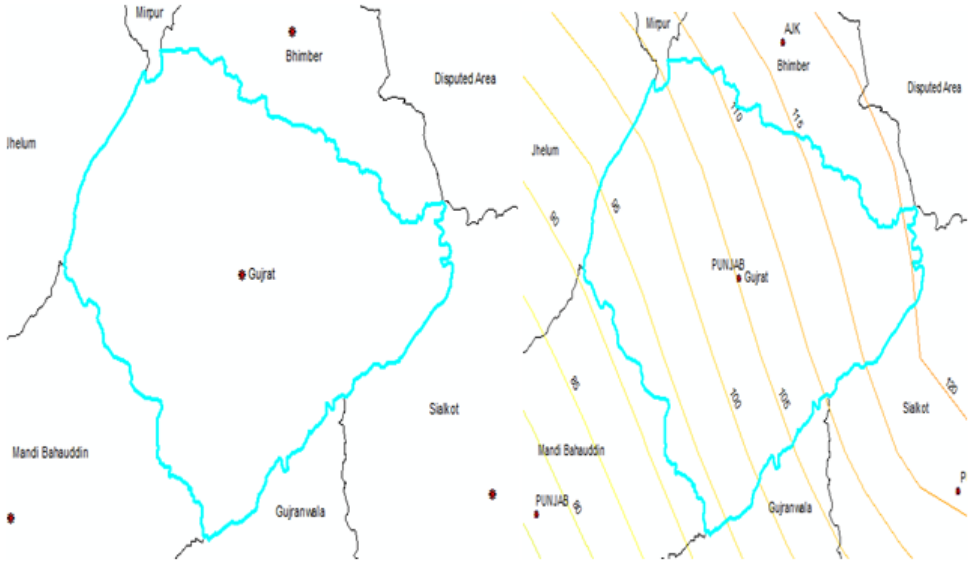
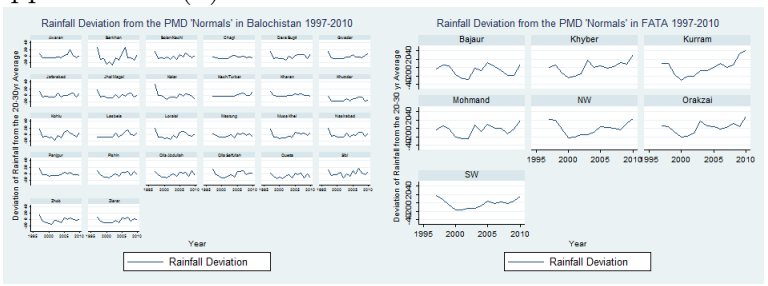
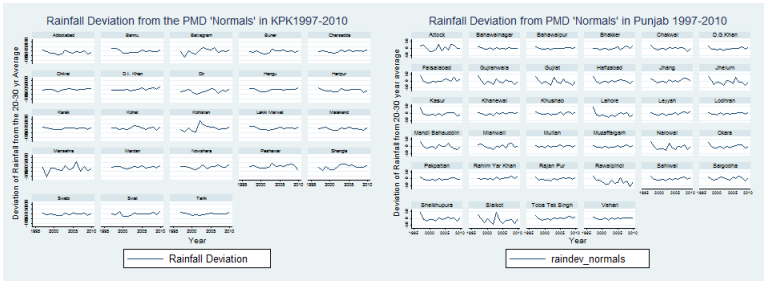
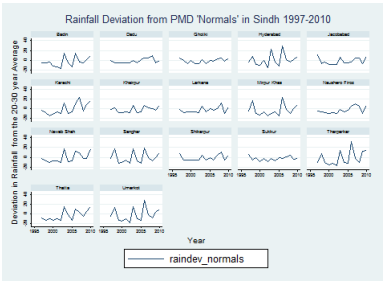


Figure A5: Centroid of Gujrat extracted; Figure A6: Isohyetal Map & Gujrat's Centroid

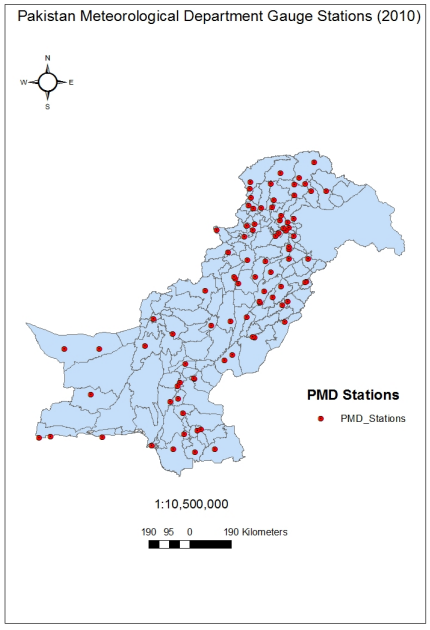
Appendix A7 (ii) Rainfall Deviation from PMD 'Normals'







