

# Diamonds Are Forever, Wars Are Not Conflict Diamonds and the Value of Firms<sup>1</sup>

Massimo Guidolin  
University of Virginia

Eliana La Ferrara  
Bocconi University and IGER

March 2003

Preliminary and incomplete  
Please do not cite

<sup>1</sup>We are grateful to Alberto Alesina, Tullio Jappelli, and to seminar participants at CSEF and Bocconi University for helpful comments. We also thank Chiara Tropea for her valuable inputs in the early stages of the project. Angelo Mele and Serguey Khovanski provided excellent research assistance. The usual disclaimer applies. Correspondence: mg8g@unix.mail.virginia.edu, eliana.laferrara@uni-bocconi.it.

# 1 Introduction

Most of the African countries that are currently plagued by internal civil conflicts, or have been so in the 1990s, derive an overwhelming share of their foreign exchange earnings from mineral exports. Among them are Algeria (98% of official foreign exchange earned is from oil), Angola (83% from oil and most of the remaining share from diamonds), Democratic Republic of Congo (78% from copper and cobalt), Nigeria (96% from oil), and Sierra Leone (96% from titanium ore and diamonds).<sup>1</sup> This observation has led to a number of recent studies on the relationship between resource abundance and the likelihood of civil conflict.<sup>2</sup> Among others, Collier and Hoeffler (2000) find that “greed” motives, such as the opportunities that natural resources offer to build rebel movements, have significantly more explanatory power than “need” or “scarcity” explanations in the analysis of the civil wars occurred in the past forty years. This has important economic as well as social consequences: if resource abundant countries are more prone to civil conflict, and if conflict depresses investment rates, then it may not be paradoxical that resource abundance is associated with lower growth (as found by Sachs and Warner (1995)).

While the above literature mostly relies on cross country regressions and case studies, the goal of this paper is to study the relationship between civil conflict and private investment in a specific setting and using microeconomic data. In particular, we focus on the civil war that has plagued Angola since independence and on one of the sectors that have been most interested by this conflict, namely diamond production, to explore investors’ reactions to changes in the intensity of conflict. We collect daily indicators of conflict between the government and the rebel movement, as well as daily stock prices of diamond mining companies that held concessions in Angola for the past four years (which include the last phase of the conflict until the death of the rebels’ leader). We can thus estimate how investors’ preceptions, as represented by changes in stock prices, respond to increases or decreases in conflict, and more precisely to different types of attacks and episodes of conflict. Our main conclusion is that the uncertainty generated by civil conflict per se is not enough to explain investors’ reactions. What seems to matter is uncertainty together with the attitudes of the country’s government towards foreign investors. In other words, political economy and rent seeking considerations seem to play a leading role together with the sheer uncertainty generated by conflict. Our most striking result in this sense regards the death of Jonas Savimbi, leader of the rebel movement for 27 years. While his death was

---

<sup>1</sup>Source: IMF, *IMF Statistics Yearbook 1998*, Washington DC, 1999. Data for DRC and Sierra Leone refer to 1996 and 1995, respectively.

<sup>2</sup>An interesting account of the relationship between civil conflict and natural resource extortion is given by Klare (2001).

unambiguously regarded by the public opinion as the end of the conflict (for reasons that will be made clear below), stock market reactions were negative rather than positive. In correspondence with Savimbi's death (and later of the official cease fire), we observe a significant decrease in the returns of diamond mining companies operating in Angola. We supplement this finding with the study of other events and with regressions analysis.

In addition to the literature on civil wars cited above, this paper is related to a growing body of work that has applied the event study framework not to firm specific or economic announcements (as is traditionally done in the finance literature), but to political events. Notable examples are Roberts (1990), Fisman (2001), Johnson and Mitton (2001), and Ramalho (2002). These studies examine events that affected specific political figures, such as US Senator Henry Jackson, Indonesian President Suharto, Brazilian President Collor de Mello, or Malaysian Prime Minister Mahathir, to estimate their impact on companies that had different degrees of political connections with those figures. Starting from a prior on which companies were more or less connected to leading personalities, they "put a price" on the value of political connections. Our analysis differs from these papers in several respects. First, our goal is not to quantify the extent of corruption but to understand the consequences of civil conflict. We have no prior on which companies have links with particular political figures and we consider events that do not target specific politicians but affect conflict in general. Furthermore, we allow for political tension not to have uniformly "positive" or "negative" effects and, as will be clear from the simple theoretical setup below, we estimate the impact of increased tension under different "regimes". Such analysis of regime switching is missing from the above literature.

The remainder of the paper is organized as follows. In section 2 we briefly sketch the main features of the Angolan civil conflict and the way in which the diamond industry is organized in Angola. Section 3 presents the first body of empirical results, using the event study methodology. In section 4 a simple two-period model is proposed to make sense of the empirical results, and more precise predictions are generated on the relationship between political tension and firm value. Section 5 tests these predictions using a switching regression framework. Finally, section 6 concludes.

