"The Economic Costs of Separatist Terrorism in Turkey"

Fırat Bilgel and Burhan Can Karahasan

IREA
Research Institute of Applied Economics

AQR
Regional Quantitative Analysis Research Group

IREA

Institut de Recerca en Economia Aplicada Regional i Públic
Research Institute of Applied Economics

WEBSITE: www.ub-irea.com • CONTACT: irea@ub.edu

AQR

Grup de Recerca Anàlisi Quantitativa Regional
Regional Quantitative Analysis Research Group

WEBSITE: www.ub.edu/aqr/ • CONTACT: aqr@ub.edu

Universitat de Barcelona
Av. Diagonal, 690 • 08034 Barcelona

The Research Institute of Applied Economics (IREA) in Barcelona was founded in 2005, as a research institute in applied economics. Three consolidated research groups make up the institute: AQR, RISK and GiM, and a large number of members are involved in the Institute. IREA focuses on four priority lines of investigation: (i) the quantitative study of regional and urban economic activity and analysis of regional and local economic policies, (ii) study of public economic activity in markets, particularly in the fields of empirical evaluation of privatization, the regulation and competition in the markets of public services using state of industrial economy, (iii) risk analysis in finance and insurance, and (iv) the development of micro and macro econometrics applied for the analysis of economic activity, particularly for quantitative evaluation of public policies.

IREA Working Papers often represent preliminary work and are circulated to encourage discussion. Citation of such a paper should account for its provisional character. For that reason, IREA Working Papers may not be reproduced or distributed without the written consent of the author. A revised version may be available directly from the author.

Any opinions expressed here are those of the author(s) and not those of IREA. Research published in this series may include views on policy, but the institute itself takes no institutional policy positions.

The Economic Costs of Separatist Terrorism in Turkey

Fırat Bilgel[*]   Burhan Can Karahasan[†]

Abstract

Turkey has been suffering from separatist terrorism and the political conflict it implies since the mid-1980s, both of which are believed to have a negative impact on economic welfare. This article investigates the economic costs of PKK (Kurdistan Workers' Party) terrorism, particularly in the Eastern and Southeastern provinces of Turkey by invoking the synthetic control method. We create a synthetic control group that mimics the socioeconomic characteristics of the provinces exposed to terrorism before the PKK terrorism emerged in the mid-1980s. We then compare the real GDP of the synthetic provinces without terrorism to the actual provinces with terrorism for the period 1975-2001. Causal inference is carried out by comparing the real per capita GDP gap between the synthetic and actual provinces and the intensity of terrorist activity as measured by the number of terrorism casualties. We find that after the emergence of terrorism, the per capita real GDP in Eastern and Southeastern Anatolia declined by about 6.6 percent relative to a comparable synthetic Eastern and Southeastern Anatolia without terrorism.

---

[*]Corresponding Author. Department of Economics, Okan University Tuzla Campus Akfırat 34959 Istanbul Turkey. Email: firat.bilgel@okan.edu.tr.

[†]Department of Economics, Okan University Tuzla Campus Akfırat 34959 Istanbul Turkey. Email: can.karahasan@okan.edu.tr.

1 Introduction

Terrorism has four major economic repercussions all of which have the ability to reduce economic welfare: Terrorist attacks reduce the human and physical capital stock; introduce higher levels of uncertainty; increase military expenditures and shift resources from productive sectors to defence industry; and adversely affect specific industries such as airline or tourism (Abadie and Gardeazabal, 2008). Although these effects may be pronounced for any type of terrorist activity, may it be domestic, transnational, separatist or radical Islamist, the nature and roots of an armed conflict is crucial in understanding the direction of causality between terrorism and economic indicators and consequently in designing effective policies in order to combat terrorism.

In this article, we investigate the economic costs of a highly chronic and invasive political and armed conflict of the modern history of Turkey, namely PKK terrorism, particularly prevalent in Eastern and Southeastern provinces of Turkey. By invoking the synthetic control method developed by Abadie and Gardeazabal (2003) and expanded by Abadie et al. (2010), we create a synthetic control group that mimics the socioeconomic characteristics of the provinces exposed to terrorism before the PKK terrorism emerged in the early 1980s by using the convex combination of provinces that have not been exposed to terrorism. We then compare the real per capita GDP of the synthetic provinces without terrorism to the actual provinces with terrorism for the period 1975-2001. Causal inference is carried out by comparing the real per capita GDP gap between the synthetic and actual provinces and the intensity of terrorist activity as measured by the number of terrorism casualties. We find that after the emergence of terrorism, the real per capita GDP in Eastern and Southeastern Anatolia declined by 6.6 percent relative to a comparable synthetic Eastern and Southeastern Anatolia without terrorism.

This study contributes to the empirical literature by investigating the causal effect of separatist terrorism on economic development using a novel methodology which is based on estimating the counterfactual: how the provincial GDP would have evolved in the absence of terrorism. In doing so, we aim to relax a set of stringent assumptions made in the literature on the causes and consequences of terrorism and to circumvent typically encountered problems of heterogeneity, endogeneity and extrapolation biases in traditional regression framework. Instead of employing a cross-country analysis using aggregate measures of terrorism (e.g. domestic vs. international or separatist vs. radical Islamist), we focus on a particular case of separatist terrorism, the PKK terrorism, which allows us to minimize heterogeneity biases. We also circumvent extrapolation biases that prevail in traditional regression analysis by restricting the analysis to the support of our data.

To the best of our knowledge, synthetic control method has not been used so far in studies on PKK

terrorism. In fact, the limited number of prior influential studies on the subject fell short in unraveling the true causal effect of separatist terrorism on economic growth. The application of synthetic control on different types of political conflicts, as advocated by Abadie and Gardeazabal (2003), may strengthen or weaken the robustness of the procedure and serve as cross validation.

The nature of PKK terrorism we investigate is structurally different than the nature of other terrorist groups such as ETA. ETA terrorism outbreaks in the highly prosperous region of Basque country in Spain and thus temporal variation in economic prosperity, as argued by Abadie and Gardeazabal (2003), is unlikely to have had a sizeable impact on ETA terrorism. In contrast, the PKK terrorism almost exclusively outbreaks in the least developed regions of Turkey. While in the ETA case, the absence of an endogenous relation between economic prosperity and the intensity of terrorist activity may be defended on legitimate grounds, in the PKK case adverse economic conditions may increase the intensity of terrorist activity and raise concerns for endogeneity.

If the conditions are satisfied, the endogenous relation between terrrorism and economic development is accounted for by the synthetic control method as opposed to instrumental variable (IV) or vector autoregression (VAR) methodology repeatedly employed in the empirical literature. While the IV is problematic because the instruments generally turn out to be weak, invalidating the consistency of the parameter of interest, the causal implication of VAR methodology is a mere prediction. The synthetic control method not only bypasses these issues, it also narrows the scope of the analysis by focusing on individual units.

Section 2 gives a brief account of regional disparities and PKK terrorism in Turkey, section 3 discusses the synthetic control method and its advantages over the traditional panel regression analysis, sections 3.3 and 3.4 respectively present the results and the placebo studies, section 3.5 performs a robustness check, section 4 discusses the findings of the analysis and the entailed methodological issues, section 5 concludes.

2 Terrorism and Regional Economic Development

2.1 Regional Disparities

Regional inequality is one of the major struggles of the Turkish economy. Tekeli (1992) relates this ongoing heterogeneity with the historical roots of the Turkish economy and underlines the social and economic determinants of regional imbalances. Tekeli (1992) gives two specific reasons regarding the continuity of the dual structure of the Turkish economy: one is the insufficiency of Turkey to integrate with Aleppo and its surrounding in the south; with Caucasus and Russia in the north. The other is the post-war era that results in a sudden sharp fall in the productive and young labor force during the early ages of the Republic and the

loss in the young and productive labor force especially in the eastern geography of Turkey, resulting from the ongoing terrorist activities over the last four decades.

The vast literature in Turkey originates from this duality and discusses whether the post-1980 liberalization era witnesses a rise or a fall in regional inequalities. The central hypothesis evolves from the traditional neoclassical convergence model of Barro and Sala-i Martin (1992); poor regions exhibit higher income growth rate relative to an already developed or high income region[1]. While studies indicate that there is little evidence for the poor locations to be growing faster with respect to the rich locations, the majority agree that this convergence struggle is far from decreasing the wide gap between western and eastern Turkey. These remarks are supported by other contemporary influential studies that focus on the additional spatial dimension of the regional imbalances in Turkey, signaling the increasing regional heterogeneity in the form of lagging east and leading west[2]. Even though it is difficult to fully capture the reasons behind the regional differences in the Turkish economy, what we can apprehend is the agglomeration of high economic activity with a better social and economic environment in the west, and clustering of relatively low level of economic activity with a social and economic environment well below the Turkish (as well as the European) average in the east and southeast.

Figure 1 maps the dispersion of provincial income for the 67 NUTS 3 (Nomenclature of Territorial Units for Statistics-3) regions of Turkey for the 1975-2001 period[3]. The spatial dispersion of per capita income during the last decades indicates a persistence of regional imbalances in Turkey; with the western regions in general well above the average per capita income of the country. Provinces in the Marmara Region, coastal provinces of the Aegean and the Mediterranean Regions as well as the provinces spread around the capital city Ankara in the Central Anatolia are located in the highest income quartile of the distribution. On the contrary, provinces in the Eastern and especially Southeastern Anatolia mostly cluster on the lowest income quartile of the distribution. Note that the middle income quartile provinces are mostly located on the Central Anatolia and behave as the transition provinces between high and low income clusters geographically. In general this dual pattern indicates that there are some positive economies generating externality-based development in the western territory on one hand and there are some other negative economies that are destroying the social and economic environment in the east. We claim that, keeping in mind various factors that might affect this pattern, the role of separatist terrorism can be a vital element behind the failure of these provinces especially in the eastern and southeastern Turkey to catch more developed locations of the west. The objective of the

---

[1]See Doğruel and Doğruel (2003), Karaca (2004), Gezici and Hewings (2004), Yıldırım and Öcal (2006), Gezici and Hewings (2007) and Öcal and Yıldırım (2010).

[2]See Kılıçaslan and Özatağan (2007), Filiztekin (2009), Filiztekin and Çelik (2010) and Çelebioğlu and Dall'erba (2010) for further dimensions of regional inequalities and the role of spatial dependence.

[3]From 1970s to 2000s, the number of provinces increased from 67 to 81. For our comparison of the 1975 and 2001 income dispersion, we aggregated these 14 provinces with the regions they were originally part of.

paper is not to focus on the factors causing this dual structure; rather we question the specific role of terrorist activities that may affect these locations negatively. Before getting into the details of our research, below, we briefly overview the history of separatist terrorism in Turkey and discuss the causal linkages between terrorism and economic development.

2.2   A Brief History of PKK terrorism in Turkey

Although the organizational history of Kurdish separatism dates back to 1974, it was formally established as a Marxist/Radical Kurdish Nationalist group in 27 October 1978 by Abdullah Öcalan and named PKK (Partiya Karkerên Kurdistan/Kurdistan Workers' Party). The organization aimed at establishing an independent Kurdish state in the region comprising Southeastern Turkey, Northern Iraq and Northeastern Syria. PKK insurgencies were concentrated mainly in the Kurdish-populated Eastern and Southeastern regions of Turkey. In the pre-1980 period, PKK imposed itself through few terrorist acts in Southeastern Turkey. Abdullah Öcalan escaped Syria shortly before the military coup of 12 September 1980, which brought PKK terrorist activities to a complete halt until the civilian regime resumed in 1983. PKK took advantage of the political repression between 1980-1983, recruited new militants and expanded its network (Sayarı, 2010). By 1984, PKK resumed its first terrorist activities in the Eastern provinces of Hakkari and Siirt. It is reported that between 1984 and 2008, 32,000 militants, about 6,500 security force members and about 5,700 civilians were killed in PKK terrorist activities[4].