Appendix A8 Pakistan Meteorological Department (PMD) Gauge Stations



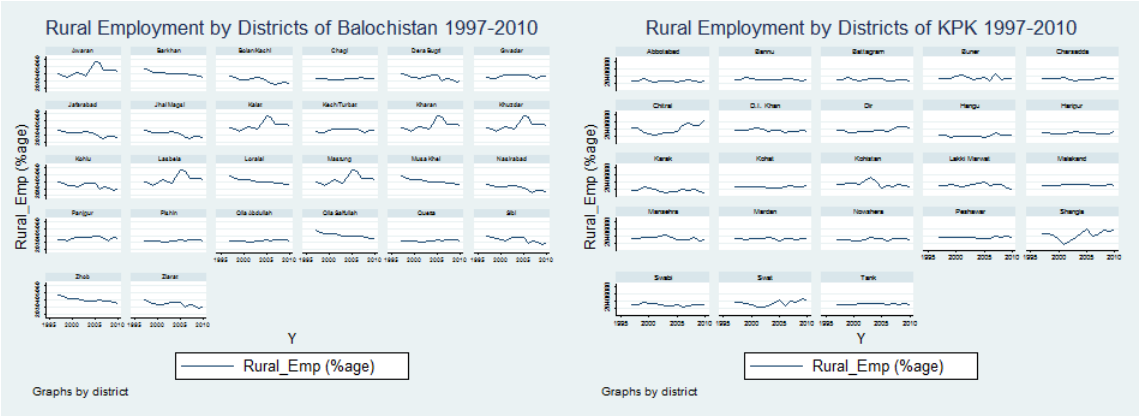
Appendix A9 (i) LFS Coding Scheme

The detailed coding scheme of LFS is described below.
A 9- digit-coding scheme to assign processing codes to the sample districts in Labour Force Survey is as under: -

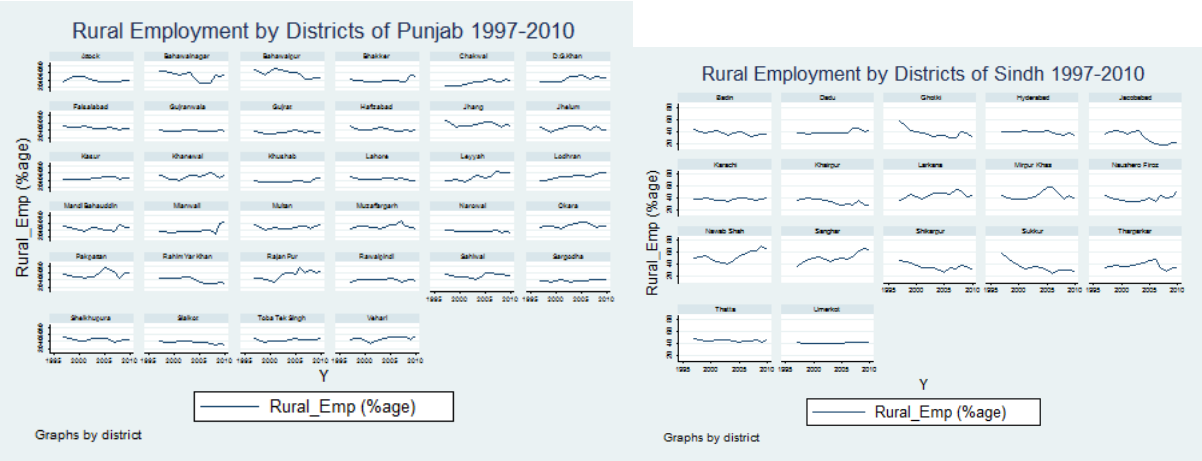
STRUCTURE OF THE CODE
I II III IV V VI VII VIII IX

POSITION:I
First digit at position I has been assigned to the four provinces of Pakistan, as under:
Province Code:
Punjab:1; Sindh:2; KPK:3; Balochistan:4
POSITION-II
One-digit code at positions II has been assigned to sub-universe comprising urban and rural areas of each province of Pakistan as under:.
Sub-universe Code:
Urban:1; Rural:2
POSITION III to IV
A two-digit code at position III & IV has been assigned to indicate stratum within a province. In rural sub-universe, districts have been taken as strata in the Punjab, Sindh, NWFP Provinces and a Division in the Balochistan Province.
POSITION V, VI & VII:
Three-digit code at position V to VII has been assigned to Primary Sampling Units i.e. Enumeration Blocks/Villages within stratum/sub-stratum
POSITION VIII & IX: A two-digit code at position VIII and IX is assigned to Secondary Sampling Units (SSUs) i.e. households within each Primary Sampling Unit (PSU) of a stratum/sub-stratum [76].
Details of the exact code assigned to various districts over years can be made available.