## **2 Civil war and the diamond industry in Angola**

Since its independence from Portugal in 1974, Angola has been plagued by a long and cruel civil war between the Movimento Popular de Libertacao de Angola (MPLA) and the Uniao Nacional para a Independencia Total de Angola (UNITA). The early stages of this conflict belong to the Cold War period, which saw the for-

mer URSS backing the Marxist-Leninist MPLA, and the US together with South Africa supporting UNITA. In September 1992 national elections were held and Jose Eduardo dos Santos, leader of MPLA won by a slight margin. This victory was never recognized by UNITA's leader, Jonas Savimbi, who started fighting a war that was perceived by many as driven by his own desire of political power as much as by ideology. Since the early 1990s, UNITA's strategy was that of occupying the areas of highest concentration of diamond mines (e.g., the Lunda Norte province and Cuango Valley), and use diamond sales to finance its arms purchases. The MPLA, on the other hand, while earning money from official diamond concessions to national and foreign mining companies, mostly relied on oil for financing its military operations through the Fuerzas Armadas de Angola (FAA). The role of diamond sales in financing this war, as well as the brutal means sometimes employed by UNITA and by FAA officials to control independent diggers (*garimpeiros*) working for them, triggered the imposition of several UN sanctions and attracted the attention of several humanitarian agencies. Among them was the British NGO Global Witness, which in 1998 published a report entitled "A Rough Trade" that brought the problem of "conflict diamonds" to the attention of the large public. This opinion movement had several consequences, among which the start of a process for the certification of origin for rough diamonds.

...

to be continued

...

### **3 Conflict and stock market reactions: evidence from an event study**

We start by testing the widely held and somehow generic notion that increases in the intensity of civil conflict, by increasing uncertainty on the possibility that diamond mining companies can operate their concessions, should reduce the value of such companies.

#### **3.1 Methodology**

Our goal is to assess the empirical relationship between political tension and the price of one share of stock issued by a company that displays in its balance sheet the opportunity to exploit mining concessions in the country. More precisely, we are interested in whether political tension contributes to explaining the sources of returns on the capital stock of the company. Following a vast literature (e.g.,

MacKinlay (1997)), we take as a benchmark the market model:

$$r_t = \alpha + \beta r_t^M + e_t,$$

where  $r_t$  is the rate of return on the company's stock (defined as the percentage change in the price of one share of stock),  $r_t^M$  is the return on the market portfolio, and  $e_t$  is an unexplained residual called the *abnormal return* on the stock. We augment this model as follows:

$$r_t = \alpha + \beta r_t^M + \theta S_t + e_t \tag{1}$$

where  $S_t$  represents a set of dummies for company-specific events that may influence the returns on the stock. Such events include announcements and implementations of: mergers and acquisitions, stock splits, joint ventures, temporary delisting, evaluations by the stock market regulation authority, new licenses obtained, and discovery of new mineral resources. We introduce these dummies for the dates at which such non-political events occur in order to filter out changes in stock price that are unrelated to political tension. Our objective thus becomes to estimate the relationship between the estimated abnormal return  $e_t$  and changes in political tension.

The event study approach relies on the observation that, if security prices reflect the present discounted value of the long-run stream of cash flows generated by an asset, the measurement of the economic effects of political tension can be performed by looking at changes of asset prices that occur in connection with particular tension episodes. Underlying the validity of this approach are the assumptions that security markets are informationally efficient, that they form unbiased expectations, and that the occurrence of the "events" considered are exogenous with respect to the change in market value of the security. This last point is particularly relevant, and in our case it is likely to be satisfied as Unita attacks in the period under consideration responded mostly to internal political strategies vis-à-vis the official government than to the economic conditions of the mining firms operating in Angola (see section 2). In our event studies, we follow the standard methodology presented, among others, by Campbell et al. (1997).

We isolated eleven distinct events (see below for the selection criteria) and used several *event windows*, i.e. several periods of time over which markets were likely to have incorporated changing expectations on future asset cash flows as a consequence of the event. The narrowest window includes only the day in which the event has been reported by the media (denoted by  $t_0$ ). A slightly larger window, which we denote with  $[-1, +1]$ , includes  $t_0$  together with the day before and the day after. In an analogous way, we have constructed windows of  $[-3, +3]$ ,  $[-5, +5]$ ,  $[-15, +15]$ , as well as asymmetric windows such as  $[-3, +15]$  and  $[-15, +3]$ . The

idea is to account for the possibility that the event may have been anticipated by investors (or reported late by the press), as well as for the possibility that markets' reaction continues for an extended period after the event date.

For each event, the series of abnormal returns for a given security was generated by estimating model (1) through OLS using two alternative fixed-length *estimation windows*  $T$ , namely  $T = 63$  and  $T = 24$  trading days before the start of the event window used. The choice of these relatively short windows is due to the high frequency of salient political events in Angola in the period under consideration, and the need not to include such events in the sample used to estimate the "normal" model. Denoting with  $t_0 - k$  ( $k = 0, 1, 3, 5, 15$ ) the first day of the chosen event window, we thus estimate (1) on the sample that goes from  $t_0 - k - T$  to  $t_0 - k - 1$ . We take the estimated parameters  $\widehat{\alpha}$ ,  $\widehat{\beta}$  and  $\widehat{\theta}$  to predict the series of abnormal returns and its variance over the estimation window:

$$e_t = r_t - \widehat{\alpha} - \widehat{\beta}r_t^M - \widehat{\theta}S_t \quad (2)$$

$$\widehat{\sigma}_e^2 = \frac{1}{T-1} \sum_{t=t_0-k-T}^{t_0-k-1} e_t^2.$$

We then predict the abnormal returns in the event window using the estimated parameters  $\widehat{\alpha}$ ,  $\widehat{\beta}$ ,  $\widehat{\theta}$  and the series  $\{r_t^M\}$  over  $t = t_0 - k, \dots, t_0 + k$  and generate the series of the *cumulative abnormal return*  $\{CAR_t\}$  as

$$CAR_t = \sum_{j=t_0-k}^t e_j.$$

After performing the above analysis for each company in isolation, we can aggregate the cumulative returns for the various companies by constructing the average cumulative abnormal return:

$$\overline{CAR}_t = \frac{1}{n} \sum_{i=1}^n CAR_t^i \quad (3)$$

where  $i = 1, \dots, n$  refers to the individual companies.