Figure 2 shows the monthly intensity of PKK terrorist activity since 1984, measured by the number of casualties. Province-by-province PKK terrorist activity is collected from the Global Terrorism Database (GTD) and extracted from the Wikipedia - PKK attacks and armed conflicts chronology[5]. The information given in these sources have been cross-checked by a number of news media sources and by the publicly available information from the Turkish General Staff to verify the details of its content.

On October 1989, Turgut Özal became the first president of non-military origin of the Republic after the 1980 military coup. His presidency witnessed a period in which the Kurdish-Turkish political conflict was on the verge of a reconciliation. In search for a resolution, president Özal stated that he would be willing

---

[4]Figures are given by Ilker Başbuğ, former Chief of General Staff. See *Radikal Gazetesi*, 16 September 2008

[5]Global Terrorism Database: http://www.start.umd.edu/gtd/

   PKK attacks and armed conflicts chronology: http://tr.wikipedia.org/wiki/PKK_saldırıları_ve_çatışmaları_kronolojisi. Other sources from which data on PKK terrorism could be collected are the Memorial Institute for the Prevention of Terrorism (MIPT) and the Global Terrorism Index (GTI). While provincial figures on the number of deaths, attacks and injured are available from the MIPT, MIPT only includes information on separatist terrorist incidents only after 1998 and the GTI measures the impact of terrorism at the country level since 2001 whereas our sample covers 1975-2001. Since our methodology does not involve a regression analysis and does not explicity use the severity or intensity of terrorist activity in constructing the synthetic controls, collecting data from a source other than the GTD would not make any difference in our analysis. A downside of the GTD is that the terrorist incidents are not accompanied by a summary. Therefore, an incident is labelled as separatist only if PKK claimed responsibility. However, there may be other separatist incidents in Turkey by the PKK but were not claimed by PKK. In those cases, we did not collect the casualties of those indicidents.

to allow broadcasting in Kurdish language and open to discuss a federal system. In response to his efforts, PKK declared the first unilateral cease-fire in March 1993. However, the sudden death of Turgut Özal in April 1993 has called off the reconciliation process. In May 1993, the National Security Council announced that PKK members who have not been involved in terrorist acts be pardoned if they surrender. During the same month, PKK announced the end of first unilateral cease-fire, resulting in 17 deaths.

Between March 1993 and August 2010, PKK declared a total of seven cease-fires of which the longest lasted 4 years and 9 months (Sept. 1999 - Jun. 2004) and the shortest lasted only 2 months (Dec. 1995 - Jan 1996). Terrorist activities were particularly intense during the 1992-1994 period. The average yearly number of recorded fatalities during this 3-year period was over 1,000. While the number of fatalities were substantially higher than the number of injuries in the pre-1994 period, this pattern has reversed in the post-1994 period with improvements in military tactics and technology.

On February 1999, Abdullah Öcalan was captured in Kenya. On September 1999, a group of PKK members surrendered after Abdullah Öcalan ordered PKK members to leave Turkey. Subsequently, PKK declared the fourth cease-fire which lasted until June 2004. During this five year period, PKK stated to have undergone a structural change in its operational tactics and declared a formal end to its terrorist activities. On April 2002, PKK changed its name to KADEK (Kongreya Azadî û Demokrasiya Kurdistanê/Kurdistan Freedom and Democracy Congress) in an attempt to operate as a legal and legitimate organization and stated that they would purely remain a political organization (Sözen, 2006). On October 2003, KADEK declared its dissolution and formed KONGRA-GEL (Kongreye Gelê Kurdistan/Kurdistan People's Congress) in order to avoid being listed as a terrorist organization by the US and the Europe (Sözen, 2006). Even though KONGRA-GEL (formerly PKK) declared to adhere to use peaceful methods in achieving its goals, the organization continued to carry out terrorist activities, citing the government's refusal to negotiate as a justification for their actions.

2.3 On the Causal Link between Political Freedom, Terrorism and Economic Development

It may be plausible to infer that the causal relationship between terrorism and economic development is bidirectional. While terrorism may have severe human and economic consequences due to destruction of physical capital, lost lives, higher levels of uncertainty which may crowd-out foreign direct investment (FDI) and an increased share of resources moving away from productive industries, macroeconomic factors may also affect terrorism. There are few interconnected channels through which macroeconomic conditions may affect terrorism. First, terrorism may be rooted in economic deprivation, characterized by poverty and inequality.

Poor economic conditions may foster frustration and despair which may in turn increase the likelihood of violence (Krieger and Meierrieks, 2011; Freytag et al., 2011). Recent evidence further indicates that economic downturns may also lead to an increasing intensity in terrorist activity or terrorist risk (Blomberg et al., 2004a,b; DiRienzo and Das, 2012). The link than runs from economic deprivation to terrorism is more likely to prevail in the case of PKK terrorism which almost exclusively strikes the poorest and the most underdeveloped regions of the country.

Economic deprivation is closely linked to low educational attainment which may feed terrorism. Unlike other terrorist organizations such as the Islamic militant group Hezbollah, PKK often recruit their militants among socio-economically deprived members of the society. This suggests that economic conditions affect terrorist activity directly through the grievances associated with faltering economic conditions and injustices and also indirectly through exploiting the conditions that impede modernization efforts. However, these two effects may not be easily decoupled from one another empirically (Krieger and Meierrieks, 2011). Poor economic conditions suppress modernization which in turn foster terrorism. Increasing terrorist activity or intensity in turn inhibits economic development and modernization.

Identifying the causal relationship between terrorism and economic development has been at the center of the empirical literature[6]. The majority of studies have found evidence supporting the view that terrorism negatively affects national income, although the range of the magnitude of this impact varies considerably. In within-country studies of Abadie and Gardeazabal (2003), Eckstein and Tsiddon (2004) and Buesa et al. (2007), separatist terrorism is found to have a sizeable impact on GDP. In cross-country studies of Gupta et al. (2004) and Blomberg et al. (2004a), domestic and transnational terrorism is found to exert some impact on GDP growth while Tavares (2004), Abadie (2005) and recently Gries et al. (2011) found no impact of domestic and/or transnational terrorism on GDP or GDP growth. In other studies, transnational terrorism is shown to impose significant and sizeable effects on the microeconomic climate[7].

To the best of our knowledge there has been five empirical papers dealing with both the roots and the consequences of terrorism in Turkey exclusively and the evidence is mixed. While Araz-Takay et al. (2009) and Derin-Güre (2011) account for a potential endogenous relation between GDP (as a proxy for economic prosperity) and terrorism using the vector autoregression (VAR) methodology, the former study finds a causal link that runs from GDP to terrorism only in recessionary periods but the latter study finds no causal link irrespective of the course of the overall economy. A potential explanation of this inconsistency, inter alia, given the methodological similarities is that the former study accounts for both domestic and transnational

---

[6]See Sandler and Enders (2008) and Krieger and Meierrieks (2011) for an excellent overview of the literature on the roots and consequences of terrorism.

[7]See Enders and Sandler (1996) and Abadie and Gardeazabal (2008) on the impact of terrorism on net FDI; Drakos and Kutan (2003), Enders and Sandler (1991) and Enders et al. (1992) on tourism; Chen and Siems (2004) and Eldor and Melnick (2004) on financial markets; and Nitsch and Schumacher (2004) on bilateral trade.

terrorism while the latter study only takes into account incidences of separatist terrorism.

Employing the geographically weighted regression (GWR) methodology to obtain local parameter estimates, Öcal and Yıldırım (2010) analyzes the economic consequences of separatist terrorism and states that terrorism hinders economic growth. In a subsequent article using the same methodology, Yıldırım and Öcal (2012) concludes that policies aimed at enhancing income, education and employment would inhibit terrorism. An earlier study by Feridun and Sezgin (2008) also suggests that GDP, in particular agriculture and government services, may be helpful in explaining separatist terrorism. While Öcal and Yıldırım (2010) seems to be the closest to ours in terms of the focus of interest, the approach followed in our study explicitly deals with endogeneity caused by the presence of time-varying unobservable provincial heterogeneity which has not been taken into account by the above studies in a causal framework[8].

A close inspection reveals that the inconsistency of the results in the literature may be attributed to (1) weak theoretical guidance on the nature and impact of terrorism, (2) failure to account for the correct type of terrorism (i.e. domestic, international, separatist, radical Islamist etc...), (3) failure to account for the endogenous relation between terrorism and socio/politico-economic factors and (4) failure of identifying the correct unit of observation at which policy decisions are made (i.e micro vs. macro, cross country vs. within country).

Political repression, identity issues and cultural clash lie at the heart of separatist terrorism. Testas (2004) and Abadie (2005) has shown that political freedom exerts a non-monotonic effect on terrorism. In a highly authoritarian or totalitarian regime, terrorist activities are unlikely to flourish due to extreme levels of political repression and less opportunities for revolt. Typical examples include Sudan, Yemen, Iran and Jordan in the highly repressive pre-1991 period (Testas, 2004). At the other extreme, political terrorism would vanish in democratic regimes because there is no incentive for conflict. In between these two extremes, countries that transcend from an authoritarian regime to democracy are more likely to be exposed to increasing levels of terrorist activity (Abadie, 2005).

In line with this view, periods of intensive terrorist activities in Turkey, as noted by some prominent scholars and intellectuals, coincide with periods of democratization. Figure 3 displays the evolution of political rights and PKK terrorist activity since 1978, in which a higher index value of political rights implies lower political freedom. The sustaining escalation of PKK terrorism in Turkey started in 1987 and peaked in 1992, in a period when political freedom reached its highest level since 1978 (an index value of 2/7). This has created opportunities for armed rebellion. After 1992, the political climate in Turkey began to destabilize. Although political freedom and civil rights and liberties lowered after 1992, the economic crisis in 1993-1994 period

---

[8]In another strand of literature, see Köşeli (2007), Başıbüyük (2008) and Derin-Güre and Elveren (2013) on poverty and inequality as the roots of terrorism, Yaya (2009) and Feridun (2011) on the effects of terrorism on tourism and Feridun and Shahbaz (2010) on the relationship between defence spending and terrorism in Turkey.

was a hard hit on Turkish economy yielding higher levels of uncertainty that lead to greater opportunities for violence in the short-run. Despite such exceptions, there has been a stable decline in terrorist activities between 1995 and 2002 while political freedom was stagnating at low levels (an index value of 4/7).

PKK terrorism is a manifestation of a political conflict. Therefore, we claim that improvements in the macroeconomic environment alone are very unlikely, if not impossible, to reduce separatist terrorist acts. This does not suggest that changes in the macroeconomic indicators do not affect terrorism but rather implies that the causal link from economic growth to terrorism is relatively weak. On the other hand, the (long-term) causal impact of PKK terrorism on economic prosperity is a more relevant and realistic issue, to which we now turn. In the following section, we seek to answer, along the lines of Abadie and Gardeazabal (2003), how the provincial GDP would have evolved in the absence of separatist terrorist activity.

