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Terrorism and fertility: evidence for a causal influence of terrorism on fertility

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Abstract

Using a panel data set of 170 countries and terrorism data from 1970 to 2007, we find that terrorist attacks decrease fertility as measured by both total fertility rates and crude birth rates. Furthermore, by using a novel instrumental variable approach, we identify a causal link and address endogeneity concerns related to the possibility of stress, caused by rising birth rates or transitioning demographics, affecting terrorism. We find that on average, terrorist attacks decrease fertility, reducing both the expected number of children a woman has over her lifetime and the number of live births occurring during each year. The results are statistically significant and robust across a multitude of model specifications, varying measures of fertility, and differing measures of terrorism.

Key words: J13, D72, C33, C36

1. Introduction

Since the onset of the twenty-first century, terrorism has grown as a significant factor affecting our lives in unforeseen ways. Much has been written regarding the causes of terrorism (Krueger and Malecková, 2003; Bueno de Mesquita, 2005; Berrebi, 2007; Krueger and Laitin, 2008; Enders *et al.*, 2014); however, the ramifications of prolonged exposure to terrorism are yet to be thoroughly studied. Terrorism's effects spread across various aspects of life, from voters' behavior (Berrebi and Klor, 2006, 2008) to the public's mental health (Boscarino *et al.*, 2003). Although terrorist attacks are a relatively rare occurrence, they generate a disproportionate amount of stress and fear, suggesting that their direct effects may be small in comparison to a range of larger and more widespread indirect effects (Becker and Rubinstein, 2004).

In recent years, research expanded to look at the effects of exposure to terrorism on physiological and birth outcomes. Earlier medical literature linked prenatal stress to elevated levels of corticotropin-releasing hormone (CRH), which regulates the duration of pregnancy and fetal maturation and escalates the risk of adverse birth outcomes (Wadhwa *et al.*, 1993, 2004; Rondo *et al.*, 2003). In Colombia, Camacho (2008) found a statistically significant link between exposure to landmines during the first trimester of pregnancy and declines in birth weight. Ascherio *et al.* (1992) conducted a nationwide analysis of infant mortality rates following the Gulf War and found evidence that the Gulf War and trade sanctions had caused a threefold surge in mortality among Iraqi children below the age of five. Further research has linked low birth weight to a wide-ranging number of other health outcomes, including increased infant mortality, higher occurrence of lung disease, and heart disease (McCormick, 1985; Barker *et al.*, 1989; Barker *et al.*, 1991; Hack *et al.*, 1991).

To the best of our knowledge, no research exists on the links between terrorism and fertility, and only a few studies focus on the more general effects of civil conflict on fertility. Although available research on civil conflicts confirms that exposure to war exerts a negative effect on birth outcomes such as birth weight and physiological outcomes, research on the effects of such exposure on overall fertility rates has been mixed. In some cases, fertility rates fell due to conflict-related insecurities. Violence, psychological stress, poor health, and wealth uncertainty increase during conflicts and can cause significant short-term declines in fertility by affecting related factors such as age at first marriage, frequency of sexual intercourse, and labor migration (Lindstrom and Berhanu, 1999; Agadjanian and Prata, 2002; Blanc, 2004; Woldemicael, 2008; Guha-Sapir and D'Aoust, 2011). Individuals value procreation and are willing to sacrifice much in order to have children (Schultz, 1974); however, if they understand that children constitute long-term investments, the stress of conflict or terrorism within a country can make the investment in children more costly.

Contrasting a possible negative relationship between conflict and fertility, in some conflicts children may act as insurance on future income, and having additional children secures a minimum level of income. During prolonged conflicts, high fertility levels can counterbalance the elevated risk of losing a child where child mortality is high (Kalemli-Ozcan, 2003). In these situations, additional children may act as a strategy against economic shocks, ensuring financial support later in life (Agadjanian and Prata, 2002; Verwimp and Van Bavel, 2005).

Huttenen and Kellokumpu (2012) illustrated that in Finland, for every 100 women displaced from their jobs, approximately 4 fewer children were born. They attributed their observed effect to exogenous shocks during the worker's career. This effect was particularly noticeable for highly educated women as there is higher attachment to the labor force and job displacement may postpone childbearing until a more stable time. Similarly, Ahn and Mira (2001) found that male joblessness resulted in strong negative effects on the fertility and a longer delay to marriage. Sobotka *et al.* (2011) conducted a review of prior research on the effect of economic performance on fertility in developed countries. Overall, most studies found positive correlation with recessions resulting in lower fertility. Negative income effects and increased uncertainty, particularly during one's most productive years, led to a delay in family formation until an adequately high economic level was attained. Terrorism's negative effect on job stability and economic conditions provide a tangible avenue through which terrorism within a country could have farther-reaching impacts on fertility.

In many ways, terrorism acts as an exogenous shock. By its very nature, it intends to shock and disrupt. The effect of terrorism on fertility could be observed through its effect on economic and labor force factors. Recent research has confirmed a negative link between terrorism and female labor force participation, indicating that terrorism can adversely affect female labor outcomes, especially when it affects industries where women occupy a disproportionate amount of the workforce (Berrebi and Ostwald, 2014). Outside of a possible indirect effect of terrorism on fertility through stress, terrorism's resultant negative shock to labor force participation rates and economic conditions of particular industries could in turn affect fertility.

When investigating the link between terrorism and fertility, issues arise when assessing a direction for the effect. While we have outlined a number of ways terrorism or conflict might influence fertility either positively or negatively, high fertility or birthrates put strain on countries, and increased competition for scarce resources can increase conflict and instability (Homer-Dixon, 1994; Weiner and Russell, 2001; Goldstone, 2002; Urdal, 2006). This presents a situation where fertility might affect terrorism just as terrorism affects fertility. To assuage these possible endogeneity concerns, identify the directionality, and isolate the effects of terrorism on fertility, this study uses multiple approaches including difference in differences, instrumental variables (IV), as well as falsification tests.