The hypothesis that the political event has no cumulative impact on the price of the stock issued by an individual company (or on the average portfolio) can be tested by exploiting the fact that  $CAR_{t_0+k}$  has a Normal distribution.<sup>3</sup>

One important feature of some of the companies under investigation is that they are *thinly traded*, as evidenced by many daily occurrences in which the closing

---

<sup>3</sup>For details on the test statistic, the reader is referred to Campbell et al. (1997), ch. 4.

price either fails to be reported or is unchanged with respect to the previous trading days. Heinkel and Kraus (1988) stress that simply ignoring security returns on days with no trading (no reported price) may be sub-optimal, in the sense that standard errors may be seriously inflated. They propose to spread the abnormal return recorded over the period of missing prices.<sup>4</sup> We have performed our tests both with and without the thin trading correction proposed by Heinkel and Kraus.

## 3.2 Financial data

We conduct our analysis over what can be considered the ‘last phase’ of the conflict between Unita and the MPLA government, namely the years 1998-2002, after Unita surrendered some of its most valuable mining sites to the government and until the death of Savimbi and the cease fire signed by the rebel movement. In particular, our sample covers the period from January 1st, 1998 to June 28th, 2002. For this period we collected both financial data for diamond mining companies and indicators of political conflict.

We started from the most comprehensive set of diamond mining companies we could put together combining information from the Angolan Ministry of Mining and Geology, from Dietrich (2000a), and from Global Witness (1998). Considering that many of those companies are not publicly traded, the final sample of companies for which we have price data and that detain diamond mining concessions in Angola over the sample period is the following (and we shall refer to it as the “Angolan” sample).

1. **America Mineral Field (AMF)**. Listed in Canada.
2. **Ashton Mining Ltd.** Listed in Australia. (From January 17th, 2001: Rio Tinto)
3. **De Beers Consolidated Mines Ltd.** Listed in South Africa. (From June 1st, 2001: Anglo American).
4. **Diamondworks Ltd.** Listed in Canada.
5. **Odebrecht**. Listed in Brazil.
6. **Southernera**. Listed in Canada.
7. **Trans Hex International**. Listed in South Africa.

---

<sup>4</sup>This rule reflects the perfect-markets style assumption that the stock price may change daily to reflect new information, but the price adjusts so that investors find trading unnecessary.

For each of the above markets, we looked for a diamond mining company that was listed on that market but did *not* have concessions in Angola, nor any ownership link with companies that did. The idea is to use these other companies as a reference point and control for potential shocks to that country or to the diamond industry as a whole (and not captured by the market index) that may have occurred at the same time of a political event. These companies, which we refer to as the “non-Angolan” sample, are:<sup>5</sup>

1. **Alcaston Mining**. Listed in Australia.
2. **Aber Diamond Corporation (ABZ)**. Listed in Canada.
3. **Mazal Mining Exploration Ltd. (MZL)**. Listed in South Africa.

For all these companies we have gathered daily price information from Datastream and Bloomberg (taking the mean of the ask and bid price), and calculated the implied return rates on the stock. We have also collected the series of the market index for each country where the above companies were listed, and specifically: AS30 for Australia, IBOV for Brazil, TS300 for Canada, and JOHMKT for South Africa.

### 3.3 Conflict indicators and event selection

Information on political events in Angola was obtained through a variety of sources. We performed a search on the Lexis-Nexis database in the category ‘World News’ from the news source ‘Middle-East and Africa’, using the following keywords: Unita, AAF, Savimbi, rebels, and diamond(s). We also did a focused search on the same database including the term Angola together with (alternatively): deaths, dead, killed, wounded, injured, attack(s), victims, strike(s). For each piece of news we recorded the number of times it was reported by different agencies. The total number of hits was 23,207 (some of which turned to be unrelated with our search). We also complemented Lexis-Nexis with several web sources.<sup>6</sup> Events were registered on the first day in which they were reported by any type of media. This may not coincide with the day in which they actually (or supposedly) happened, but it seems the most reliable way of setting the date at which investors may have come to know about them.<sup>7</sup>

---

<sup>5</sup>For Brazil we could not find any publicly traded company satisfying the criteria.

<sup>6</sup>Among the most frequently used were the Integrated Regional Information Networks Africa (<http://www.irinnews.org>), the UN Office for the Coordination of Humanitarian Affairs (<http://www.reliefweb.int>), and War News (<http://www.warnews.it/ita/angola.html>).

<sup>7</sup>In a few instances in which the announcement is one of Unita’s periodical accounts of its activities over a long period, and the figures on casualties are largely inflated, such figures have been ignored.

On the basis of the number of casualties and/or of the relevance given by the media to the episode, we have selected the following eleven events.

1. **24 July 1998.** Unita attack in the town of Bula (Lunda Norte province). More than 200 civilians involved. The press reports it as the worst killing since the Lusaka protocol in 1994.
2. **18 November 1998.** Unita attack to Diamondwork's Yetwene mine (Lunda Norte province). 24 civilians involved (killed or wounded)
3. **7 January 1999.** Unita attack to Ashton Mining's Luzamba mine. 4 civilians involved.
4. **26 January 1999.** Endiama's managing director Jose Dias unexpectedly suspended. Allegations of corruption.
5. **3 August 1999.** Unita attack in the town of Malanje. Some sources report over 900 deaths in the shelling of Malanje.
6. **19 January 2000.** Unita attack in the town of Chinguar (Bie province). 115 civilians involved.
7. **24 October 2000.** Unita attack on diamond field in Cambulo (1000 km east of Luanda). 65 garimpeiros killed.
8. **10 August 2001.** Unita attack to train line between Luanda and Dondo. High symbolic valence to prevent elections.
9. **5 October 2001.** Unita attack on diamond field in Kuango area. 80 garimpeiros killed.
10. **22 February 2002.** Savimbi's death during an ambush.
11. **4 April 2002.** Cease fire between Unita and MPLA government.