3   Synthetic Control Method

The synthetic control method, developed by Abadie and Gardeazabal (2003) and extended by Abadie et al. (2010) and Abadie et al. (2012), has a number of advantages over the traditional panel data regression framework. In traditional regression analysis, the choice of the comparison units is left at the discretion of the researcher, based on the degree of similarity between the control and the affected units. In the synthetic control method, the choice of the appropriate counterfactual is selected from a pool of unaffected units (the *donor pool*) to compare to the treated province. The appropriate comparison unit is based on observable and quantifiable characteristics which reduces subjectivity and allows for better causal inference (Abadie et al., 2010).

Unlike traditional regression analysis which relies on extrapolation outside the support of the data, the synthetic control method constructs a linear combination of provinces unexposed to terrorism with positive weights that sum to one. The traditional regression also, but rather in an implicit way, computes these weights which can be positive or negative but not necessarily sum to one. This may lead to severe extrapolation biases. In synthetic control method, the weights are assigned to provinces in the donor pool in such a way that the pre-terrorism GDP and the covariates that are thought to influence GDP are comparable to those of the treated province before the outbreak of terrorism[9]. This comparability is determined by the minimization of root mean square prediction error (hence RMSPE) in the pre-terrorism period, which measures the lack of fit between the trajectory of the outcome varible and its synthetic counterpart (Abadie et al., 2012)[10].

The synthetic control method allows the effect of unobservable provincial heterogeneity to vary over time.

---

[9]For technical details, consult appendix D of this article and Abadie et al. (2010) p:494-496.

[10]The pre-terrorism RMSPE is $\left(\frac{1}{T_0} \sum_{t=1}^{T_0} \left(Y_{1t} - \sum_{j=2}^{P+1} w_j^* Y_{jt} \right)^2 \right)^{1/2}$ and the post-terrorism RMSPE is

In the fixed effects (FE) model and the difference-in-differences (DiD) estimator, the effect of unobservable heterogeneity is assumed to be fixed over time. Hence, the synthetic control method provides an improvement over FE and DiD methods and deals better with endogeneity caused by the presence of time-varying unobservable confounders, all of which were presumed to have been accounted in the traditional regression framework.

3.1 Prerequisites

As explained in Dhungana (2011), the accuracy of the synthetic control (i.e. the synthetic control correctly isolates the impact of terrorism on GDP) depends on a number of prerequisites. The intervention, which is in our case the terrorist activity, has to be significant in the sense that the intervention has the potential to affect the economy and should sustain for a period of time. This implies that if the terrorist activity is observed for a year or two and ceased to exist thereafter, then the synthetic control would not be able to pick up any effect of terrorism in that region.

The pre-terrorism period should be sufficiently long so that the synthetic control method minimizes possible biases arising due to unobservable time-variant provincial heterogeneity[11]. In our sample, the pre-terrorism period ranges from 9 to 15 years depending on the year in which a particular province first exposed to terrorism. If the number of pre-terrorism periods is large, matching on pre-terrorism outcomes allows to control for heterogenous responses to multiple unobserved factors. The intuition is that only provinces that are alike in both observed and unobserved determinants as well as in the effect of those determinants on GDP should produce similar trajectories of the GDP over extended periods of time (Abadie et al., 2012).

The treated province should not have undergone a structural shock, exclusive to that region or province. For example, if the treated province experienced a sizeable blue-collar strike or an earthquake and terrorist activity during the same period, it is not possible to isolate the effect of terrorism in the variable of interest. On the other hand, structural breaks such as nationwide economic crises or military interventions that affect both the treated provinces and the donor pool do not invalidate the synthetic control estimates.

Terrorist activity should not have an effect on provinces not exposed to terrorism (absence of geographical spillover). If terrorism in a particular treated province had negative spillover effects on the GDP of the synthetic control provinces, then the synthetic control provinces would underestimate the counterfactual GDP trajectory of the treated province in the absence of terrorism and the synthetic control estimates would

---

$\left(\frac{1}{T_1} \sum_{t=T_0+1}^{T_1} \left(Y_{1t} - \sum_{j=2}^{P+1} w_j^* Y_{jt} \right)^2 \right)^{1/2}$ where T_0 and T_1 are the pre-terrorism and post-terrorism number of periods respectively, $w_j^* Y_{jt}$ is the synthetic GDP using the jth unexposed province with weight w^* and Y_{1t} is the actual GDP of the treated province.

[11] The bias of the synthetic control estimator is bounded as the number of preintervention periods increases. See Abadie et al. (2010) p:504.

be biased downward. On the other hand, spillover effects on provinces not included in the synthetic control do not affect synthetic control estimates (Abadie et al., 2012).

The intervention should not affect the treated province before or after it actually takes place (absence of temporal spillover). For example, the presence of anticipatory effects is a typical concern when the intervention is a large-scale policy change or legislation which may induce a significant alteration in economic behavior in response to its anticipated rather than actual effects. In the presence of anticipatory effects, the intervention date may be reassigned to a period in which the outcome is known to react to the intervention (Abadie et al., 2012). On the other extreme, the intervention may have lagged effects. In this case, the effects of the intervention are observed after a certain period of time.

The method constructs a synthetic version of the treated province by using some weighted combination of unexposed provinces (convex-hull criteria). This means that the synthetic control would not yield accurate trajectories of the provinces with extreme values of the variable of interest and other observable characteristics. The synthetic control method would fail to mimic the pre-terrorism real GDP of the poorest and the wealthiest treated province in the sample because the linear weighted combination of the real GDP of the donor provinces cannot yield a synthetic real GDP as low as the GDP of the poorest and as high as the GDP of the wealthiest treated province.

The synthetic control estimates are based on a linear model. This suggests that the donor pool may have to be restricted to provinces with similar observable characteristics in order to yield a good approximation.

3.2 Data and Sample

We use province-level panel data for the period 1975-2001. Our sample period begins in 1975 because it is the earliest year for which data on real per capita GDP is available at the provincial level. Our sample period ends in 2001 because provincial real GDP has not been made available after 2001.

Table 1 displays the descriptive statistics for a selected number of socio-economic and demographic indicators and the intensity of PKK terrorist activity in the Eastern and Southeastern Anatolia, where PKK activities have been mainly concentrated, vis-a-vis the rest of Turkey. In order to facilitate the comparisons, we report the variables in relative terms with values corresponding to each indicator normalized to 100 for the entire country. A striking fact in these comparisons is that the Eastern and Southeastern Anatolia regions have systematically lower per capita GDP, productivity and low educational attainment at almost all education levels; but also these regions are exposed to high levels of PKK terrorist activity (about 87 percent of all terrorism casualties) compared to the rest of the country.

Currently there are 81 provinces in Turkey of which 14 of them became province between 1989 and 1999.

However, since our sample period goes back to 1975, we aggregated these 14 new provinces into the existing 67 provinces. As shown in figure 4, of these 67 provinces, 30 were exposed to terrorist activity during this period, of which, ten were seldom exposed to terrorism with very few casualties and very infrequent incidents (i.e. they failed to exhibit sustained activity), therefore were shifted into the donor pool.[12].

As mentioned in section 3.1, one of the prerequisites for the synthetic control method to correctly isolate the impact of separatist terrorism on GDP is that the treated unit should not have undergone a structural shock, exclusive to that region or province. Table 2 summarizes nationwide as well as exclusive structural shocks during the period of 1975-2001. There were seven economic crises all of which had nationwide or global effects affecting all treatment and donor provinces[13]. Therefore, the effects of these economic crises do not invalidate the synthetic control estimates. What may be of high concern is the presence of eight natural disasters sufficiently severe to strike the local economy in the sample period. Four of these disasters affected the treated provinces (Diyarbakir in 1975, Van in 1976, Erzurum in 1983 and Erzincan in 1992) and the remaining four affected provinces in the donor pool (Afyon in 1995, Adana in 1998, Kocaeli and Bolu in 1999). Therefore we removed these four provinces from the treated units and the four provinces from the donor pool. Additionally, we also removed Istanbul from among the treated units on the grounds that Istanbul is the largest and wealthiest province with a high economic growth rate and its inclusion may undermine the impact of terrorism. This yields a total of 43 provinces to be used in the donor pool and 15 potential provinces to be treated all of which are located in the Eastern or Southeastern Anatolia. As the descriptive statistics in table 1 show, Eastern and Southeastern Anatolia regions have systematically lower real per capita GDP, indicating that the synthetic control method will fail to synthetize the real GDP trajectory of the poorest treated provinces in the Eastern and Southeastern Anatolia (i.e failure to satisfy the convex-hull criteria).

First, in order to satisfy the requirement of a sufficiently long pre-terrorism period and the convex-hull criteria, we dropped four provinces (Hakkari, Siirt, Mardin and Ağrı) from among the treated units which were on and off exposed to terrorism in the pre-1988 period and which are fairly poorer, not only compared to the rest of Turkey but also compared to the rest of Eastern and Southeastern Anatolia. Second, in order to increase the power of the synthetic control, we aggregated all the remaining 11 provinces into a single treated

---

[12]These provinces are Gümüşhane, Sivas, Hatay, Adana, Ankara, Içel, Bursa, Artvin, Çankırı and Isparta all of which are located outside Eastern and Southeastern regions. Although PKK terrorist activities occured in other regions, they have been mainly concentrated in the Eastern and Southeastern Turkey. We claim that due to very low and infrequent activity these provinces are not as heavily affected directly by PKK terrorism as the other eastern and southeastern provinces, implying that their inclusion in the donor pool would have a negligible, if any, bias on our synthetic control estimates. In our view the negligible effect of direct terrorist activity in these ten provinces make them indifferent with respect to the other provinces in the donor pool that are not directly affected by terrorism. Moreover, we justify our strategy by referring to Abadie and Gardeazabal (2003) which use a combination of two Spanish regions (Catalonia and Madrid) to synthetize the real GDP of the Basque country in the absence of terrorism although ETA terrorism occurred in these two control regions.

[13]Although these economic crises may have distinct effects on different regions based on methods of production and employment structures, the provinces in our sample that were directly exposed to terrorism have similar production structures historically.

unit (Eastern and Southeastern Anatolia) by calculating the weighted averages of all treated provinces for the outcome variable and the covariates for every year in the sample period on the grounds that a temporal spillover effect may exist among the provinces affected by PKK terrorism[14]. The first year of terrorist activity for the constructed Eastern and Southeastern Anatolia is 1988 which is the earliest year of first PKK terrorist activity reported within this region or treated unit (the latest year of first terrorist activity for a particular treated province in our sample is 1990). For example, one of the provinces (Bingöl) used in the aggregation to construct the treated unit of Eastern and Southeastern Anatolia was first exposed to PKK terrorism in 1988 and another neighboring province (Muş) used in the aggregation was first exposed to PKK terrorism in 1990. We treat the province of Muş as if it was affected by PKK terrorism in 1988, although it was exposed in 1990. Given the historical similarities of the provinces in the region and the short time period between the earliest and the latest year of first terrorist activity, we argue that the threat of PKK is a compelling indication for treating all late-terror-exposed provinces as if they were affected in 1988. The synthetic version of Eastern and Southeastern Anatolia is constructed from the weighted combination of provinces in the donor pool which were not exposed to or were not affected by terrorism at any year in the sample period.

The set of socioeconomic characteristics we consider to synthetize our outcome variable, the provincial real per capita GDP of Eastern and Southeastern Anatolia are the provincial real per capita GDP of the unaffected control provinces for every year in the pre-terrorism period, provincial GDP growth, population density, real wage (manufacturing industry), productivity (manufacturing industry), unemployment rate and a selection of human capital measures for the period 1975-2001. The real per capita GDP data is available for each year under consideration, hence used for every year in the pre-terrorism period. Yet other social and economic indicators cannot be gathered for each year under investigation. Thus these covariates are used when available at least for one year in the pre-terrorism period.