This study is the first to empirically investigate the effects of terrorism on fertility, and it does so using a comprehensive set of countries and time periods. Using a panel data set composed of data on terrorist attacks from 1970 to 2007 as well as a variety of demographic controls, we implement a robust panel analysis and measure the effects of terrorist activity on fertility as expressed by total fertility rate (TFR) and crude birthrate (CBR). We find that terrorism, measured by both the incidents and deaths caused by terrorism, exerts a statistically significant negative effect on fertility rates for both TFR and CBR. Results were tested through a variety of falsification approaches as well as through implementing an IV approach using domestic terrorism in neighboring countries. Overall, we observed consistent and statistically significant negative effects of terrorism on fertility. Although earlier studies investigated the effects of conflict on birth outcomes such as birth weight and infant mortality for a narrower selection of countries and years, our findings represent the first structured analysis of a far-reaching and persistent impact of terrorism on overall fertility.

2. Data

To analyse the effects of terrorism on fertility rates, we constructed a panel data set consisting of demographic and terrorism data for total of 170 countries over the period 1970–2007. The base specification consisted of 170 countries and 5,842 individual country-year observations.

2.1 Fertility data

Data on fertility were derived from the World Bank Development Indicators database (World Bank, 2010). TFR and CBR were used to assess the effects of terrorism on fertility. CBR is a commonly used measure of the number of live births occurring each year per 1,000 population and is estimated at the mid-year. TFR represents the expected number of children born to a woman if she were to live to the end of her childbearing years and bear children in accordance with current age-specific fertility rates (World Bank, 2010). Both measures were used to ensure a robust analytic design; however, TFR is used as our primary outcome variable because it is generally considered a better indicator of current fertility rates as, unlike the CBR, it is unaffected by the age distribution of the population.

2.2 Terrorism data

Terrorism measures were derived from the National Consortium for the Study of Terrorism and Responses to Terrorism (START), Global Terrorism Database (2010). The Global Terrorism Database (GTD) contains information on target type, weapons used, date of attack, number of casualties, and location. The data are obtained primarily from contemporary news articles and other news sources. The GTD refrains from establishing a single definition of terrorism and instead includes criteria covering a broad set of definitions of terrorism. For an event to be included in the database, it must first meet the following three base criteria (START, 2010):

(i) Incident had to be intentional—the result of a conscious calculation on the part of the perpetrator.
(ii) It had to entail some level of violence or threat of violence—includes damage to property.
(iii) The perpetrators of the incidents had to be subnational actors—does not include acts of state terrorism.

To better understand terrorism phenomena and the various types of terrorism, we used modified GTD data from Enders *et al.* (2011) who established a method for filtering the data within the GTD into transnational and domestic terrorist incidents. According to their methodology, transnational attacks are defined as those attacks in which victims, targets, perpetrators, or venues differ in nationality. Incidents are categorized as transnational if the terrorist(s) crosses international borders or attacks international organizations or peacekeepers. Domestic terrorist incidents are defined as those in which all of these characteristics share the same nationality. Their data were further restricted to require three additional criteria for an incident to be included. Similarly, we further restricted the data and required the same three criteria be present.

(i) The act had to be aimed at attaining a political, economic, religious, or social goal. Exclusive pursuit of profit does not satisfy this criterion.
(ii) There had to be evidence of an intention to coerce, intimidate, or convey some other message to a larger audience (or audiences) than the immediate victims.
(iii) The action had to be outside the context of legitimate warfare activities.

Additionally, cases labeled as 'doubted' were removed. These include incidents involving insurgency or guerilla warfare, internecine conflict, mass murder, and criminal acts. This filtering narrowed our set of attacks to approximately 66,000 terrorist incidents.

2.3 Data on demographic, economic, and social indicators

Data on other demographic and economic-related covariates were obtained from the World Bank (2010). Indicators for civil liberties were obtained from the Freedom in the World survey[1] (Freedom House, 2010; World Bank, 2010). What follows is a list of included covariates: population size, urban population (% of total population), gross

1 We inverted the original scales for this indicator so that 7 indicated the highest levels for civil liberties or political rights. We then summed the civil liberties and political rights indicators from this survey into one indicator labeled civil liberties.

domestic product (GDP) *per capita* in constant 2000 US dollars, gross government final consumption expenditures (GFCE) (% of GDP), and civil liberties. The covariates were chosen to best assess and control for a wide range of economic, demographic, and social characteristics that the literature suggests might influence both fertility rates and terrorism. In addition, we use either country/year fixed-effects or first differences to control for time-invariant differences between countries and country-invariant changes over time.

2.4 Data on borders and country proximity

To strengthen the causal interpretation of the results, an IV approach was implemented for a country's level of terrorist attack incidents. Data on country borders and distances was obtained from the bilateral distance file created by the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII, 2010). The data set contains bilateral data on countries including whether two countries share a border as well as their weighted distances based on city-level data of the geographic population distribution (2004) within a nation (Mayer and Zignago, 2006). Using these data, we generated lagged measures of domestic terrorist attacks and deaths in neighboring countries to use as instruments for a country's level of terrorist incidents. When a country did not share any borders, weighted distances were used to determine its nearest five neighbors and then similar measures of proximate terrorism were created. The nearest five were chosen because at this cutoff, the means and standard deviations were closest to those observed in the contiguous, shared-border group.

Table 1 presents summary statistics of the observations within the data set. We included only countries with at least 1 terrorist attack, thus on average, countries within the data set suffered 9.6 terrorist attacks per year and 18.9 deaths from terrorist attacks per year. Total fertility rates average 4.1 children per women and ranges from a minimum of 0.9 to a maximum of 8.7. Crude birth rates range from 6.9 to 57.8 births per 1,000 population with an average of 29.3. Percentiles (5th, 50th/median, and 95th) are presented in Table 1 as P5, P50, and P95, respectively. In the case of our terrorism measures, these statistics show a positive skewness to the variables, which would indicate that, most often, countries suffer few terrorist attacks; however, there are some years in which countries may suffer much higher attacks and deaths. To reduce the distributions' positive skewness, we chose to log transform these variables in our analyses.