In our analysis we shall try and estimate the impact of such events, accounting for their different nature. We shall discuss the results grouping the above events into four categories:

- (a) Unita attacks on towns and civilians (7/24/98, 8/3/99, 1/19/00, 8/10/01);
- (b) Unita attacks on mines or diamond fields (11/18/98, 1/7/99, 10/24/00, 10/5/01)
- (c) Changes in management of diamond industry (1/26/99)
- (d) End of conflict (2/22/02, 4/4/02)

While the event under category (c) is not strictly related to the armed conflict, we use it to assess a potential line of interpretation of our results.

### 3.4 Results

The natural starting point for our event study is the end of the conflict. This is because, while on a priori ground we cannot know whether a given attack was perceived as an increase or a decrease in the likelihood of conflict resolution (say, depending on the overall climate of tension and on the outcome of the attack), the theoretical impact of the last two events can be signed with certainty. Savimbi's death was unanimously perceived as the ending point of the conflict between the MPLA and Unita. To quote one source out of hundreds, "(Savimbi's death) brings to an end Unita's long military struggle with the Angolan government. The FAA have achieved an unequivocal military victory over Unita."<sup>8</sup> This was because Savimbi's personality, with its military and political acumen and its ambition for power, was seen as the key obstacle to the peace process: "he embarked on a 27-year long quest for power which eventually took on the character of an obsession. (...) UNITA's military power was progressively weakened (...). For a brilliant tactician, there was no way out. The only option left was peace on the government's terms and a role for himself as a private citizen. It was not one he was prepared to consider".<sup>9</sup> Indeed, one and a half months after Savimbi's death, a formal cease fire had already been signed putting an end to the Angolan conflict.

[Insert Figure 1]

Figure 1 reports the evolution over time of the average cumulative abnormal return (3) for the sample of "Angolan" companies in correspondence of Savimbi's death (top panel) and of the cease fire (bottom panel). The  $\overline{CAR}_t$  is plotted over a window of 15 trading days before and after each event. Quite strikingly, instead of observing an increase in abnormal returns, we observe a sizeable *decrease* leading to negative values. In both cases the hypothesis that  $\overline{CAR}_t$  is zero in correspondence of the event is rejected at the 5 percent level. In other words, investors did not perceive the end of the conflict as "good news" for the companies detaining mining concessions in Angola.

The trends in the figure suggest that both events were to a certain extent anticipated by investors. This is not as surprising as it may seem. In fact, a few days before February 22 two prominent figures of Unita had been killed by the FAA, namely Almeida Ezequiel Chicende (deputy chief of staff) and General Galiano da Silva e Sousa (national political commissioner). Furthermore, the strategy adopted by FAA in late 2001 to push civilians away from the countryside in order to deprive Unita's fighters of food supplies had been quite successful. Senior officials of the rebel movement, including the vice-president Antonio Dembo, were said

---

<sup>8</sup>EIU Country Report, May 2002, p.13.

<sup>9</sup>Ibidem, pp. 13-14.

to be starving and short of medical supplies. The ceasefire of April 4 was even easier to predict. On March 13th the government had announced its intention to suspend offensive operations and begin peace talks with Unita leadership. A ceasefire memorandum had been signed on March 30th and the formal ceasefire four days later sanctioned the end of the war.

[Insert Figures 2,3]

To verify that the declining  $\overline{CAR}_t$  is not driven by other contemporaneous events, in figures 2 and 3 we plot each “Angolan” company’s  $CAR_t$  including in the same graph the CAR of a “non-Angolan” one listed in the same market. Any extraneous event affecting the diamond industry as a whole or the stock market where the company is traded should have produced a similar trend in the CAR of the “non-Angolan” counterpart. Instead, this does not seem to be the case.

How can we explain the apparently paradoxical reaction of investors to the end of the conflict? Our interpretation is that the positive effects of the resolution of uncertainty were counterbalanced by expectations that the newly acquired stability of the government would allow it to extract more rents from companies holding concessions. An explicit quote in this sense is the following: “The end of the war will undoubtedly open up new areas to exploitation by foreign and Angolan mining companies. However, most foreign companies are wary of conditions in Angola following years of contract-breaking by the Angolan authorities”.<sup>10</sup>

That the management of government licenses was not perceived as particularly beneficial to foreign diamond companies can be seen by looking at an earlier political event: the unexpected suspension by the vice-minister of geology and mines of Endiama’s managing director, Jose Dias, on allegations of corruption on January 26, 1999.

[Insert Figures 4,5]

Figure 4 reports the average CAR for “Angolan” companies in correspondence of this event. The impact of this event is positive and significant. The result is even clearer if we look at the returns of individual companies (figure 5). The  $CAR_t$ ’s of relatively small companies like America Mineral Fields, Diamondworks, and TransHex exhibit a sizeable jump up in correspondence of the announcement of the change in Endiama’s leadership. Ashton mining, on the other hand, experiences a decline, which is not too surprising given that Ashton was in a consortium together with Endiama and Odebrecht for the Luzamba mine.