Our real GDP data comes from three different sources. The earliest provincial real per capita GDP data is collected from Özötün (1980) for the period 1975-1978; Özötün (1988) for the period 1979-1986 and the Turkish Statistics Office (TURKSTAT) for the period 1987-2001[15]. Data on manufacturing wages and productivity comes from the Annual Manufacturing Survey of TURKSTAT, population density, unemployment rate and the selected human capital indicators come from the 1985 and 1990 Annual Population Censuses (TURKSTAT).

In the final specification for which we report our results, we dropped all the covariates except the real per

---

[14]This temporal spillover effect should not be confused with the geographical spillover effect whose absence is one of the requirements of the synthetic control. Here, we take into account the likelihood that the outbreak of terrorism in one of the provinces may have a spillover effect in another province which was later hit by terrorism whereas the requirement of the absence of a geographical spillover effect for employing the synthetic control states that the spillover effect should not infect the provinces in the donor pool (unaffected units) which we assume is met.

[15]See appendix C for a brief explanation about the steps that are carried out to make these three datasets comparable and consistent.

capita GDP of the unaffected control provinces for every year in the pre-terrorism period and the average real per capita GDP growth rate because neither did other covariates improve the pre-terrorism fit of the trajectory of real GDP nor yield accurate GDP trajectories when all the covariates except the real GDP of the unaffected control provinces were used. This implies that the pre-terrorism actual GDP trajectory of Eastern and Southeastern Anatolia is best reproduced by some linear combination of the GDP of the unaffected provinces.

3.3 Results

In the preliminary analysis, we performed the synthetic control both at the province level and by province-aggregation based on the first year of terrorist activity. The results, which are available upon request, either proved to be of little significance in properly snythetizing the actual GDP trajectory in the pre-terrorism period although we did find significant causal effects in the post-terrorism period for a small subset of treated units, or failed to pass the falsification tests[16].

Figure 5 plots the trends in real GDP for Eastern and Southeastern Anatolia and its synthetic counterpart over the period 1975-2001. The synthetic real GDP trajectory is constructed by using the convex combination of provinces in the donor pool that closely resembled Eastern and Southeastern Anatolia before the outbreak of terrorism[17]. The synthetic GDP trajectory almost perfectly mimics the actual GDP trajectory in the pre-terrorism period, which is an initial sign of success of the synthetic Eastern and Southeastern Anatolia. In the next three years following the intervention, the actual GDP rises sharply while while its synthetic counterpart rises slightly and slowly. After this period, the synthetic GDP trajectory rises sharply above the actual GDP trajectory of the Eastern and Southeastern Anatolia over the entire sample period.

The estimate of the impact of terrorism on economic development for Eastern and Southeastern Anatolia is given by the difference between the actual and the synthetic GDP, as shown in figure 6. In figure 6, we further plot the intensity of terrorist activity and attempt to establish the link between separatist terrorism and the gap between actual GDP and its synthetic counterpart. The real GDP gap in Eastern and Southeastern Anatolia very closely tracks in the zero-gap-line in the pre-terrorism period (indicating good fit) and begins to dive approximately two years after being exposed to terrorist activity; in 1992 when the PKK terrorism peaks. The gap between the actual GDP and its synthetic version deepens as the Eastern and Southeastern Anatolia is exposed to an increasing intensity of terrorist activity, measured by the number of reported casualties. This suggests that separatist terrorism imposes a sizeable and increasing effect on the real GDP over time. Our findings suggest that in the post-terrorism period, the real GDP declined on average by 6.6

---

[16]See Section 3.4 on the falsification tests.
[17]We use the `synth` command in STATA, which can be found at http://www.mit.edu/~jhainm/synthpage.html

percent relative to a synthetic Eastern and Southeastern Anatolia without terrorism[18].

3.4 Inference about the Impact of Terrorism

In order to ensure that a particular synthetic control estimate reflects the impact of terrorism (i.e. the synthetic controls provide good predictors of the trajectory of per capita GDP in pre-terrorism periods), we perform a series of falsification tests known as *in-space placebo* test, in which we artificially reassign the terrorism period to each of the 43 provinces not directly exposed to terrorism and shift the treated unit into the donor pool. If the Eastern and Southeastern Anatolia was heavily exposed to terrorism and other provinces were not, our expectation is that the unexposed units that are subject to the synthetic control method should not be affected by terrorism, thus should not yield a diverging actual and synthetic GDP akin to that of the treated unit. Therefore, our confidence that a sizeable synthetic control estimate reflects the effect of terrorism would be severely undermined if similar or larger estimated GDP gaps are obtained when terrorism is artificially assigned to provinces not directly exposed to terrorism (Abadie et al., 2010)[19].

Figure 7 reports the results of the placebo experiments. The black line represents the estimated GDP gap of Eastern and Southeastern Anatolia and the gray lines represent the estimated GDP gap for provinces not directly exposed to terrorism. In order to infer that separatist terrorism imposes a significant negative effect on real GDP, the estimated GDP gap (actual−synthetic) of Eastern and Southeastern Anatolia should be very close to zero in the pre-terrorism period (i.e. should yield a good fit) but should also stand out in the post-terrorism period (i.e. the gap should be as negative as possible) relative to the estimated gaps for the provinces in the donor pool. Otherwise, we would either infer that the post-terrorism GDP gap is artificially created by a lack of fit (Abadie et al., 2010), or separatist terrorism does not have any sizeable impact on real GDP of the treated unit. The former may happen when the pre-terrorism fit is poor and the latter may happen when the synthetic GDP closely tracks the actual over the entire sample period. Along the placebo experiments ran for all the provinces in the donor pool, we additionally report two sets of the placebo results for a restricted number of placebo runs based on a mean square prediction error (MSPE) cut-off level. The upper panel in figure 7 displays the estimated real GDP gap for Eastern and Southeastern Anatolia and the placebo gaps for the remaining 43 provinces in the donor pool. The synthetic real GDP yields an excellent fit in the pre-terrorism period. The middle panel in figure 7 discards all the provinces with a MSPE ten times higher than the treated unit's. At this cutoff level, 12 provinces are discarded from the donor pool.

---

[18]This causal effect is calculated by taking the ratio of the difference between the average real GDP of the synthetic and the average real GDP of the actual Eastern and Southeastern Anatolia to the average real GDP of the synthetic Eastern and Southeastern Anatolia in the post-terrorism period.

[19]A second array of falsification tests is known as *in-time placebo* tests, in which the outbreak of terrorism is artificially reassigned to dates earlier than the actual date. We did not perform in-time placebos because our sample period is not sufficiently long to assign an artificial date of intervention for Eastern and Southeastern Anatolia.

the lower panel in figure 7 discards all the provinces with a MSPE five times higher than the treated unit's. At this cutoff level, a total of 26 provinces are discarded[20]. In the post-terrorism period, the estimated gap widens (in absolute value) and clearly stands out. Although the post-terrorism real GDP gap for Eastern and Southeastern Anatolia is not one of the largest among all the placebo gaps, indicating that the impact of PKK terrorism is not huge, this post-terrorism real GDP gap, as shown below, is a causal rather than a random effect.

In order to assess this, we apply the synthetic control method to estimate *in-space* placebo GDP gaps for every potential control province in order to create a distribution of placebo effects. This distribution enables us to identify the exact significance level of the estimated effect of separatist terrorism. Our confidence that a sizeable synthetic control estimate reflects the effect of terrorism would be severely undermined if the estimated gap fell well inside the distribution of placebo gaps (Abadie et al., 2012). This would imply that our results were driven by randomness rather than causality. In other words, a significant causal effect of separatist terrorism on the treated unit requires that the estimated effect should be unusually large relative to the distribution of placebo effects. The estimated effect of terrorism for the treated unit is evaluated by calculating the ratio of post-terrorism RMSPE to pre-terrorism RMSPE that are equal to or greater than the one for the treated unit. This ratio is the p-value that can be interpreted as the probability of obtaining a post/pre-terrorism RMSPE that is at least as large as the one obtained for Eastern and Southeastern Anatolia when terrorism is artificially and randomly reassigned to an unexposed province (Abadie et al., 2012).

Figure 8 plots the distribution of placebo effects for Eastern and Southeastern Anatolia and for every 43 province in the donor pool. The estimated GDP gap fell well outside the distribution of placebo gaps. This means that, if a province would have been randomly selected from the sample, the probability of obtaining a post/pre-terrorism RMSPE ratio as high as that of Eastern and Southeastern Anatolia would be $1/44 = 0.0227$. No control province in the sample achieves such a high ratio. This p-value is below the 5-percent conventional test level used to reject the null hypothesis for testing the significance of a parameter estimate in the traditional regression analysis.

3.5 Robustness Test

In this section, we perform a robustness check to test the sensitivity of our results to the changes in the synthetic control province weights induced by the exclusion of any particular province from the sample. From table 4, the synthetic Eastern and Southeastern Anatolia is constructed by the weighted average of nine provinces, namely Ankara, Artvin, Çankırı, Giresun, Gümüşhane, Muğla, Sivas, Tokat and Uşak. We

---

[20]When the cut-off MSPE level is two times higher than the Eastern and Southeastern Anatolia's, all 43 control provinces are discarded (not reported).

iteratively re-estimate our model to construct a synthetic Eastern and Southeastern Anatolia omitting in each iteration one of the provinces that was assigned a weight in table 4. Our aim is the assess the extent to which our results are driven by any particular province. Figure 9 displays the results in which the black solid line is the actual real GDP, the black dashed line is the synthetic real GDP of Eastern and Southeastern Anatolia with all nine weight-assigned provinces and the gray lines are the leave-one-out estimates. The leave-one-out distribution of the synthetic control shows that our main result reported in Figure 5 is fairly robust to the exclusion of any particular province. The average of all nine leave-one-out estimates of the synthetic control (gray lines) are on average 0.04 percent higher than the actual real GDP of Eastern and Southeastern Anatolia (black solid line) in the pre-terrorism period and 0.04 percent lower than the original synthetic Eastern and Southeastern Anatolia (black dashed line) in the pre-terrorism period. In the post-terrorism period, the average of all nine leave-one-out estimates of the synthetic control are on average 0.01 percent higher than the original synthetic Eastern and Southeastern Anatolia.

4 Discussion

There exists a systematic relation between the breadth of PKK terrorism, ethnicity, poverty and geography. Eastern and Southeastern regions of Turkey where PKK terrorism reigns are distinguishably mountainous, Kurdish-populated and less prosperous than the rest of the country. In the shadow of a persistent gap between the Western and Eastern regions of Turkey, this relation compels us to discuss the policy implications of our analysis within the scope of convergence and regional inequality debate. While we find a sizeable, significant and increasing effect of terrorism on economic growth in these regions, it would be misleading to state that income inequality and underdevelopment would not have existed if PKK terrorism had never emerged. The comparison of the 1975 and 2001 per capita income dispersion in Turkey suggests that the regional income gap between western and eastern Turkey around the 2000s has its roots in the pre-terrorism period of the mid 1970s. Given the persistence of the income gaps, the roots of these inequalities should be attributed to different regional fundamentals as well as to historical developments of these regions. Separatist terrorism plays a crucial role in understanding the rigidity of the spatial heterogenous income pattern in Turkey with almost no sign of regional convergence. This suggest that terror-stricken provinces may not fully catch up but only approximate the "average" province with a 7 percent higher real GDP that would have been enjoyed in the absence of terrorism. An income gap of this size is substantial considering the low GDP levels in the Eastern and Southeastern provinces relative to the rest of Turkey and enough to expect a reduction in regional inequalities had a local or macro-level policy initiative implemented with the aim of depressing the level of PKK terrorist activity.