Table 1. Summary statistics

Measures by country-year	*N*	Mean	SD	Min	Max	P50	P5	P95
Total fertility rate (births per woman)	5,874.0	4.1	2.0	0.9	8.7	3.8	1.4	7.2
Crude birth rate (per 1000 population)	6,131.0	29.3	13.2	6.9	57.8	29.1	10.2	49.0
# of terrorist attacks	6,371.0	9.6	41.0	0.0	727.0	0.0	0.0	43.0
# of terrorist attack deaths	6,371.0	18.9	129.6	0.0	4,658.0	0.0	0.0	68.0
# of neighboring country domestic attacks	6,371.0	30.3	80.9	0.0	1,032.0	3.0	0.0	150.0
Population size in millions	6,213.0	30.4	111.9	0.0	1,320.0	6.6	0.2	99.9
Percent urban population	6,237.0	49.2	24.8	2.4	100.0	48.8	11.7	90.8
GDP *per capita*	5,374.0	5,991.4	8,952.4	62.2	72,296.0	1,759.6	174.4	24753.6
GFCE (% of GDP)	5,127.0	16.1	6.8	2.3	76.2	15.2	7.3	28.1
Civil liberties	5,484.0	8.1	4.1	2.0	14.0	8.0	2.0	14.0

3. Methodology

To assess the relationship between fertility rate and terrorism we initially estimated the following models.
Fixed effects model:

$$fertility_{i,t+1} = \beta \cdot \ln\left(terrorism_{i,t-j}\right) + \alpha \cdot demographic_{i,t} + \delta \cdot economic_{i,t} + \theta \cdot social_{i,t} + \rho \cdot year_t + \phi \cdot country_i + \mu_{i,t} \quad (1)$$

First differenced model:

$$\Delta fertility_{i,t+1} = \beta \cdot \Delta\ln\left(terrorism_{i,t-j}\right) + \alpha \cdot \Delta demographic_{i,t} + \delta \cdot \Delta economic_{i,t} + \theta \cdot \Delta social_{i,t} + \rho \cdot \Delta year_t + \Delta\mu_{i,t} \quad (2)$$

where:

$fertility_{i,t+1}$	Total fertility rate or crude birth rate in country i, year $t+1$.[2]
$terrorism_{i,t-j}$	Terrorism attack incidents in country i, year $t-j$ where j ranges from 0 to 1 (i.e., terrorist attacks in current year and lagged year)
$demographic_{i,t}$	Population size, % of urban population in country i, year t.
$economic_{i,t}$	GDP *per capita* (constant 2000 US$), general government final consumption expenditure GFCE (% of GDP) in country i, year t.
$social_{i,t}$	Civil liberties in country i, year t.
$year_t, country_i$	Year and country fixed effects.
$\Delta outcome_{i,t}$	$\left(outcome_{i,t} - outcome_{i,t-1}\right)$ or $\left(outcome_{i,t-j} - outcome_{i,t-j-1}\right)$.

Research has shown statistically significant relationships between geographic factors—such as elevation, tropical location, and country area—and terrorism (Abadie, 2006). Additionally, geographic and environmental factors could affect access to childcare, which influences fertility decisions (Del Boca, 2002; Hank and Kreyenfeld, 2003). Factors such as geographic location and physical characteristics do not change over time, and country fixed-effects models allow us to control for these and any other time-invariant factors. Year fixed effects allow us to control for the average effects of specific periods over all countries. Moreover, they help reduce bias from overall trends and events that occurred at a specific time and that might have influenced the average global level of terrorism or fertility. For example, we might want to account for the global effects of the era of communism and the period of the Global War on Terror, or we might be concerned with average global changes in healthcare, which influence birth outcomes and fertility.

Our specifications use an ordinary least squares (OLS) framework with both country and year fixed effects or differencing, which mitigate many of the concerns for potential omitted variable bias. The advantage of this method over analyzing cross-sectional variation is that we are able to control for country-specific, time-invariant, unobserved heterogeneity, which could lead to bias in standard estimators like OLS. Country fixed effects help control for any time-invariant, country-specific factors. Year fixed effects control for any country-invariant factors such as global trends in fertility or birthrates. Differencing serves the same purpose as country fixed effects, eliminating country-specific,

2 We used $t+1$ in the specification because observed changes in birthrates are more likely to be observed in the following year due to the natural timelines for fertility.

time-invariant factors; however, it has the additional benefit of alleviating some concerns related to serial correlation and endogeneity as well as focusing explicitly on the effects of changes in terrorism on changes in fertility.[3]

While country and year fixed effects reduce many issues related to omitted variable bias, our panel model requires additional assumptions to be valid. Namely, after controlling for our economic and demographic factors, our measures of terrorism must be strictly exogenous. In our case, strict exogeneity requires that the within-country variations in terrorism must be unrelated to the within-country changes in unobservable factors affecting fertility. Our demographic and economic factors were carefully chosen to best control for a diverse range of characteristics that the literature suggests might influence both fertility rates and terrorism; however, there may remain omitted variables which vary over country and year and introduce bias by influencing both terrorism and fertility. Although we have confidence in our choice of covariates, our analysis employs multiple specifications using various covariate groupings, measures of terrorism, and measures of fertility to best demonstrate robust and stable findings over a variety of models.

Even with these precautions, there is some concern regarding a direct endogenous relationship between terrorism and fertility that could result in biased estimates. One way to alleviate both the omitted variable concerns the direct endogeneity problem is to use an IV approach to isolate terrorism's effect. For such an approach, it is necessary to find a variable associated with levels of terrorism, but not associated with the fertility or birthrates except through its influence on terrorism levels. To be valid, the IV must be predictive of the endogenous regressor while maintaining its independence from the error term. Our approach uses lagged domestic terrorism incidents in neighboring countries as an instrument for a country's level of terrorism.