---

<sup>10</sup>Economist Intelligence Unit, Country Report, May 2002, p.27.

Our conjecture is that the threat constituted by UNITA posed a limit to the monopoly power of the government, and this moderated the extent of exploitation that the latter could impose on foreign mining companies. Once the “competitive force” of civil conflict disappeared, fears of mismanagement seem to have prevailed over relief for the end of the war in the mind of investors. Before incorporating this conjecture in a simple theoretical framework and conducting further empirical analysis, we briefly review the results for the remaining two categories of events.

[Insert figure 6]

The analysis of events related to UNITA attacks on civilians did not reveal any systematic pattern. As shown in figure 6, in general there is no significant impact on the average CAR of “Angolan” companies. This is probably due to the fact that those attacks occurred in the context of harsh and prolonged phases of armed conflict in which they represented easily identifiable episodes, but not surprises that would alter the probability of victory from one day to the other.

[Insert figure 7]

Slightly different results are obtained for the attacks on official mines, which should directly concern diamond mining companies. Figure 7 reports the results for the attacks on Diamondworks’ Yetwene mine in November 1998 (left panel), and on Ashton’s Luzamba mine in January 1999 (right panel). Notice that these attacks should not be viewed as deliberate hostility towards individual companies or as attempts to take over their mines, but as strategic attempts to reduce the MPLA’s revenues coming from official diamond concessions. In the words of an Angolan politician, they “would not necessarily be an attempt to take over but to destabilize the (diamond) industry, because part of the tactic would be to reduce the capacity of the government to get any form of revenue for the purpose of having the resources to carry out the war”.<sup>11</sup> Our results show that while the CARs of the companies directly attacked are negative and significant (bottom part of the figure), the average impact on the seven companies in our “Angolan” sample is not (top part of the figure). The effect on Diamondworks seems particularly dramatic: in fact following the attack the company suspended production at Yetwene for one year, imposing substantial financial losses on the company.

---

<sup>11</sup>Wefile Nhlapho, Foreign Affairs deputy director general for Africa, commenting on an attack in August 2000.

## 4 A simple theoretical framework

We next turn to a simple two-period model to analyze the relationship between civil conflict, uncertainty over the possibility to exploit mining concessions, the costs for retaining such concessions, and the value of firms. The goal is not to provide a general model but to sketch the simplest framework containing the main elements that emerge from our event study, and generate further testable predictions.

### 4.1 Setup

Consider a company that detains exploitation rights on a mine in a country that is torn apart by a civil war between the official government and the “rebels”. There are two periods,  $t = 0$  and  $t = 1$ . At  $t = 0$ , the situation of political tension prevents the company from extracting diamonds so the concession is left idle and net profits are zero. However, there are chances that at  $t = 1$  the mine be (re-)opened by paying a fixed and known cost  $I$  once and for all. In this case the exploitation of the mine will produce a perpetual net profit stream of  $\{\pi_t\}_{t=1}^{\infty}$ , where  $\pi_t$  is a random variable.

The possibility to re-open the mine crucially depends on the evolution of the political uncertainty, which we assume to take the following form. Between  $t = 0$  and  $t = 1$  the incumbent government prevails in the conflict with probability  $\lambda_g \in [0, 1]$ , while the rebels prevail with probability  $\lambda_r \in [0, 1]$ . In either case, when one of the parties takes over the conflict ends forever and the ban over the extraction is lifted. On the other hand, with probability  $1 - \lambda_g - \lambda_r$  the civil war continues and the ban on exploiting diamond concessions applies forever. The probabilities  $\lambda_g, \lambda_r$  are public information. In what follows, we denote by  $\lambda \equiv \lambda_g + \lambda_r$  be the probability of conflict resolution.

We also assume that, regardless of the political environment, profits are uncertain, say because of market phenomena (chiefly the evolution of the price for diamonds of quality homogeneous to those extracted in the mine under consideration). In particular, there is a probability  $p \in (0, 1)$  that profits will be “high” at a value  $\pi_1 = \bar{\pi}$  in  $t = 1$ , and will remain high forever, and a probability  $1 - p$  that they will be “low” at  $\pi_1 = \underline{\pi}$  and remain low forever, with  $\underline{\pi} < \bar{\pi}$ .

The above assumptions regarding the evolution of political and economic uncertainty give the model a very simple two-period structure. Generalizations are of course possible but at the cost of additional analytical complexity and without big payoffs in terms of intuition. Figure 8 depicts the laws of motion of the relevant random variables and illustrates the valuation problem faced by the company.

[Insert Figure 8]

As stressed by the real options literature on optimal investment choices (e.g., Pindyck (1991)), the company does not have to decide today whether the mine will be re-opened or not at  $t = 1$ . In our simple setting, it is possible to pay the fixed investment cost after the political uncertainty is resolved and before the realization of the profit variable occurs, or wait until the uncertainty on  $\pi_1$  is resolved and only invest when  $\pi_1 = \bar{\pi}$ . Assuming a constant risk premium, the value of the firm can then be calculated using standard net present value (NPV) from capital budgeting theory.<sup>12</sup> The NPV from investing in the project before the realization of  $\pi_1$  is:

$$\begin{aligned} NPV &= \lambda \left\{ \sum_{t=1}^{\infty} \frac{1}{(1+r)^t} [p\bar{\pi} + (1-p)\underline{\pi}] - \frac{1}{1+r} I \right\} \\ &= \lambda \left\{ \frac{1}{r} [p\bar{\pi} + (1-p)\underline{\pi}] - \frac{1}{1+r} I \right\}. \end{aligned} \quad (4)$$