There are other, prominently leftist or Islamist groups that have carried out terrorist activities throughout our sample period and that are of non-separatist nature[21]. A particular concern is that the causal effect of PKK terrorism on economic prosperity would be contaminated and our synthetic control estimates would be unable to isolate the causal effect of PKK if leftist or Islamist terrorist activities took place in the treated unit or in the weight-assigned provinces in the donor pool to the extent that these activities are significant and sustained for a period of time. A close inspection of the GTD data on leftist and Islamist terrorist groups in Turkey reveals that both types of terrorism in Turkey are significantly weak, unsustained and prevailed in major cities like Istanbul, Izmir and Ankara although there are solitary cases in other provinces. While Istanbul is discarded from the analysis and Izmir is not a weight-assigned province in the donor pool, there were a total of 49 casualties (fatalities+injured) associated with leftist terrorism and 14 casualties associated with Islamist terrorism in the capital city Ankara during the period 1975-2001. Absence of significant terrorist activity by these groups suggests that they are unlikely to confound the causal effect of PKK. Even if these types of terrorism were supposed to have had any impact on the economic environment, our findings would still be admissible because the robustness check reported in section 3.5 and in figure 9 reveal that the omission of Ankara from the synthetic control leaves our results virtually unchanged. Therefore we argue that the presence of leftist or Islamist terrorist groups in Turkey does not invalidate our synthetic control estimates.

The endogeneity central to our research question is a fact for Turkey. The spatial dispersion of per capita GDP already give us hints about the validity of this issue. Provinces that have been exposed to terrorist activity are predominantly the ones with the lowest per capita income in 1975. Inevitably, this should raise concerns about the local links that feed the evolution of terrorism that prevails mostly in these locations. This, however, does not diminish the impeding role that is attributed to separatist terrorism for further development and growth struggles of these locations. Moreover the synthetic control method we employ in this paper does not suffer from endogeneity bias caused by the omission of time-variant unobservable provincial heterogeneity that has been observed in other studies on PKK terrorism. Even though there is not a single province in the Eastern and Southeastern Anatolia that was not affected by terrorism and that terror-stricken areas are typically poorer that the rest of Turkey, our methodology made it possible to successfully synthetize the real GDP of terror-stricken regions by using the convex combinations of unaffected provinces that are all located outside the Eastern and Southeastern Anatolia.

One important fact that has to be considered for the Eastern and Southeastern Turkey is the underdevelopment phenomenon. Given the endogeneity issues, this underdevelopment may be of concern once the direct and indirect interventions of the central government towards these underdeveloped areas are considered. One

---

[21]The major leftist terrorist groups are Dev-Sol, Revolutionary People's Liberation Party-Front (DHKP-C), Marxist-Leninist Armed Propaganda Unit, Turkish People's Liberation Army and Turkish People's Liberation Front (THKP-C). Notable Islamist terrorist organizations are the Great Eastern Islamic Raiders Front (IBDA-C) and Hezbollah.

important intervention is the Priority Development Area (PDA) Program. The PDA is one of the most remarkable policy implementations of Turkey against regional inequalities and underdevelopment. The first program was taken into the policy-making agenda in 1968 with 22 provinces. The PDA is implemented not only in all terror-stricken provinces in Turkey but also in provinces which were not affected by or exposed to PKK terrorism (donor pool). In fact, the latest figures for 2003 indicate that the number of provinces subject to PDA project is 50 and well beyond the number of terror-exposed units in our sample[22]. Therefore, the presence of the PDA program does not invalidate our synthetic control estimates as it affects both Eastern and Southeastern Anatolia as well as the units in the donor pool in our sample period.

Our estimates should be considered minimum for at least two reasons. First, the regional unequal distribution of prosperity in Turkey is a concern in the five-year development plans of the state during the post-1960 era. Although there are a number of policy recommendations, mostly through the allocation of public investments and subsidies, in general, their implementation is far from being successful. The specific policy of PDA mentioned above aims to support the least developed regions but cannot reach the targets. Similarly, the public investment directed towards these less developed regions of Turkey are unable to alter the local economic environment. Second, the presence of PKK and the threat of terrorism cause a larger share to be devoted to military expenditures, albeit higher levels of military expenditures are not entirely caused by PKK terrorism. The overall increase in the state budget due to an increased share of military expenditure can only be offset by shifting resources away from productive sectors such as health or education and towards the defence industry. By a mere conjecture, not only the share of the military budget would be lower but also the resource allocation would be efficient in the absence of terrorism. These factors suggest that the size of our estimate represents the lower bound of the causal effect of PKK terrorism on economic growth.

Finally, a natural experiment akin to that of Abadie and Gardeazabal (2003), could be conducted for the period 2000-2004 during which PKK declared its longest unilateral cease-fire. This would have enabled us to investigate whether an extended and credible cease-fire period is reflected in a recovering economic performance of Eastern and Southeastern Turkey. Unfortunately, provincial per capita GDP has not been made available for the post-2001 period and therefore we were unable to test this prediction.

---

[22]See Ministry of Development for the spatial and historical dispersion of the provinces that are subject to the PDA Program (http://www.kalkinma.gov.tr/PortalDesign/PortalControls/WebIcerikGosterim.aspx?Enc=83D5A6FF03C7B4FC0B6C445B8568FF66 accessed on 21 July 2013)

5 Conclusion

We use province-level panel data for the period 1975-2001 in order to reveal the causal impact of separatist terrorism on real GDP in the Eastern and Southeastern Anatolia in Turkey. We employ the synthetic control method which is based on estimating the counterfactual: how the provincial GDP would have evolved in the absence of terrorism. Extended over a period of 14 years (from 1988 to 2001), we find an average gap of about 7 percent between the actual real GDP of Eastern and Southeastern Anatolia and the real GDP of a comparable synthetic Eastern and Southeastern Anatolia without terrorism. This estimated gap is attributed to PKK terrorism and increases over time.

Province aggregation helps dealing with a number of challenges we face in this study. First, province aggregation not only increases the power of the synthetic control but also becomes useful when the synthetic version of the individual treated unit cannot be properly produced from the convex combination of control units due to the failure to fulfil the convex-hull requirements. Second, province aggregation deals with potential geographical spillover effects of terrorism among the provinces affected by terrorism. By aggregating the provinces in the Eastern and Southeastern Anatolia, we were able to construct a synthetic version of the region's GDP with a very good fit in the pre-terrorism period and a higher GDP in the post-terrorism period in the absence of PKK terrorism. Permutation tests (placebo experiments) indicated that the impact of PKK terrorism on the region's economy is a causal rather than a random effect with no compelling evidence beyond reasonable doubt. Further, robustness tests show that our result is fairly robust to the exclusion of any particular province.

The PKK terrorism has been at the center of the political debate for almost four decades. The odds for a permanent resolution is plagued by friction and disunity and thus appears to be low in the near future. PKK terrorism not only impedes the nation's democratization and modernization efforts but also reduces the country's ability to flourish economically. We hope that our research, at least from the point where economic prosperity matters, will help hasten the peace process.

References

Abadie, A. (2005): Poverty, Political Freedom, and the Roots of Terrorism. *American Economic Review*, 95:50–56.

Abadie, A.; A. Diamond; and J. Hainmueller (2010): Synthetic Control Methods for Comparative Case Studies: Estimating the Effect of California's Tobacco Control Program. *Journal of the American Statistical Association*, 105:493–505.

Abadie, A.; A. Diamond; and J. Hainmueller (2012): Comparative Politics and The Synthetic Control Method. *Available at: http://ssrn.com/abstract=1950298*, pp. 1–31.

Abadie, A. and J. Gardeazabal (2003): The economic costs of conflict: A case study of the Basque Country. *American Economic Review*, 93:113–132.

Abadie, A. and J. Gardeazabal (2008): Terrorism and the world economy. *European Economic Review*, 52(1):1–27.

Araz-Takay, B.; K.P. Arin; and T. Omay (2009): The endogenous and non-linear relationship between terrorism and economic performance: Turkish evidence. *Defence and Peace Economics*, 20(1):1–10.

Barro, R.J. and X. Sala-i Martin (1992): Convergence. *Journal of Political Economy*, pp. 223–251.

Başıbüyük, O (2008): *Social disorganization and terror related crimes in Turkey*. Ph.D. thesis, University of North Texas, Denton, Texas, UMI NO. AAT 3376021.

Blomberg, S.; G.D. Hess; and A. Orphanides (2004a): The Macroeconomic Consequences of Terrorism. *Journal of Monetary Economics*, 51:1007–1032.

Blomberg, S.; G.D. Hess; and A. Weerapana (2004b): Economic Conditions and Terrorism. *European Journal of Political Economy*, 20:463–478.

Buesa, M.; A. Valino; J. Heijs; T. Baumert; and J.G. Gomez (2007): The Economic Cost of March 11: Measuring the direct economic cost of the terrorist attack on March 11, 2004 in Madrid. *Terrorism and Political Violence*, 19(4):489–509.

Çelebioğlu, F. and S. Dall'erba (2010): Spatial disparities across the regions of Turkey: an exploratory spatial data analysis. *The Annals of Regional Science*, 45(2):379–400.

Chen, A.H. and T.F. Siems (2004): The effects of terrorism on global capital markets. *European Journal of Political Economy*, 20(2):349–366.
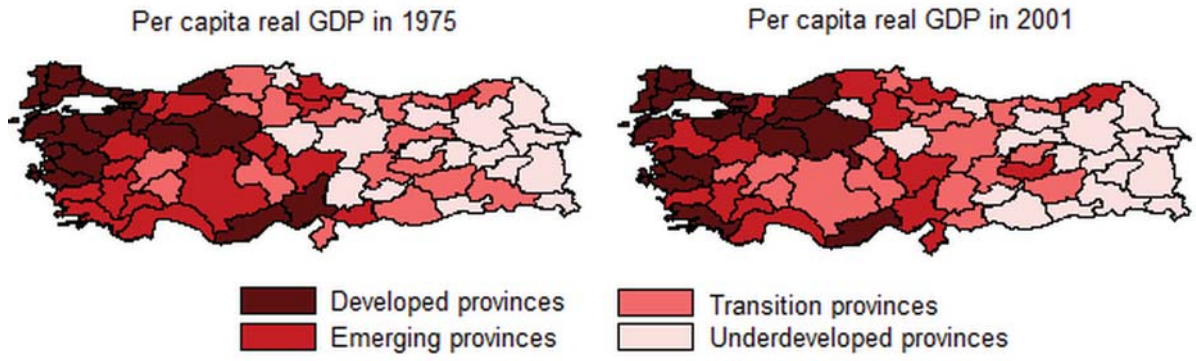
Derin-Güre, P. (2011): Separatist Terrorism and the Economic conditions in South-Eastern Turkey. *Defence and Peace Economics*, 22(4):393–407.

Derin-Güre, P. and A.Y. Elveren (2013): Does Income Inequality Derive the Separatist Terrorism in Turkey? *Defence and Peace Economics*, http://dx.doi.org/10.1080/10242694.2013.763627.