Empirical studies have shown that shocks to terrorism can influence levels of transnational and domestic terrorism in neighboring countries (Enders *et al*., 2011; Berrebi and Ostwald, 2013). Terrorist groups share information with other groups regarding tactics and techniques. In some cases, groups will use neighboring countries as safe havens to conduct attacks against their targets. Enders *et al*. (2011) empirically demonstrated the potential for domestic terrorism to spread into other countries, finding that domestic terrorism often results in spillover transnational terrorism. They further show that domestic terrorist events Granger-cause domestic and transnational terrorist incidents, but transnational terrorist events only Granger-cause themselves. Furthermore, as the terrorist groups, targets, and venues are all of the same nationality for domestic terrorist attacks, the impetus for domestic terrorism is most often isolated to conditions particular to a country and its government. Piazza (2011) identified some of these causes and factors that lead to domestic terrorism, finding that countries that permit economic discrimination against their minority groups significantly intensified their vulnerability to domestic terrorism.

Our methodology assumes there is exogeneity in our instruments, and that after controlling for the above-mentioned covariates, fertility and birthrates are affected by neighboring country domestic terrorism only through its effect on the local country's terrorist attacks.

3 After conducting a panel Durbin-Watson test, first-order autocorrelation was identified as a possibility in the fertility data, thus justifying the analysis with differencing which results in more efficient estimates than the fixed-effect approach in the presence of serial correlation (Wooldridge, 2010). Both models are consistent and unbiased under conditions of strict exogeneity; however, providing both analyses increases the robustness of our findings.

We chose domestic terrorism in neighboring countries as our IV because intuitively, attacks by terrorists of one nationality in their own country against targets that share their nationality are more likely to have economic and psychological effects isolated to that particular state. Terrorism in neighboring countries may influence some individual decisions, such as the decision to travel or invest in those countries; however, it is dubious that these considerations would directly or indirectly influence fertility. Domestic terrorism's ability to directly create spillover terrorism is the most plausible channel; however, one might imagine a case where regional terrorism outside of one's own country induces stress and leads to altered fertility decisions based on the anticipation of spillover terrorism. This case could affect the validity of our instruments and potentially result in both biased and inconsistent estimates. We perform tests for weak identification and overidentifying restrictions, which assuages some of the concern related to the validity of our instrument choice. While persuasive, these tests don't completely guarantee the validity of any instrument; thus, we employ several falsification/placebo approaches to add further confidence in the direction of our effect from terrorism to fertility.

For our IV specifications we use the two lags of neighboring domestic terrorism incidents as our instruments and one lag of terrorist attacks as our explanatory variable of interest.[4] We chose to present the analysis containing only one lag of terrorist attack incidents because the majority of our effect was observed in that period for our FE and FD models. When including both lags in the IV estimation, the signs of the effects remain, but the significance drops to marginal levels due to the multiple stages of the IV attempting to estimate both terrorism measures over two lagged periods. Given that our previous FE/FD models showed the effect predominantly in the first lag, we believe that the one-lag specification is more appropriate for the IV approach. Apart from this, we control for time and individual country effects to account for inherent year shocks and fixed differences over time between countries. What follow are the specifications of our formal two-stage least squares (2SLS) IV model for the effect of terrorist attacks on fertility.[5]

Second stage:

$$fertility_{i,t+1} = \ln\left(terrorism_{i,t-1}\right)\alpha + pop\_char_{i,t}\rho + year_t\beta_t + country_i\lambda_i + \mu_{it} \tag{3}$$

First stage neighboring terrorism:

$$\ln(terrorism_{it-1}) = \sum_{k=1}^{2}\left(near\_terr_{i,t-k}\right)\omega_{t-k} + pop\_char_{it}\rho + year_t\beta_t + country_i\lambda_i + \varepsilon_{it} \tag{4}$$

The excluded instrument used was $near\_terr_{i,t-k}$ where i designates country and t designates year. Year and country fixed effects are designated as $year_t$ and $country_i$, respectively, and *pop_char* is a vector of our demographic, economic, and social freedom characteristics. Additionally, we implemented our IV approach with two first-differenced specifications. In those models, the variables in both stages are first-differenced and there are no country fixed-effects as those factors are differenced out.

4 Results of these analyses are available from the authors on request.

5 Our IV analysis uses a 2SLS approach and reports standard errors that are corrected for the 2SLS approach and are robust for both arbitrary heteroskedasticity and arbitrary intragroup correlation based on Schaffer (2005).

Table 2. Panel OLS: TFR fixed effects, models

Models: *TFR* ($t+1$)	(1) b/SE	(2) b/SE	(3) b/SE	(4) b/SE	(5) b/SE
Log terrorist attacks	−0.041*	−0.033**	−0.031**	−0.025*	−0.020
	(0.024)	(0.016)	(0.016)	(0.015)	(0.016)
Log terrorist attacks (t − 1)	−0.126***	−0.039**	−0.037**	−0.032**	−0.028*
	(0.020)	(0.015)	(0.015)	(0.014)	(0.015)
Population size / 1M			−0.001	−0.001	−0.001
			(0.001)	(0.001)	(0.001)
Population urban (% of total population)			−0.030***	−0.030***	−0.030***
			(0.009)	(0.009)	(0.009)
GDP *per capita* / 1K				0.086***	0.100***
				(0.013)	(0.015)
GFCE (% of GDP)				0.008	0.007
				(0.005)	(0.005)
Civil liberties					0.029**
					(0.013)
Year effects	No	Yes	Yes	Yes	Yes
Country effects	No	Yes	Yes	Yes	Yes
Observations	5,567	5,567	5,554	4,611	4,358
Number of countries	170	170	170	162	156
Log likelihood		−3,893.3	−3,739.2	−2,158.8	−1,893.4
AIC		7,860.6	7,556.5	4,399.7	3,868.8
BIC		8,105.7	7,814.7	4,663.5	4,130.3

Notes: Significance level at which the null hypothesis is rejected: *** 1%; ** 5%; and * 10%. Reported standard errors are robust to clustering by country and arbitrary heteroskedasticity. Coefficients that have been scaled are indicated as such with their scaling factor.