If instead the company invests after observing a high realization of  $\pi_1$ , we have:

$$\begin{aligned} NPV|_{\pi_1=\bar{\pi}} &= \lambda p \left\{ \sum_{t=1}^{\infty} \frac{1}{(1+r)^t} \bar{\pi} - \frac{1}{1+r} I \right\} \\ &= \lambda p \left( \frac{1}{r} \bar{\pi} - \frac{1}{1+r} I \right) \end{aligned} \quad (5)$$

It is easily seen that (4) > (5) if and only if the following condition holds:

$$\frac{I}{1+r} < \frac{\pi}{r} \quad (6)$$

i.e., if and only if investment costs are relatively low compared to the minimum profit margins. The value of the mining project is then

$$V_0 = \max \left\{ \lambda \left[ \frac{p\bar{\pi} + (1-p)\underline{\pi}}{r} - \frac{I}{1+r} \right], \lambda p \left( \frac{\bar{\pi}}{r} - \frac{I}{1+r} \right), 0 \right\}. \quad (7)$$

---

<sup>12</sup>Our assumption that the rate of return in excess of the riskless rate  $r$  that companies require of uncertain mining projects is constant over time is not too restrictive. This is especially true if the company under consideration is a highly diversified conglomerate with mining operations in several countries and on different commodities. In such case the political and economic risks may be diversified and their potential time-variation does not need to impress significant changes to the required rate of return employed by the firm to calculate the NPV by discounting future cash flows from mining projects.

## 4.2 Political tension, uncertainty, and the value of the firm

Suppose that political tension is measured by a continuous variable  $\tau \geq 0$ , with  $\tau = 0$  indicating that the incumbent government is uncontested and increases in  $\tau$  corresponding to increases in the probability that rebel groups gain control. The variable  $\tau$  could be thought of as military attacks or occupations of portions of the territory, for example. We assume that  $\lambda_g$  and  $\lambda_r$  are a function of  $\tau$  and that the following conditions hold:

$$\begin{aligned} \text{(A1)} \quad & \lambda'_g(\tau) < 0, \lambda''_g(\tau) \geq 0, \lambda_g(0) = 1, \lim_{\tau \rightarrow \infty} \lambda_g(\tau) = 0 \\ \text{(A2)} \quad & \lambda'_r(\tau) > 0, \lambda''_r(\tau) \leq 0, \lambda_r(0) = 0, \lim_{\tau \rightarrow \infty} \lambda_r(\tau) = 1 \end{aligned}$$

where the assumptions on the second derivatives imply non-increasing returns to political tension for the rebels.<sup>13</sup> Figure 9 shows the typical behavior of  $\lambda_g(\tau)$ ,  $\lambda_r(\tau)$ , and as a result of  $\lambda(\tau) \equiv \lambda_g(\tau) + \lambda_r(\tau)$ . Notice that under our assumptions there exists a level of political tension  $\tau^* > 0$  for which  $\lambda(\cdot)$  reaches a minimum, i.e. uncertainty over the outcome of the conflict is maximum.

[Insert Figure 9]

Recalling that from (7) we have  $\frac{\partial V_0}{\partial \lambda} \geq 0$ , a link between political tension and the value of the firm can be established.

*Result 1.* The effect of an increase in political tension,  $d\tau > 0$ , on the value of the firm is ambiguous. In particular,  $V_0$  weakly decreases (increases) if and only if  $\tau < (\geq) \tau^*$ .

The above result suggests that political tension is not necessarily bad for the firm. If the initial level of tension is relatively high and the country is on the verge of a change in the political leadership, further tension may force the situation to an end and represent good news for the firm. On the opposite, a relatively peaceful country with increasing tension and increasing political uncertainty represents a difficult theatre of operations for a firm, the value of which is likely to decline.

## 4.3 Political tension and side payments

The discussion in sections 2 and 3 suggests that political tension may not simply act through the sheer impact on the likelihood of conflict resolution. In particular, in “predatory” states it is common for political élites to extract rents from private investors, for example by granting licences or concessions in exchange for (explicit

---

<sup>13</sup>To guarantee that an interior solution for the level of tension exists, in what follows we shall also require that the second derivatives of  $\lambda_g$  and  $\lambda_r$  are non zero at least over some range, and that  $\lim_{\tau \rightarrow 0} \lambda'_g(\tau) = -\infty$ ,  $\lim_{\tau \rightarrow 0} \lambda'_r(\tau) = +\infty$ .

or implicit) monetary payments. In the Angola, for example, concessions for the exploitation of mining sites are preferentially granted to foreign companies that form partnerships with local ones owned by prominent political figures. Furthermore, the “markup” that such practices impose on firms’ operating costs is likely to increase with the degree of “monopoly” of natural resources of the incumbent government, in the sense that when it holds power uncontested, there is no choice for the firm but to give the required side payments, while when part of the territory is under the control of the rebels, the firm may choose to “buy protection” from the latter to operate its mines.