Dhungana, S. (2011): Identifying and Evaluating Large Scale Policy Interventions. What Questions Can We Answer? *The World Bank Poverty Reduction and Economic Management Unit, Policy Research Working Paper*, 5918:1–26.

DiRienzo, C. and J. Das (2012): Terrorist Risk and Income Revisited. *Behavioral Sciences of Terrorism and Political Agression*, 4:175–194.

Doğruel, F. and A.S. Doğruel (2003): *Türkiye'de Bölgesel Gelir Farklılıkları ve Büyüme. (in Iktisat üzerine yazılar)*. Iletisim Yayınları.

Drakos, K. and A.M. Kutan (2003): Regional Effects of Terrorism on Tourism in Three Mediterranean Countries. *Journal of Conflict Resolution*, 47:621–641.

Eckstein, Z. and D Tsiddon (2004): Macroeconomic Consequences of Terror: Theory and the case of Israel. *Journal of Monetary Economics*, 51:971–1002.

Eldor, R. and R. Melnick (2004): Financial Markets and Terroris. *European Journal of Political Economy*, 20:367–386.

Enders, W. and T. Sandler (1991): Causality between Transnational Terrorism and Tourism: The Case of Spain. *Terrorism*, 14:49–58.

Enders, W. and T. Sandler (1996): Terrorism and foreign direct investment in Spain and Greece. *Kyklos*, 49(3):331–352.

Enders, W.; T. Sandler; and G.F. Parise (1992): An Econometrics Analysis of the Impact of Terrorism on Tourism. *Kyklos*, 45:531–554.

Feridun, M. (2011): Impact of terrorism on tourism in Turkey: Empirical Evidence from Turkey. *Applied Economics*, 43:3349–3354.

Feridun, M. and S. Sezgin (2008): Regional underdevelopment and terrorism: the case of south eastern Turkey. *Defence and Peace Economics*, 19(3):225–233.

Feridun, M. and M. Shahbaz (2010): Fighting Terrorism: Are Military Measures Effective? Empirical Evidence From Turkey. *Defence and Peace Economics*, 21:193–205.

Filiztekin, A. (2009): Regional unemployment in Turkey. *Papers in Regional Science*, 88(4):863–878.

Filiztekin, A. and M.A. Çelik (2010): Regional Income Inequality in Turkey. *Megaron*, 5:116–127.

Freytag, A.; J.J. Krüger; D. Meierrieks; and F. Schneider (2011): The origins of terrorism: Cross-country estimates of socio-economic determinants of terrorism. *European Journal of Political Economy*, 27:5–16.

Gezici, F. and G.J.D. Hewings (2004): Regional convergence and the economic performance of peripheral areas in Turkey. *Review of Urban & Regional Development Studies*, 16(2):113–132.

Gezici, F. and G.J.D. Hewings (2007): Spatial analysis of regional inequalities in Turkey. *European Planning Studies*, 15(3):383–403.

Gries, T.; T. Krieger; and D. Meierrieks (2011): Causal linkages between domestic terrorism and economic growth. *Defence and Peace Economics*, 22(5):493–508.

Gupta, S.; B. Clements; R. Bhattacharya; and S. Chakravarti (2004): Fiscal consequences of armed conflict and terrorism in low-and middle-income countries. *European Journal of Political Economy*, 20(2):403–421.

Karaca, O. (2004): *Türkiye'de Bölgelerarası Gelir Farlılıkları: Yakınsama Var mı?* Tech. rep., Turkish Economic Association.

Kılıçaslan, Y. and G. Özatağan (2007): Impact of relative population change on regional income convergence: evidence from turkey. *Review of Urban & Regional Development Studies*, 19(3):210–223.

Köşeli, M. (2007): *The poverty, inequality and terrorism relationship: An empirical analysis of some root causes of terrorism. In Understanding terrorism: Analysis of Sociological and Pyschological Aspects.* Washington , DC: IOS Press.

Krieger, T. and D. Meierrieks (2011): What causes terrorism? *Public Choice*, 147:3–27.

Nitsch, V. and D. Schumacher (2004): Terrorism and International Trade: An Empirical Investigation. *European Journal of Political Economy*, 20:423–433.

Öcal, N. and J. Yıldırım (2010): Regional effects of terrorism on economic growth in Turkey: A geographically weighted regression approach. *Journal of Peace Research*, 47(4):477–489.

Özötün, E. (1980): *Iller itibariyle Türkiye gayri safi yurtiçi hasılası - kaynak ve yöntemler, 1975-1978. Yayın no 907.* Devlet Istatistik Enstitüsü, Ankara.

Özötün, E. (1988): *Türkiye gayri safi yurtiçi hasılasının iller itibariyle dağılımı, 1979-1986. Yayın no. 1988/8.* Istanbul Ticaret Odası Araştırma Bölümü, Istanbul.

Sandler, T. and W. Enders (2008): *Economic Consequences of Terrorism in Developed and Developing Countries: An Overview (in Terrorism, Economic Development, and Political Openness).* Cambridge University Press.

Sayarı, S. (2010): Political Violence and Terrorism in Turkey, 1976-1980: A Retrospective Analysis. *Terrorism and Political Violence*, 22:198–215.

Sözen, A. (2006): *Terrorism and the Politics of Anti-Terrorism in Turkey (in National Counter-Terrorism Strategies)*, vol. 14. IOS Press.

Tavares, J. (2004): The Open Society Assesses its Enemies: Shocks, Disasters and Terrorist Attacks. *Journal of Monetary Economics*, 51:1039–1070.

Tekeli, I. (1992): *UNDP Insanca Gelişme Raporu: Bölgesel Kalkınma Politikaları üzerindeki etkileri.* Tech. rep., Insanca Gelişme Birinci Türkiye Konferansı, T.C Hükümeti ve Birleşmiş Milletler Kalkınma Programı.

Testas, A. (2004): Determinants of terrorism in the Muslim world: an empirical cross-sectional analysis. *Terrorism and Political Violence*, 16(2):253–273.

Yaya, M.E. (2009): Terrorism and Tourism: The Case of Turkey. *Defence and Peace Economics*, 20:477–497.

Yıldırım, J. and N. Öcal (2006): Income inequality and economic convergence in Turkey. *Transition Studies Review*, 13(3):559–568.

Yıldırım, J. and N. Öcal (2012): Analysing the Determinants of Terrorism in Turkey using Geographically Weighted Regression. *Defence and Peace Economics (Forthcoming)*, DOI:10.1080/10242694.2012.69503.
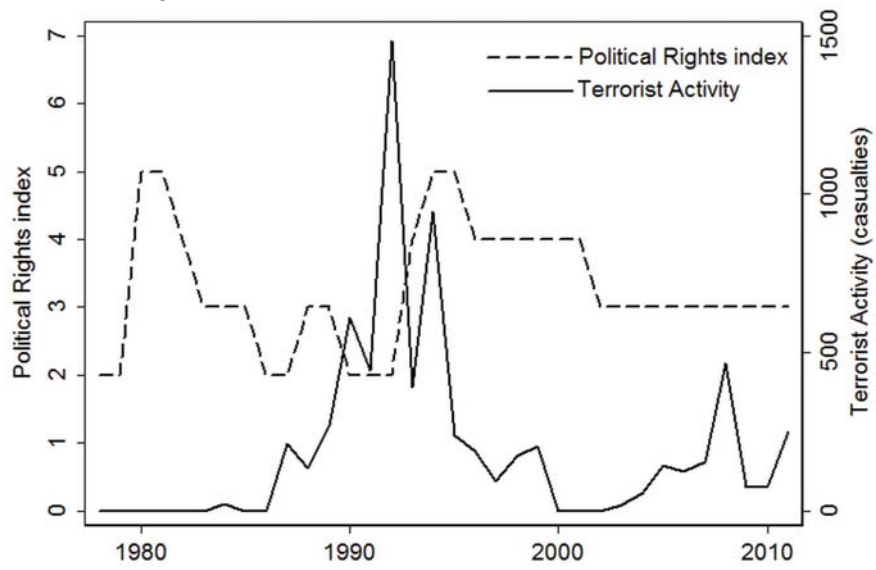
A   Figures

Figure 1: Spatial Distribution of per capita real GDP in Turkey, 1975-2001

Per capita real GDP in 1975 — Per capita real GDP in 2001

Developed provinces — Transition provinces
Emerging provinces — Underdeveloped provinces

Source: TURKSTAT, Özötün (1980), Özötün (1988).

Figure 3: Political Freedom and Terrorism, 1978-2011

Figure 2: PKK terrorist activity timeline, 1984-2011

March 1993: PKK declared the first unilateral cease-fire
April 1993: The death of President Turgut Özal
May 1993: The National Security Council recommends PKK members who have
not been involved in terrorist acts be pardoned if they surrender
PKK announced the end of cease-fire
December 1995: PKK declared the second unilateral cease-fire
January 1996: PKK announced the end of cease-fire
June 1996: Refah-Yol coalition
September 1998: PKK declared the third cease-fire
PKK announced the end of cease-fire
February 1999: PKK leader Abdullah Öcalan was captured in Kenya
April 1999: Parliamentary elections
September 1999: A group of PKK members surrendered after Abdullah Öcalan ordered PKK members to leave Turkey
PKK declared the fourth cease-fire

June 2004: PKK announced the end of
cease-fire. First Kurdish
radio broadcasting
G-8 Summit
October 2006: PKK declared the fifth cease-fire
April 2007: PKK announced the end of cease-fire
October 2007: Referendum on constitutional
amendment
May 2009: PKK declared the sixth cease-fire
August 2009: Democratic Initiative process begins
May 2010: PKK announced the end of cease-fire
August 2010: PKK declared the seventh cease-fire
June 2011: PKK announced the end of cease-fire

Fatalities
Injured

Source: Global Terrorism Database: http://www.start.umd.edu/gtd/. PKK attacks and armed conflicts chronology: http://tr.wikipedia.org/wiki/PKK_saldırıları_ve_çatışmaları_kronolojisi

27

Figure 4: Spatial Distribution of PKK Terrorist Activity in Turkey, all casualties, 1984-2001
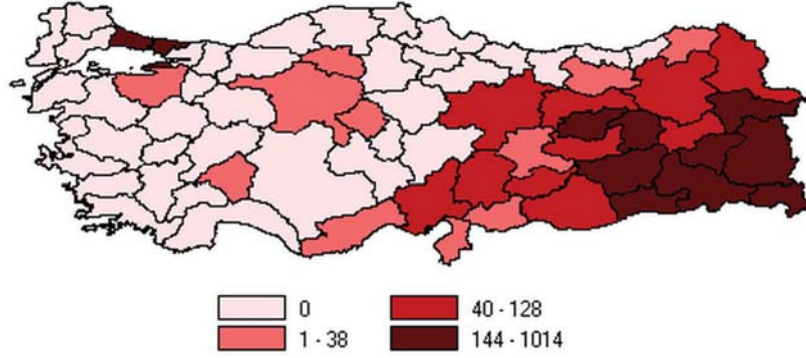
Source: Global Terrorism Database: http://www.start.umd.edu/gtd/. PKK attacks and armed
conflicts chronology: http://tr.wikipedia.org/wiki/PKK_saldırıları_ve_çatışmaları_kronolojisi
Note: Figures may underestimate the total volume of activity due to inexact location of a
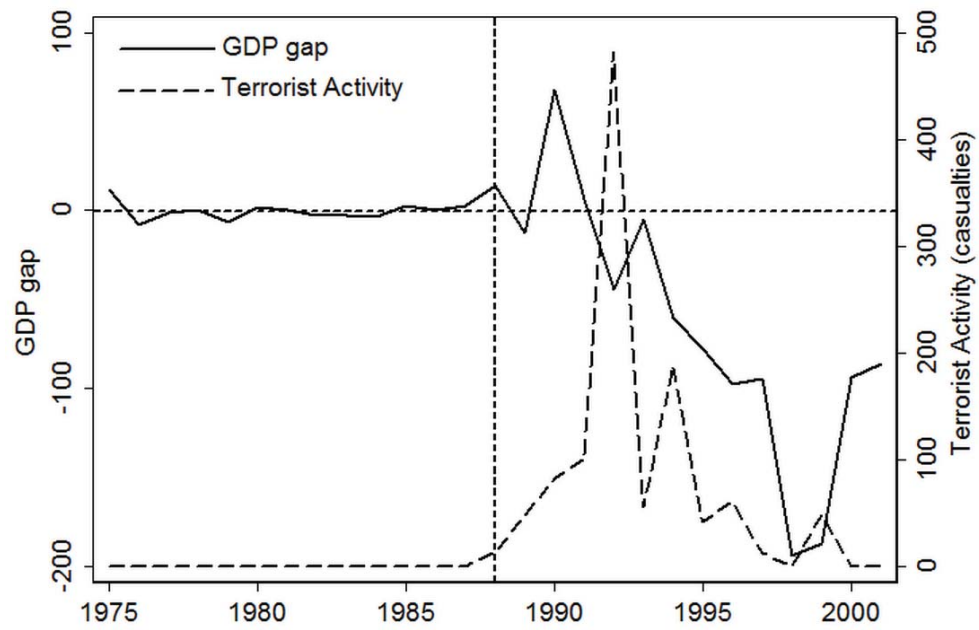number of reported armed conflicts.