4. Empirical results

Table 2 estimates the effect of terrorist attacks on fertility using OLS with year and country fixed effects. The results show a statistically significant negative correlation for the first two lags of terrorist attacks with the following year's TFR. This effect translates to a 0.018 decrease in fertility rate observed two years following a standard deviation increase in log terrorist attacks.[6] Although this may seem small, it's important to put it into context. An increase in terrorism by 1 standard deviation results, on average, in a ~0.5% reduction in births.[7] In an average population where terrorism increased by 1 standard deviation, for every one million women, 18,000 fewer children will be born over a lifetime. Within the other covariates we see that a higher percentage urban population would expect a lower TFR; however, higher GDP *per capita* and civil liberties within a country correlate to an increased fertility rate. The negative relationship observed between percentage urban population and TFR is expected as urban areas are associated with higher levels of education for

6 $\Delta E[TFR] = \beta * \ln(1 + \sigma_{\ln(attack\_count)}) = -0.028 * \ln(1.91) = -0.0181$, 1 standard deviation equals 0.91.

7 This results in a 0.452% reduction given the overall average TFR of 4.002 across all countries. Lower fertility countries would observe a larger reduction if the same effect size holds.

women, usually have better access to family planning services, and tend to have fewer children than those living in rural areas, where children are used to perform essential tasks (Jaffe, 1942; Hiday, 1978; White *et al.*, 2008).

While it had generally been observed that more developed, high GDP countries have lower fertility rates, within a given country, changes in GDP *per capita* can result in varying associations with TFR (Becker and Tomes, 1976; Luci and Thévenon, 2010; Bongaarts and Sobotka, 2012). Overall, we find that increasing GDP *per capita* has generally been associated with increasing TFR over the time period analysed. After controlling for year and country fixed effects and the other demographic and economic indicators, we also observe that increases in civil and political freedoms are associated with higher fertility rates within a country. This positive relationship disappears and reverses sign when year effects are not included in the model, which would indicate that unobserved temporal shocks play an important role in the effect of this measure.

The fixed effects estimator helps address country-specific omitted variable concerns; however, in cases of serial correlation the standard errors can be underestimated. Given the close association between fertility rates year to year, there is a possibility of serial correlation in the fixed effects estimates. We implemented a first-differenced model in Table 3 to address this and test the robustness of our findings. As before, we find that the change in the first lag of terrorism attack incidents is statistically associated with a reduction in fertility. In the other covariates, we find similar statistically significant results as in the

Table 3. TFR first-difference models

Models: Δ*Total Fertility Rate* (*t* + 1)	(1) b/SE	(2) b/SE	(3) b/SE	(4) b/SE	(5) b/SE
ΔLog terrorist attacks	−0.004***	−0.004***	−0.004***	−0.003***	−0.003**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ΔLog terrorist attacks (*t* − 1)	−0.005***	−0.005***	−0.005***	−0.005***	−0.005***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ΔPopulation size / 1M			−0.003**	−0.003**	−0.002**
			(0.001)	(0.001)	(0.001)
ΔPopulation urban (% of total Population)			−0.013*	−0.018**	−0.024***
			(0.007)	(0.007)	(0.007)
ΔGDP *per capita* / 1K				0.035***	0.045***
				(0.007)	(0.005)
ΔGFCE (% of GDP)				0.001*	0.001**
				(0.000)	(0.000)
ΔCivil liberties					0.002*
					(0.001)
Year effects	No	Yes	Yes	Yes	Yes
Observations	5,298	5,298	5,285	4,377	4,131
Number of countries	169	169	169	159	154
Log likelihood	6,406.8	6,512.0	6,528.6	5,630.1	5,384.8
AIC	−12,807.7	−12,950	−12,979.2	−11,178.2	−10,687.6
BIC	−12,787.9	−12,706.7	−12,722.9	−10,916.4	−10,428.2

Notes: Significance level at which the null hypothesis is rejected: *** 1%; ** 5%; and * 10%. Reported standard errors are robust to clustering by country and arbitrary heteroskedasticity. Coefficients that have been scaled are indicated as such with their scaling factor.

Table 4. Fixed effects/first-difference models for CBR

Outcome: crude birthrate ($t+1$)	CBR ($t+1$)	
Model: first differenced (FD) or fixed effects (FE)	FE b/SE	FD b/SE
Terrorist attacks	−0.085	−0.020**
	(0.086)	(0.008)
Terrorist attacks ($t-1$)	−0.134*	−0.026***
	(0.077)	(0.009)
Population size / 1M	−0.003	−0.014**
	(0.006)	(0.006)
Population urban (% of total Population)	−0.179***	−0.136***
	(0.055)	(0.044)
GDP *per capita* / 1K	0.450***	0.214***
	(0.070)	(0.034)
GFCE (% of GDP)	0.022	0.006*
	(0.027)	(0.003)
Civil liberties	0.164**	0.008
	(0.066)	(0.006)
Year effects	Yes	Yes
Fixed effects (country)	Yes	No
Observations	4,499	4,319
Number of countries	158	157
Log likelihood	−9,729.0	−2,846.4
AIC	19,540	5,774.8
BIC	19,802.9	6,036.0

Notes: Significance level at which the null hypothesis is rejected: *** 1%; ** 5%; and * 10%. Reported standard errors are robust to clustering by country and arbitrary heteroskedasticity. Coefficients that have been scaled are indicated as such with their scaling factor.

fixed-effects specifications. Furthermore, we find that in these specifications, increases in population size are negatively associated with changes in TFR, whereas variations in GFCE are positively associated with changes in fertility.

In Table 4, we expand the analysis of our fixed-effects and first-differenced models with an additional measure of fertility, CBR. Again we observe statistically significant, negative effects of terrorism on fertility. The direction of effects for the other covariates remains unchanged, and the results further bolster the robustness of the overall finding. In Table 5, we evaluate the first-differenced model using a different measure of terrorism. We use deaths caused by terrorism and compare the results to those of terrorism attack incidents. The results using deaths from terrorism are much the same as the results with terrorism attacks for both measures of fertility. Consistent results, across multiple measures of fertility and terrorism, support the existence and direction of the observed effects.