Appendix A9 (ii) Rural Employment by Districts in Pakistan 1997-2010



[76]Sampling Plan, Labour Force Section, Pakistan Bureau of Statistics



Appendix Table A1: Details of Control Variables

Control Variables	Punjab	Sindh	Balochistan	KPK	FATA
Level at which data available					
Other Occupations					
Total livestock slaughtered*	District	District	District	District	Tribal Agency
Area under Forest *	District	District	District	District	Tribal Agency
Mineral Production*	District	Provincial***	District	District	Tribal Agency
Number of registered factories *	District	District	Provincial***	District	Tribal Agency
Fish Production*	District	District	District	District	Tribal Agency
Other Agricultural Inputs					
Irrigated area*	District	District	District	District	Tribal Agency
Cropped area*	District	District	District	District	Tribal Agency
Fertilizer consumption*	District	District	District	District	Tribal Agency
Agri-electricity consumers*	Provincial***	Provincial***	Provincial***	District	Tribal Agency
Total low quality road km*	District	District	District	District	Tribal Agency
Population estimates^	District	District	District	District	Tribal Agency
Percentage of pop married**	Rural Area	Rural Area	Rural Area	Rural Area	NA
Rural Inter-dist Migration Rate**	Rural Area	Rural Area	Rural Area	Rural Area	NA
Radicalization					
No. of Madrassah/ Mosque Scls	District	NA	District^^	District	Tribal Agency

* Source: Development Statistics of the four provinces and FATA

** Source: Survey data of Labour Force Survey 1997-2010

***NB: Provincial/divisional average is used for all districts, on the assumption that the value is not systematically different for districts within the province/division

^NB: District level projected estimates using 1981-1998 intercensal district level population growth rates. Source: 1998 Population Census of Pakistan

^^NB: A lot of missing values

TABLE 10. Descriptive Statistics of Control Variables

	Mean	Min	Max	Std Dev	N
Population	1,489,925	33340	1.39e+07	1,703,380	1498
Percentage of Married rural population	44.42	28	68	8.33	1397
Percentage of rural population living in the same district since birth	94	57.91	100	6.32	1400
Fertilizer consumed (N. Tons)	41,829	0	780,000	68,005	1498
Total low quality roads (km.)	633.01	0	3487	638.60	1498
Irrigated Area	181,461.4	0	940,000	220,480.1	1498
Cropped Area	137,381.8	0	960,000	163,470	1498
Agricultural Electricity Consumers	1776.93	0	5996	1668.30	1498
Quantity of fish produced	1076.45	0	45,134	6564.48	1386
Total registered factories	99.89	0	1899	223.36	1484
Mineral production	236,038.9	0	1.09e+07	776,945.8	1498
Forest Area	152,658.1	0	2,624,000	321,818.5	1470
No. of Mosque Madrassah Schools	145.96	0	702	125.62	1050
Livestock Slaughtered	159,855.3	0	2,235,000	288,330.3	1498

Note:The dataset includes 100 districts from four provinces of Pakistan i.e. Punjab, Balochistan, Khyber-Pakhtunkhawa (KPK), Sindh and 7 Tribal Agencies from the Federally Administered Tribal Areas (FATA) from 1997-2010. Labour Force Survey is not carried out in FATA and so rural married population and percentage of rural population living in the same district since birth is reported excluding FATA.

TABLE 11. Descriptive Statistics of Rural Household Zakat Data

	Mean	Min	Max	Std Dev	N
Zakat Received					
Zakat Binary	1.976	1	2	0.152	126,337
Govt. Zakat	93.57	0	60,000	1138.77	126,856
Pvt. Zakat	77.16	0	160,000	1028.59	126,856
T. Zakat Received	122.86	0	162,400	1354.06	207,757
Zakat Paid					
Zakat Binary	1.93	1	2	0.258	126,520
Govt. Zakat	5.022	0	80,000	306.61	126,856
Pvt. Zakat	195.06	0	300,000	1832.54	126,856
T. Zakat Paid	291.37	0	300,000	1630.78	207,757

Note: Zakat is stated zakat compiled from Household Integrated Economic Survey (HIES). The dataset includes household level data of four provinces of Pakistan i.e. Punjab, Balochistan, Khyber-Pakhtunkhawa (KPK), Sindh for 1998, 2001, 2005, 2007 and 2010.

TABLE 12. FE Regression of Rural Employment and Terrorist Attacks with controls

	Terrorist Attacks Dummy (1) FE	No. of Terrorist Attacks (2) FE
Rural Employment	0.0029	0.0469
	(0.0026)	(0.0414)
Observations	1344	1344
Districts	96	96
District Fixed Effect	Yes	Yes
Time Fixed Effect	Yes	Yes

Clustered standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
The legal labour market measure is rural employment in districts of Pakistan as a percentage of total unemployed and employed population. Terrorist Attacks dummy takes on a value of one if there is a terrorist attack within a district in a year and zero otherwise. The continuous variable, number of terrorist attacks, captures the number of attacks in a district within a year. The original dataset includes 100 districts of four provinces of Pakistan i.e. Punjab, KPK, Sindh and Balochistan from 1997-2010. All specifications include district level quantity of fish produced, total registered factories, mineral production, forest area and livestock slaughtered, rural inter-district migration rate, population estimates, rural population married estimates, fertilizer consumed, agricultural electricity consumers, irrigated and cropped area and total low quality road kilometers.

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