Figure 5: Trends in real GDP: Treated vs. Synthetic Eastern and Southeastern Anatolia
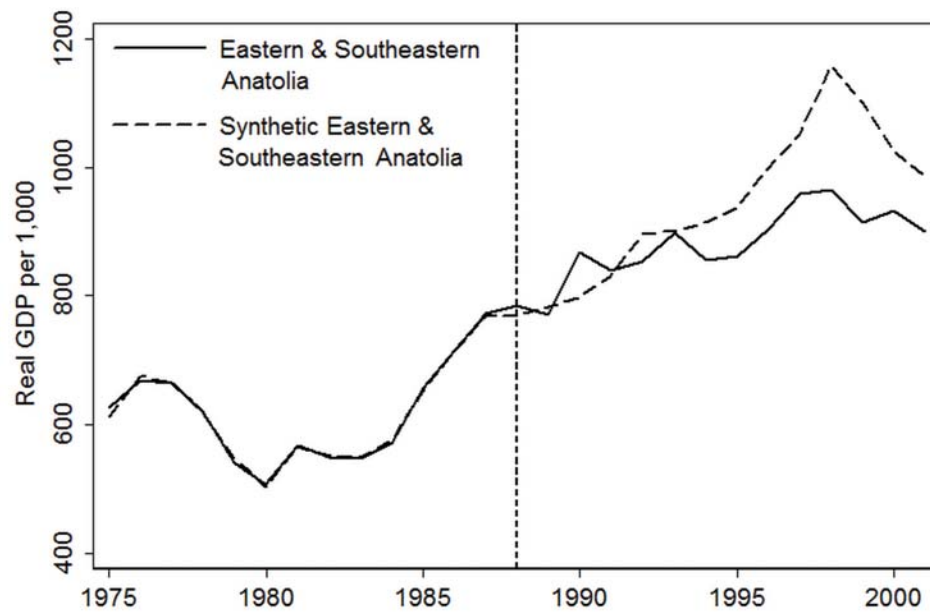
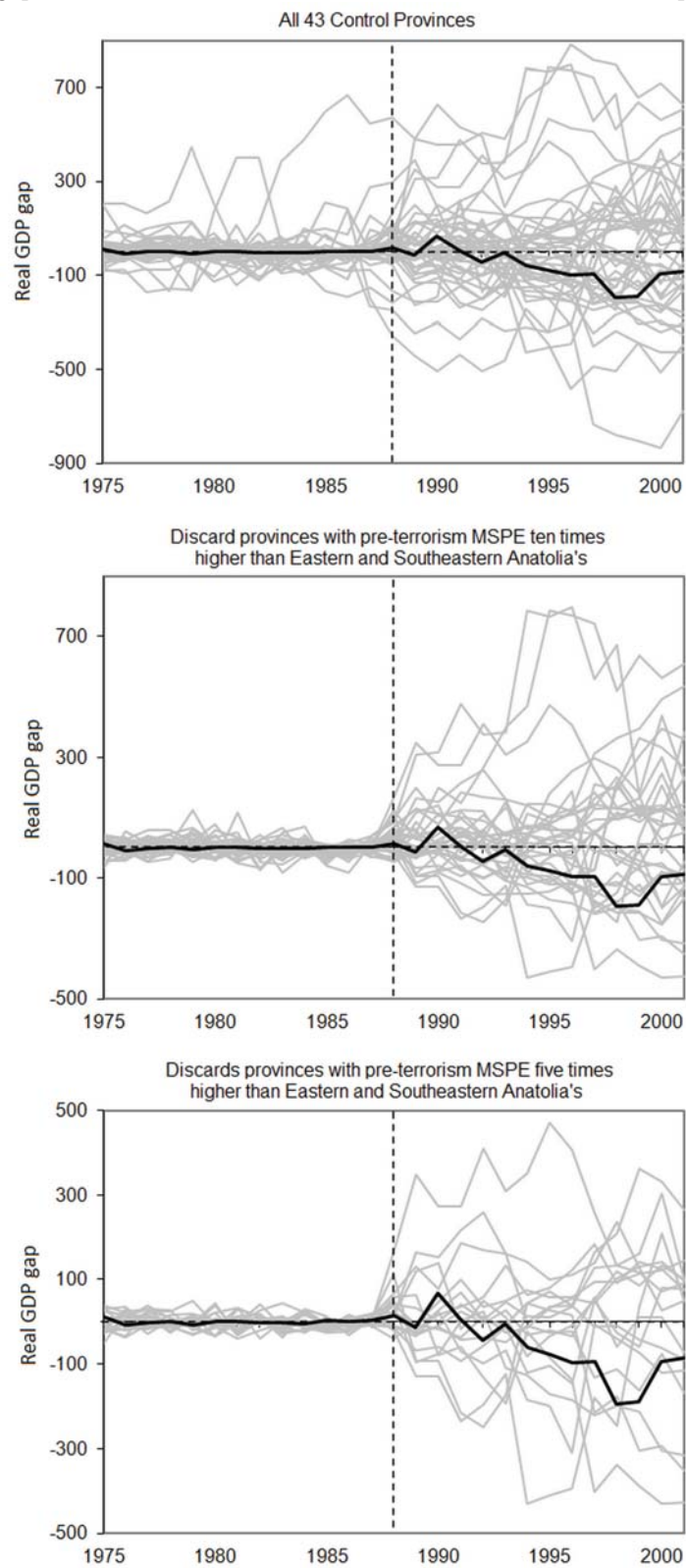Source: Authors' own calculations.

Notes: The Eastern and Southeastern Anatolia excludes Hakkari, Siirt, Mardin, Ağrı.

Figure 6: Estimated Real GDP Gap and Terrorist Activity, 1975-2001
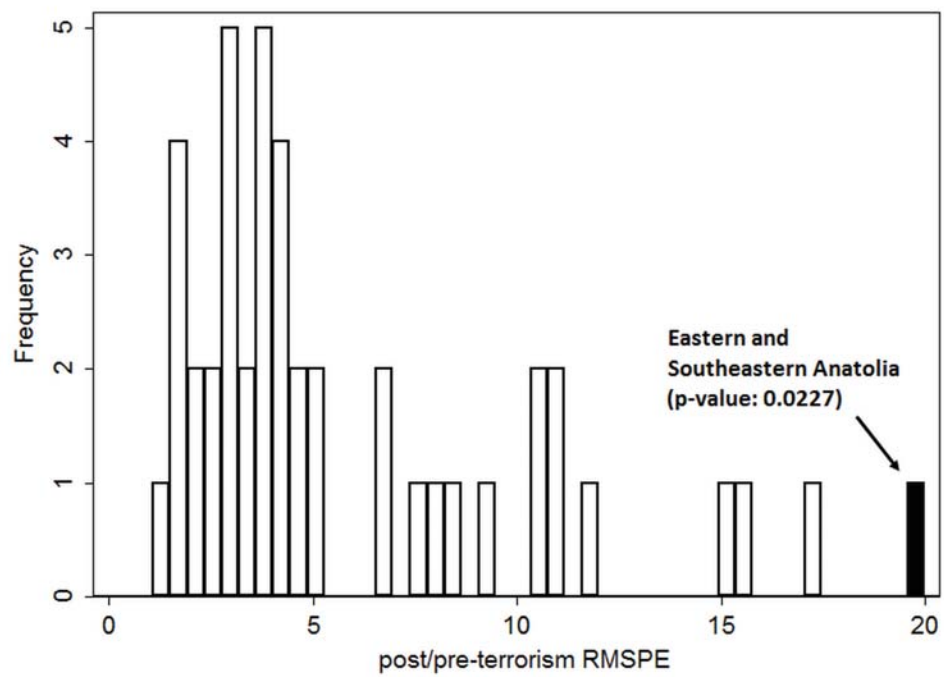

Source: Authors' own calculations.

Figure 7: Real GDP gaps in Eastern and Southeastern Anatolia and Placebo Gaps in Control Provinces
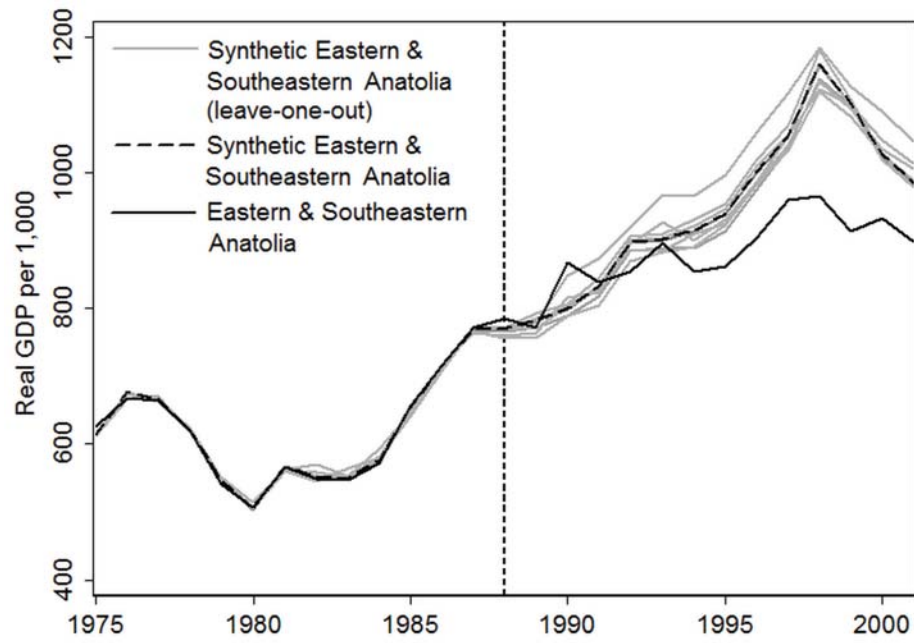
Figure 8: In-space Placebo Distributions, Eastern and Southeastern Anatolia

Source: Authors' own calculations.