Endogeneity between fertility and terrorism is a concern that must be addressed to establish a causal relationship and direction of effect. Although we believe terrorism is exerting a clear effect on fertility, it is within reason to consider that significant changes in fertility rates might incur stress on a population and result in conflict and terrorism as groups compete for scarce resources. In Table 6, we implement our IV approach on two different measures of fertility using domestic terrorist attacks in neighboring countries as

Table 5. First-differenced CBR and TFR versus terrorist attack deaths

Outcome: total fertility rate and crude birthrate Terrorism attack measure: deaths	TFR ($t+1$) b/SE	CBR ($t+1$) b/SE
Terrorism attack deaths	−0.002**	−0.010*
	(0.001)	(0.005)
Terrorist attack deaths ($t-1$)	−0.002**	−0.011*
	(0.001)	(0.006)
Population size / 1M	−0.003**	−0.014**
	(0.001)	(0.006)
Population urban (% of total population)	−0.024***	−0.135***
	(0.007)	(0.044)
GDP *per capita* / 1K	0.045***	0.214***
	(0.005)	(0.034)
GFCE (% of GDP)	0.001*	0.005
	(0.000)	(0.003)
Civil liberties	0.002*	0.008
	(0.001)	(0.006)
Year effects	Yes	Yes
Observations	4,131	4,319
Number of countries	154	157
Log likelihood	5,380.6	−2,849
AIC	−10,679.2	5,779.9
BIC	−10,419.9	6,041.1

Notes: Significance level at which the null hypothesis is rejected: *** 1%; ** 5%; and * 10%. Reported standard errors are robust to clustering by country and arbitrary heteroskedasticity. Coefficients that have been scaled are indicated as such with their scaling factor.

instruments for terrorist attacks. Overall, terrorism exerts a negative effect on fertility, observed in both TFR and CBR. Our instruments pass tests for weak identification and of overidentifying restrictions, which indicate support for both conditions of relevance and exclusion required for their validity. The direction of effect for the other covariates remains consistent with the previous findings. Results indicates that after controlling for unobserved country-invariant and time-invariant shocks, GDP *per capita* and civil liberties have an overall positive association with fertility, whereas higher urban populations are associated with lower overall fertility rates.

While the IV models are a strong indicator of a causal relationship between terrorism and fertility, it is important to further verify the robustness of our results. For example, terrorism should not change fertility rates before it occurs. Results demonstrating such a link would indicate a covariance between trends in fertility and terrorism rates resulting from omitted variables and/or endogeneity. Our initial falsification approach tests whether terrorist attacks occurring in the future have statistically significant predictive power in forecasting past fertility, a finding which could obviously not be viewed as causal. If $\beta_{Attack\ Count_{t+2}}$ is the coefficient for terrorist attack incidents in the next year following our measure of fertility, then the timing of this test establishes our hypothesis as H_0: $\beta_{Attack\ Count_{t+2}} = 0$ and H_1: $\beta_{Attack\ Count_{t+2}} \neq 0$. A finding of H_1 would indicate that terrorism/fertility sorting patterns by country are not wholly accounted for by the variables included in our specifications, implying a misspecification and correlation between omitted variables affecting fertility and terrorist attacks. Table 7

Table 6. IV approach: nearby domestic terrorist attacks

Instrumental variable	Neighboring country domestic terrorist sttacks			
Model: first differenced (FD) or fixed effects (FE)	FE		FD	
Outcome: total fertility rate and crude birthrate ($t+1$)	TFR b/SE	BR b/SE	TFR b/SE	BR b/SE
Terrorist attacks ($t-1$)	−0.149**	−0.654*	−0.029**	−0.167*
	(0.071)	(0.395)	(0.015)	(0.101)
Population size / 1M	0.000	0.000	−0.002**	−0.013**
	(0.001)	(0.005)	(0.001)	(0.006)
Population urban (% of total population)	−0.032***	−0.184***	−0.024***	−0.140***
	(0.009)	(0.055)	(0.007)	(0.044)
GDP *per capita* / 1K	0.094***	0.426***	0.045***	0.214***
	(0.014)	(0.067)	(0.005)	(0.032)
GFCE (% of countries)	0.008	0.025	0.001**	0.006*
	(0.006)	(0.028)	(0.000)	(0.003)
Civil liberties	0.027**	0.154**	0.002*	0.008
	(0.013)	(0.065)	(0.001)	(0.006)
Year effects	Yes	Yes	Yes	Yes
Fixed effects (country)	Yes	Yes	No	No
Observations	4,358	4,499	4,131	4,319
Number of countries	156	158	154	157
Log likelihood	−2,024.8	−9,808.3	5,223.1	−2,962.9
AIC	4,129.5	19,696.5	−10,366.3	6,005.8
BIC	4,384.7	19,953	−10,113.2	6,260.7
Hansen J (p-value)	0.37	0.23	0.15	0.12
Kleibergen-Paap rk Wald F statistic	15.11	15.2	15.86	15.23

Notes: Significance level at which the null hypothesis is rejected: *** 1%; ** 5%; and * 10%. Reported standard errors are corrected for 2SLS and robust to clustering by country and arbitrary heteroskedasticity. As we don't assume i.i.d. errors, we report the Kleibergen-Paap rk Wald F statistic as our test for weak instruments (Kleibergen and Paap, 2006). Coefficients that have been scaled are indicated as such with their scaling factor.

implements a falsification approach to test this possible concern. As expected, future terrorism rates are not statistically correlated with previous year fertility rates in both our fixed effects and first-differenced estimators of TFR and CBR.