The simplest way to capture this possibility is to assume that there is a cost  $C$  to be paid to retain the concession between  $t = 0$  and  $t = 1$ , and that this cost is a decreasing function of political uncertainty, say  $C = C(\lambda)$  with

$$(A3) \quad C'(\lambda) > 0, C''(\lambda) \geq 0.$$

Assumption (A3) implies that if it is expected that one party will become the uncontested winner of the conflict, be it the government or the rebels, this party is in a position to impose higher costs on the firm compared to a leader who rules over a divided and war-torn country.<sup>14</sup>

Going back to the valuation of the firm, when (4) and (5) are modified to add the cost  $C(\lambda)$ , the relationship between  $V_0$  and  $\lambda$  may become non-monotonic. Consider first expression (4). Its derivative with respect to  $\lambda$  is:

$$\frac{\partial NPV}{\partial \lambda} = \frac{p\bar{\pi} + (1-p)\underline{\pi}}{r} - \frac{I}{1+r} - C'(\lambda). \quad (8)$$

Intuitively, increases in the probability of conflict resolution on the one hand increase the likelihood that the firm can make positive profits, but on the other hand raise the costs to be borne in order to retain the concession. Notice that under our assumptions  $NPV$  equals zero at  $\lambda = 0$  and then increases for low values of  $\lambda$ . Whether it actually starts decreasing at some point depends on parameter values. To make the problem interesting and differentiate the analysis from that of the previous section, we assume that

$$(A4) \quad \frac{p\bar{\pi} + (1-p)\underline{\pi}}{r} - \frac{I}{1+r} < C'(1)$$

so that there exists a range of values of  $\lambda$  for which  $NPV$  is actually decreasing. Denoting by  $\hat{\lambda}$  the value of  $\lambda$  for which expression (8) equals 0, we can depict the relationship between  $\lambda$  and  $NPV$  as in the top panel of figure 10.<sup>15</sup>

<sup>14</sup>The assumption on the second derivative is sufficient, though not necessary, to obtain the results below.

<sup>15</sup>Figure 10 is drawn under the assumption that  $\hat{\lambda} < 1$  and that  $\frac{p\bar{\pi} + (1-p)\underline{\pi}}{r} > \frac{I}{1+r} + C(1)$ , i.e. the firm can still make positive net profits from mining even when the side payment extracted is maximum.

[Insert Figures 10,11]

Turning to the relationship between political tension and the value of the firm, when we combine the U-shaped relationship between  $\tau$  and  $\lambda$  with the non-monotonic relationship between  $\lambda$  and  $NPV$ , our results become more complicated. If  $\hat{\lambda} \geq 1$ , then the basic pattern of the case without side payments remains prevalent, and the relationship between  $NPV$  and  $\tau$  is first decreasing and then increasing, as shown in the top panel of figure 11. But when  $\hat{\lambda} < 1$  as in figure 10, it is not enough to know whether  $\tau$  is smaller or greater than  $\tau^*$  to assess the impact of political tension. Let us denote by  $\underline{\tau}$  and  $\bar{\tau}$  the values for which  $\lambda = \hat{\lambda}$ , with  $\underline{\tau} < \bar{\tau}$  (the former is associated with a high  $\lambda_g$  and a low  $\lambda_r$ , while the latter with a low  $\lambda_g$  and a high  $\lambda_r$ ). The link between political tension and the value of the firm is then depicted in the bottom panel of figure 11 and can be summarized in the following.

*Result 2.* A marginal increase in political tension,  $d\tau > 0$ , has the following effects:

- (i) for  $\tau \in [0, \underline{\tau}]$ ,  $\lambda$  decreases and  $V_0$  (weakly) increases;
- (ii) for  $\tau \in [\underline{\tau}, \tau^*]$ ,  $\lambda$  decreases and  $V_0$  (weakly) decreases;
- (iii) for  $\tau \in [\tau^*, \bar{\tau}]$ ,  $\lambda$  increases and  $V_0$  (weakly) increases;
- (iv) for  $\tau \geq \bar{\tau}$ ,  $\lambda$  increases and  $V_0$  (weakly) decreases.

This result suggests that, apart from the effect on the probability of conflict resolution, political tension can be “beneficial” for the firm if it helps to moderate the requests of side payments on behalf of the rulers. The interplay between the different effects makes the overall relationship non-trivial. Notice that the same argument applies if the firm waits until the resolution of economic uncertainty before paying the investment cost: all we need is to apply the above reasoning to expression (5), and the qualitative results are unchanged.

## 4.4 Extensions

So far we have neglected any effect of political tension that is not related to uncertainty over conflict resolution. However, it is conceivable that political tension in the form of military operations may affect firm costs by damaging public infrastructure in the area where the mine is located. To this purpose, we can start from our baseline specification (without side payments) and define  $G(d\tau)$  as an indicator variable that takes value 1 if an increase in tension occurs in the geographic area where the mine is located, and zero otherwise. We can then make the investment cost depend on this variable assuming that  $I|_{G(d\tau)=1} > I|_{G(d\tau)=0}$ . As in the case of side payments, this changes the relationship between political tension and the value of the firm in non-trivial ways.

*Result 3.* A marginal increase in political tension,  $d\tau > 0$ , which occurs in the area where the mine is located ( $G(d\tau) = 1$ ) has the following impact:

- (i) for  $\tau < \tau^*$ ,  $V_0$  (weakly) decreases;
- (ii) for  $\tau \geq \tau^*$ ,  $V_0$  can increase or decrease depending on whether or not the “political uncertainty” effect prevails on the “physical infrastructure” effect.