Figure 9: Leave-one-out Distribution of the Synthetic Control

Source: Authors' own calculations.

B Tables

Table 1: Descriptive Statistics, 1975-2001 (Turkey = 100)

	Eastern Anatolia	Southeastern Anatolia	Rest of Turkey
Demography & Geography			
Total population	9.7	9.0	81.3
Population density	46.7	123.5	113.0
Surface	20.8	7.3	71.9
Economic indicators			
Per capita real GDP	42.7	56.1	111.7
Real wages	108.1	67.1	100.5
Productivity	56.7	57.6	102.1
Human Capital			
No education	109.3	93.3	99.6
Primary education	77.6	55.4	107.6
Secondary education	77.7	55.0	107.6
Higher education	75.2	51.0	108.4
University education	54.2	42.0	111.9
PKK terrorist activity			
Total Deaths	42.8	48.6	8.6
Total Injured	32.2	43.2	24.6
Total casualties	39.6	47.0	13.4

Source: TURKSTAT, Özötün (1980), Özötün (1988).

Notes: Total population, per capita GDP and population density figures are averaged over the 1975-2001 period. Real wages and productivity figures are averaged over the 1980-1997 period. Human capital measures are from the 1985 population census. Deaths, injured and casualties are the sums over the sample period.

Table 2: Structural Economic, Political and Other Shocks in Turkey, 1975-2001

Date	Event	Impact area	Impact
2 September 1975	Earthquake	Lice, Diyarbakır	Dead: 2370, Injured: 4500, Damage: Severe[a]
24 November 1976	Earthquake	Çaldıran, Van	Dead: 3900, Injured: 497, Damage: Severe[a]
1978-1979	Economic crisis	Nationwide	Turkish lira (TL) devalued by 30 percent in 1978 and 77 percent in 1979[c,d].
1979-1980	Oil crisis	Global	OPEC raised the petroleum price by 150 percent. Unemployment rate: 20 percent, Inflation rate: 69 percent,TL devalued by 49 percent[c,d].
12 September 1980	Military coup	Nationwide	650,000 people were taken into custody, 230,000 were tried, 7000 people sentenced to death, 517 death sentences were executed. All political parties were abolished[b].
30 October 1983	Earthquake	Horasan, Erzurum	Dead: 1400, Injured: 537, Damage: Severe[a]
1989	Financial Liberalization	Nationwide	Higher economic volatility, dependent determination of exchange and interest rates[e].
13 March 1992	Earthquake	Erzincan	Dead: 652, Injured: 2000, Damage: Considerable[a]
Late 1993-1994	Economic crisis	Nationwide	500,000 people were laid-off, net capital outflow: $4.2 billion, interest rate on treasury bonds: 400 percent, CPI: 106 percent, short-term debt: $18.5 billion[c,d].
1 October 1995	Earthquake	Dinar, Afyon	Dead: 101, Injured: 348, Damage: Moderate[a]
27 June 1998	Earthquake	Ceyhan, Adana	Dead: 145, Injured: 1500, Damage: Considerable[a]
1999	Economic Crisis	Nationwide	$6 billion hot money outflow, GDP fell by 6.4 percent, real interest rate: 37 percent, foreign debt: $103 billion[c,d].
17 August 1999	Earthquake	Gölcük, Kocaeli	Dead: 17118 , Injured: 50000, Damage: Extreme[a]
12 November 1999	Earthquake	Düzce	Dead: 894, Injured: 4948 , Damage: Severe[a]
22 November 2000	Economic Crisis	Nationwide	Overnight interest rate skyrocketed, foreign debt: $114 billion, short-term debt: $29 billion[c,d].

Sources: [a]Utsu Catalog, International Institute of Seismology and Earthquake Engineering, http://iisee.kenken.go.jp

[b]*Cumhuriyet Gazetesi*, "Darbenin Bilançosu", 12 September 2000 http://www.cumhuriyet.com.tr

[c]*Sabah Gazetesi*, "Türkiye'de Ekonomik Krizler", 19 April 2011 http://www.sabah.com.tr/

[d]Akpınar, A.T. (2009) "Türkiye'de Meydana Gelen 15 Ekonomik Krizin Kısa Analizi", http://sinestezi.wordpress.com

[e]Yeldan, E. (2001), Küreselleşme Sürecinde Türkiye Ekonomisi: Bölüşüm, Birikim ve Büyüme, Istanbul: Iletişim Yayınları

	Eastern & South-eastern Anatolia	Synthetic Eastern & Southeastern Anatolia
Real GDP (1975)	625.42	613.60
Real GDP (1976)	668.39	676.71
Real GDP (1977)	664.88	665.79
Real GDP (1978)	620.03	619.82
Real GDP (1979)	540.69	547.41
Real GDP (1980)	506.18	504.50
Real GDP (1981)	567.02	566.78
Real GDP (1982)	549.50	552.49
Real GDP (1983)	547.08	550.00
Real GDP (1984)	572.37	576.19
Real GDP (1985)	656.84	654.46
Real GDP (1986)	716.41	715.94
Real GDP (1987)	771.78	769.35
Real GDP growth rate	2.09	1.85

Table 3: Pre-terrorism Predictor Balance

Source: Authors' own calculations.

Table 4: Synthetic Control Weights, Eastern and Southeastern Anatolia

Province	Weight	Province	Weight	Province	Weight
Ankara	0.021	Giresun	0.227	Sivas	0.055
Artvin	0.035	Gümüşhane	0.404	Tokat	0.167
Çankırı	0.004	Muğla	0.086	Uşak	0.001

Source: Authors' own calculations.

C   Concatenation of GDP Data

One of the most striking issues about the provincial GDP is the inconsistency of the three data sets (1975-1978, 1979-1986 and 1987-2001) used to construct the provincial GDP series for the period 1975-2001. While a specific transformation is offered by Karaca (2004), we performed a number of similar procedures to cope with this inconsistency which is summarized below.

The 1975-1978 and 1979-1986 data sets are constructed by Özötün (1980) and Özötün (1988). First, these two data sets are concatenated in current prices. However in its original form, they will not be consistent with the 1987-2001 data because the TURKSTAT data is constructed by the new revised GDP calculations in Turkey. To deal with this inconsistency, we first calculated the percentage share of provincial total GDP in current prices for each of the 67 provinces for the period 1975-1986. Then the revised total GDP measures at the country level for the 1975-1986 period is multiplied by the calculated provincial GDP shares to reach the new revised provincial total GDP figures for the 1975-1986 period. Following these transformations, the provincial total GDP for the 1975-1986 period is deflated by the GDP deflator (1987=100) to obtain the provincial real total GDP. The per capita real GDP values for the 1975-1986 period are calculated by dividing the provincial real total GDP by the provincial population to obtain the provincial real GDP per capita. This transformed GDP series is then concatenated with the 1987-2001 provincial real GDP (at 1987 constant prices) to obtain a consistent and comparable provincial real GDP per capita from 1975 to 2001.

The transformed GDP figures used in this study are consistent with the provincial GDP figures supplied by Karaca (2004). Furthermore, in comparison to our transformed GDP data set, the data set given by Karaca (2004) does not yield significant differences in terms of constructing the synthetic GDP trajectories. Both the transformed GDP figures and the synthetic control estimates using Karaca (2004) data set are available from the authors upon request.

D Technical Details

The synthetic control method is developed by Abadie and Gardeazabal (2003) and expanded by Abadie et al. (2010) and Abadie et al. (2012). In this section, we overview the technical details of the methodology and discuss its advantages over the traditional regression framework.

Suppose there are $P+1$ provinces in the sample, indexed by $i = 1, 2, \ldots, P+1$ over T periods, $t = 1, 2, \ldots, T$. Only province $i = 1$ is exposed to terrorism and the remaining P provinces are the potential control provinces unaffected by terrorist activity, called the *donor pool*. There are T_0 number of pre-terrorism periods and T_1 number of post-terrorism periods so that $T_0 + T_1 = T$. The effect of terrorism for unit i at time t is given by $\alpha_{it} = Y_{it}^I - Y_{it}^N$ where Y_{it}^I is the real per capita GDP of unit i if exposed to terrorism in $T_0 + 1$ to T and Y_{it}^N is the real per capita GDP in the absence of terrorism. Since only unit $i = 1$ is exposed to terrorism, we need to estimate $(\alpha_{1T_0+1}, \ldots, \alpha_{1T})$. We first estimate Y_{it}^N by the following factor model:

$$Y_{it}^N = \delta_t + \theta_t Z_i + \lambda_t \mu_i + \varepsilon_{it} \tag{1}$$

where δ_t is an unknown common factor invariant across units, Z_i is the covariate vector not affected by terrorist activity, θ_t is a vector of unknown time-specific parameters, λ_t is a vector of unknown common factors, μ_i is the province-specific unobservable and the error term ε_{it} are the zero-mean transitory shocks. The presence of anticipatory effects are irrelevant in our case, implying that all the elements in Z_i that belong to pre-terrorism period are unaffected by terrorism.

Equation (1) allows the effect of unobservable provincial heterogeneity to vary over time. In the fixed effects (FE) model and the difference-in-differences (DiD) estimator, the effect of unobservable heterogeneity, λ_t, is assumed to be fixed over time. Hence, the synthetic control method provides an improvement over FE and DiD methods and deals better with endogeneity caused by the presence of time-varying unobservable confounders, all of which were presumed to have been accounted in the traditional regression framework.

The method aims to construct the missing counterfactual, Y_{it}^N, from provinces not affected by terrorism. Let $W = (w_2, \ldots, w_{P+1})'$ be $(P \times 1)$ vector of weights such that $0 \leq w_j \leq 1$ for $j = 2, 3, \ldots, P+1$ and $\sum_{j=2}^{P+1} w_j = 1$. Define the linear combination of pre-terrorism values of real GDP as $\bar{Y}_j^k = \sum_{m=1}^{T_0} k_m Y_{jm}$. Abadie et al. (2010) show that if the following conditions hold, then the estimate of the effect of terrorism for the affected/exposed unit, $\hat{\alpha}_{1t} = Y_{1t} - \sum_{j=2}^{P+1} w_j^* Y_{jt}$, is an unbiased estimator of α_{1t}:

$$\sum_{j=2}^{P+1} w_j^* Z_j = Z_1 \quad \wedge \quad \sum_{j=2}^{P+1} w_j^* \bar{Y}_j^k = \bar{Y}_1^k \tag{2}$$

where w_j^* is the weight assigned to the jth unexposed province.

Equation (2) can hold exactly only if $\left(\bar{Y}_1^k, Z_1\right)$ belongs to the convex hull of $\left[\left(\bar{Y}_2^k, Z_2\right), \ldots, \left(\bar{Y}_{P+1}^k, Z_{P+1}\right)\right]$. This means that the pre-terrorism real per capita GDP of some of the exposed provinces may not be synthetized accurately using the pre-terrorism characteristics of the unexposed provinces.

The vector W^* is chosen to minimize the distance between the vector of pre-terrorism characteristics for the exposed province (X_1) and the weighted matrix that contains the pre-terrorism characteristics of unexposed provinces (X_0): $\parallel X_1 - X_0 W \parallel = \sqrt{(X_1 - X_0 W)' V (X_1 - X_0 W)}$ where V is a symmetric and positive semidefinite matrix. This minimization procedure is subject to the constraints that the weight assigned to each unexposed province should lie between zero and one and that the sum of the weights is bounded by one.