Table 8 implements our second falsification approach, where we test the reverse association of our fertility measures on our measure of terrorism. This approach helps confirm the direction of the effect and alleviates some concerns related to endogeneity. Statistically significant effects would imply that fertility contains useful information for predicting future values of terrorism. In our previous results, it's clear that terrorism contains useful information for forecasting fertility; however, if we conclude the same about fertility it would imply that terrorism and fertility are both endogenous. Although we address endogeneity with our IV approach, this simple test further strengthens the estimates from our FE and FD models as it assuages some of the initial concerns regarding endogeneity. Testing the joint significance of the included lags of fertility, we find in support of the null hypothesis, H_0: $\beta_{Fertility_t}, \ \beta_{Fertility_t-1} = 0$.[8] The results are clear and indicate that both measures of

8 This test was carried out to further lags with similar results in favor of H_0.

Table 7. Falsification approach 1: estimate future terrorism on TFR and CBR

Outcome: total fertility rate and crude birthrate	TFR (*t* + 1)		CBR (*t* + 1)	
Model: first differenced *(FD)* or fixed effects *(FE)*	FD b/SE	FE b/SE	FD b/SE	FE b/SE
Terrorist attacks (*t* + 2)	−0.002	−0.009	−0.011	−0.028
	(0.001)	(0.017)	(0.009)	(0.097)
Terrorist attacks	−0.003**	−0.015	−0.019**	−0.069
	(0.001)	(0.010)	(0.008)	(0.053)
Terrorist attacks (*t* – 1)	−0.005***	−0.027**	−0.026***	−0.131*
	(0.001)	(0.013)	(0.009)	(0.069)
Population size / 1M	−0.002**	−0.001	−0.014**	−0.003
	(0.001)	(0.001)	(0.006)	(0.006)
Population urban (% of total population)	−0.023***	−0.030***	−0.129***	−0.175***
	(0.008)	(0.010)	(0.045)	(0.057)
GDP *per capita* / 1K	0.044***	0.100***	0.213***	0.457***
	(0.005)	(0.015)	(0.033)	(0.071)
GFCE (% of GDP)	0.001*	0.007	0.005	0.022
	(0.000)	(0.006)	(0.003)	(0.027)
Civil liberties	0.002**	0.029**	0.008	0.161**
	(0.001)	(0.013)	(0.006)	(0.066)
Year effects	Yes	Yes	Yes	Yes
Fixed effects (country)	No	Yes	No	Yes
Observations	3,987	4,213	4,173	4,352
Number of countries	154	156	157	158
Log likelihood	5,169.9	−1,786.2	−2,779.6	−9,367.8
AIC	−10,257.9	3,654.3	5,641.1	18,817.6
BIC	−10,000.0	3,914.5	5,900.9	19,079.1

Notes: Significance level at which the null hypothesis is rejected: *** 1%; ** 5%; and * 10%. Reported standard errors are robust to clustering by country and arbitrary heteroskedasticity. Coefficients that have been scaled are indicated as such with their scaling factor.

fertility are not statistically correlated with future terrorism in both the fixed effects and first-differenced estimators.

One question that arises is whether the results are equally present over different cross-sections of countries. This split between developed and developing countries is of particular interest as there may be different motivating factors for fertility between these groups. We reconducted the analysis to discern how the effects differ across countries based on development characteristics by splitting the data into two groups based on median average GDP *per capita* (see Fig. 1). Initial insight suggested that we should find a greater effect in lesser-developed regions where fertility rates are relatively higher.[9]

Contrary to initial expectations, in our analysis in Table 9, we find that the effect is concentrated in higher GDP *per capita* countries. Upon deeper consideration of the mechanisms

9 Interestingly, more developed countries, as measured by GDP *per capita*, observed a higher average number of terrorist attacks during our timeframe. As expected, average birthrates and total fertility rates were higher in less developed countries.

Table 8. Falsification approach 2: estimate TFR and birthrate on terrorist attacks

Outcome: terrorist attack counts ($t+1$)				
Fertility measure: *TFR* and *CBR*	TFR		CBR	
Model: first differenced *(FD)* or fixed effects *(FE)*	FD b/SE	FE b/SE	FD b/SE	FE b/SE
Fertility measure	−0.038	−0.835	−0.013	−0.065
	(0.321)	(0.573)	(0.033)	(0.059)
Fertility measure ($t-1$)	−0.108	0.679	−0.011	0.046
	(0.312)	(0.531)	(0.033)	(0.056)
Population size / 1M	0.005**	0.007***	0.006**	0.007***
	(0.003)	(0.002)	(0.003)	(0.002)
Population urban (% of total population)	−0.033***	−0.013	−0.030**	−0.013
	(0.012)	(0.010)	(0.012)	(0.010)
GDP *per capita* / 1K	−0.033	−0.034*	−0.039*	−0.042**
	(0.023)	(0.018)	(0.022)	(0.017)
GFCE (% of GDP)	−0.004	0.005	−0.003	0.003
	(0.005)	(0.008)	(0.005)	(0.008)
Civil liberties	0.014	−0.024	0.016	−0.022
	(0.015)	(0.021)	(0.015)	(0.020)
Year effects	Yes	Yes	Yes	Yes
Fixed effects (country)	No	Yes	No	Yes
Observations	4,110	4,282	4,319	4,489
Number of countries	153	153	157	157
Log likelihood	−4,563.7	−5,348.2	−4,798.1	−5,572.8
AIC	9,209.4	10,778.5	9,678.2	11,227.7
BIC	9,468.6	11,039.3	9,939.4	11,490.4
F-stat (p-value) joint significance H_0:$\beta_{fertility_{t,\,t-1}} = 0$	0.42	0.28	0.37	0.46

Notes: Significance level at which the null hypothesis is rejected: *** 1%; ** 5%; and * 10%. Reported standard errors are robust to clustering by country and arbitrary heteroskedasticity. Coefficients that have been scaled are indicated as such with their scaling factor.

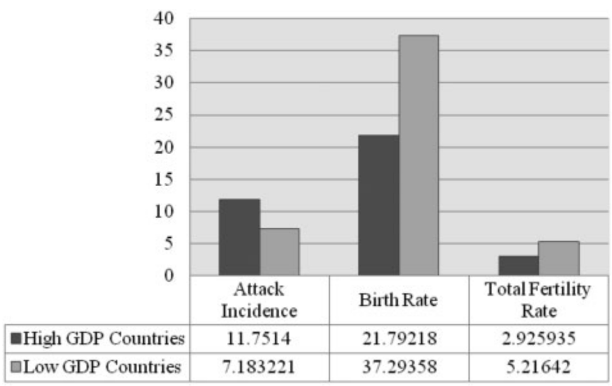

Fig. 1. Mean attack incidents, crude birthrate, and total fertility rate by GDP *per capita* (high/low)

Table 9. Mean attack incidents, CBR, and TFR by GDP *per capita* (high/low)

GDP *per capita* (high/low)	High				Low			
Outcomes: *TFR* and *CBR*	TFR $(t+1)$		CBR $(t+1)$		TFR $(t+1)$		CBR $(t+1)$	
Models: first differenced *(FD)* or fixed effects *(FE)*	FE b/SE	FD b/SE	FE b/SE	FD b/SE	FE b/SE	FD b/SE	FE b/SE	FD b/SE
Terrorist attacks	−0.041	−0.004**	−0.228	−0.020*	0.009	−0.002	0.021	−0.016
	(0.031)	(0.002)	(0.160)	(0.012)	(0.020)	(0.002)	(0.116)	(0.011)
Terrorist attacks $(t-1)$	−0.061***	−0.007***	−0.282**	−0.038***	0.004	−0.001	−0.037	−0.009
	(0.022)	(0.002)	(0.109)	(0.013)	(0.022)	(0.002)	(0.122)	(0.012)
Population size / 1M	−0.008	−0.009	−0.043	−0.063	0.000	−0.002*	−0.002	−0.011**
	(0.012)	(0.012)	(0.057)	(0.066)	(0.001)	(0.001)	(0.006)	(0.005)
Population urban (% of total population)	−0.055***	−0.036***	−0.278***	−0.182***	−0.017	−0.007	−0.147*	−0.076
	(0.012)	(0.011)	(0.070)	(0.063)	(0.014)	(0.011)	(0.084)	(0.067)
GDP *per capita* / 1K	0.002	−0.001	−0.062	0.001	−0.002	0.000	−0.008	0.001
	(0.013)	(0.001)	(0.078)	(0.009)	(0.006)	(0.000)	(0.031)	(0.002)
GFCE (% of GDP)	−0.004	0.002*	−0.037	0.002	0.052***	0.002*	0.269***	0.017**
	(0.016)	(0.001)	(0.090)	(0.012)	(0.019)	(0.001)	(0.102)	(0.008)
Civil liberties	−0.041	−0.004**	−0.228	−0.020*	0.009	−0.002	0.021	−0.016
	(0.031)	(0.002)	(0.160)	(0.012)	(0.020)	(0.002)	(0.116)	(0.011)
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed effects (country)	Yes	No	Yes	No	Yes	No	Yes	No
Observations	2,218	2,084	2,308	2,209	2,200	2,101	2,255	2,167
Number of countries	78	77	79	79	80	79	81	81
Log likelihood	−1,066.4	2,678.9	−5,115.3	−1,645.3	−1,151.6	2,801.6	−5,194.9	−1,268.9
AIC	2,212.8	−5,277.9	10,310.6	3,370.6	2,383.3	−5,523.2	10,469.7	2,617.8
BIC	2,440.9	−5,052.2	10,540.3	3,598.7	2,611.1	−5,297.2	10,698.6	2,845.1

Notes: Significance level at which the null hypothesis is rejected: *** 1%; ** 5%; and * 10%. Reported standard errors are robust to clustering by country and arbitrary heteroskedasticity. Coefficients that have been scaled are indicated as such with their scaling factor.

of the effect, theory supports a greater effect among wealthier countries. The increased risk of poor birth outcomes and infant mortality caused by the stress of terror and conflict endangers life such that the value of the future relative to the present is reduced; hence, a rise in terrorist activity results in decreased investment (Eckstein and Tsiddon, 2004). In wealthier countries individuals are more likely to better understand that children constitute a long-term investment and take it into greater consideration in their family size planning and investment strategies. Similar arguments have been made to explain the procyclical relationship between fertility and declining employment rates by the end of the 1990s in relatively wealthier European countries. Accordingly, delaying the search for a new career or job due to childbearing results in greater future earnings losses in wealthier societies, where there is more attachment to the labor force, particularly for highly educated women, and career concerns after job displacement may motivate the decision to postpone childbearing until a more stable time (Huttunen and Kellokumpu, 2012). Berrebi and Ostwald (2014) found clear evidence of declining female labor force participation following upsurges in terrorism that would further induce this delayed childrearing. With this logic, it is expected that the shock of terrorism could have a greater impact among more developed countries. Additionally, replacement effects following periods of increased risk from terrorism or conflict have been observed and reported for less developed countries, which often rely on children as workers (Agadjanian and Prata, 2002; Verwimp and Van Bavel, 2005). In these countries a positive relationship between fertility and risk is theorized to manifest from higher fertility acting as insurance against child mortality, thereby securing future income following economic shocks (Schultz, 1969, 1994; Pörtner, 2001).

5. Conclusion

This study empirically identifies a previously overlooked relationship between terrorism and fertility. Although this article demonstrates the relationship across a robust set of model types and specifications, there are still limitations and areas of further research. In particular, while our results justify a causal link, terrorism is likely acting through other specific mechanisms to influence fertility. As discussed in previous research on female labor force participation as well as civil conflicts, terrorism is likely to act on fertility through avenues of increased income and job uncertainty, psychological stress, and resultant poor health, which can cause significant short-term declines in fertility by affecting related factors such as time to first birth, age at marriage, frequency of sexual intercourse, and labor migration (Lindstrom and Berhanu, 1999; Agadjanian and Prata, 2002; Blanc, 2004; Woldemicael, 2008; Guha-Sapir and D'Aoust, 2011; Del Bono *et al.*, 2012; Berrebi and Ostwald, 2014). Future research into this area should include investigations to identify the underlying channels through which terrorism is acting on fertility.

This study is the first to empirically identify and quantify an effect of terrorism on fertility. Besides illuminating another far-reaching effect of terrorism, this relationship will be critical to understand when policy makers attempt to deal with other demographic transitions and security concerns. How societies act in response to the perception of threat from terrorist groups has far-reaching implications. Rather than demographic change being the root cause of terrorism, using a sophisticated empirical analysis, we were able to empirically identify causal effects of terrorism on larger-scale demographic transitions. Our findings explain some of the disparities between previous theories and results and put to rest some notions suggesting reverse directionality. Furthermore, these findings suggest that policy makers must be acutely aware of possible implications of terrorism on the fertility.

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