Another possible extension is to consider the case in which political tension increases the volatility of firm profits.<sup>16</sup> For instance, increasing political uncertainty creates uncertainty on future variable costs (e.g. wages, fuel prices, etc.) required by mining activities. Abstracting from the effects of political tension on  $\lambda$ , one could analyze the case in which  $d\tau > 0$  induces a mean preserving spread in the profits expected by the company. To this purpose, we assume that

$$(A5) \quad \bar{\pi}'(\tau) > 0 \text{ and } \underline{\pi}'(\tau) < 0$$

$$(A6) \quad p\bar{\pi} + (1-p)\underline{\pi} = \pi^* > 0$$

Assumption (A5), by saying that profits in the good state increase with  $\tau$  while profits in the bad state decrease with  $\tau$ , captures a situation in which political tension creates both opportunities for increased future profitability in the mining industry, but also foreshadows dangers of permanently diminished returns. Assumption (A6) is introduced to focus on the pure effects of tension on the variance of profits and says that while profit variance is increasing in  $\tau$ , mean profits are not.<sup>17</sup> This assumption implicitly imposes a constraint on the probability  $p$  of high profits as a function of  $\bar{\pi}$  and  $\underline{\pi}$ , namely that  $p = (\pi^* - \underline{\pi})/(\bar{\pi} - \underline{\pi})$ . This implies that any change in tension is associated with a corresponding change in  $p$  to keep mean profits at  $\pi^*$ , so

$$\frac{\partial p}{\partial \tau} = \frac{-\underline{\pi}'(\bar{\pi} - \underline{\pi}) - (\pi^* - \underline{\pi})(\bar{\pi}' - \underline{\pi}')}{(\bar{\pi} - \underline{\pi})^2} = \frac{\bar{\pi}'(\underline{\pi} - \pi^*) + \underline{\pi}'(\pi^* - \bar{\pi})}{(\bar{\pi} - \underline{\pi})^2}. \quad (9)$$

The sign of (9) is ambiguous, depending on the relative sensitivity of  $\bar{\pi}$  and  $\underline{\pi}$  to changes in political tension.

Under the above assumptions, and disregarding the effect of political tension on the probability  $\lambda$  of conflict resolution, the value of the firm reacts to increases in  $\tau$  as follows.

*Result 4.* Consider an increase in political tension  $d\tau > 0$  that induces a mean preserving spread in profits. Then:

- (i) if condition (6) holds, then  $V_0$  is unchanged;

---

<sup>16</sup>This would require departing from the interpretation of  $\bar{\pi}$  and  $\underline{\pi}$  as purely determined by fluctuations in the price of diamonds at the world level.

<sup>17</sup>Since  $Var[\pi] = p(\bar{\pi} - \pi^*)^2 + (1-p)(\underline{\pi} - \pi^*)^2$ , we have  $\partial Var(\pi)/\partial \tau = 2p(\bar{\pi} - \pi^*)\bar{\pi}'(\tau) + 2(1-p)(\underline{\pi} - \pi^*)\underline{\pi}'(\tau) > 0$

(ii) if condition (6) does not hold, then the effect on  $V_0$  is ambiguous. A sufficient condition for  $V_0$  to increase is that (9)  $> 0$ .

Recall that the inequality (6) is the condition under which the firm prefers to invest before the resolution of uncertainty on the size of operating profits rather than to wait. It is then obvious that when firms sunk the investment before the profit uncertainty is resolved, our mean-preserving spread and risk-neutrality assumptions deliver a neutrality result for political tension. However, when the firm waits for the realization of the good state, there are two possibly opposite effects. On the one hand,  $\bar{\pi}$  positively reacts to political tension and this increases  $V_0$ . On the other hand, the change in  $\tau$  may require a compensating increase or reduction in  $p$  to maintain mean profits at  $\pi^*$ . If  $p$  increases, this unambiguously also increases  $V_0$  (hence the sufficient condition in Result 4).<sup>18</sup> If  $p$  decreases, then the net effect on  $V_0$  can be positive or negative depending on whether or not the impact on  $\bar{\pi}$  prevails over that on  $p$ . Interestingly enough, it is possible for the value of the firm to increase when political tension increases.

## 5 Conflict and stock market reactions: evidence on regime switching

### 5.1 Methodology

The switching regression approach is closely linked to the predictions of the above theoretical framework. In particular, the baseline version of our model (without side payments) implies the following nonlinear relationship:

$$e_t = \alpha + \beta X_{\tau < \tau^*} \Delta\tau_t + \gamma(1 - X_{\tau < \tau^*}) \Delta\tau_t + \epsilon_t \quad (10)$$

where  $X_{\tau < \tau^*}$  is a dummy taking value of 1 when  $\tau < \tau^*$  and 0 otherwise,  $\Delta\tau_t$  represents changes in the level of political tension at time  $t$ , and  $\epsilon_t$  is white noise. The model predicts that  $\beta < 0$  and  $\gamma > 0$ . Considering that the time series  $\{\tau_t\}$  can be written as  $\tau_t = \tau_0 + \sum_{j=1}^t \Delta\tau_j$ , the problem is nonstandard. In fact the regressors in (10) are interactions between  $X_{\tau < \tau^*}$  and observables  $\Delta\tau_t$ , with the  $X_{\tau < \tau^*}$ s themselves functions of two additional parameters to be estimated,  $\tau_0$  (the initial level of tension) and  $\tau^*$  (the  $\tau$  minimizing  $\lambda$ ). Nonlinearity derives from the way in which the parameters  $\tau_0$  and  $\tau^*$  enter the estimation problem.

---

<sup>18</sup>Formally,  $\frac{\partial NPV|_{\pi=\bar{\pi}}}{\partial \tau} = \lambda \frac{\partial p}{\partial \tau} \left( \frac{\bar{\pi}}{r} - \frac{I}{1+r} \right) + \lambda p \frac{\bar{\pi}'}{r}$ . While the second addendum is always positive, the first can have either sign.

In our empirical analysis we generalize (10) by allowing both intercepts and variances to be regime dependent and estimate the following model:<sup>19</sup>

$$e_t = \begin{cases} \alpha_1 + \beta_1 \Delta\tau_t + \sigma_1 \epsilon_t & \text{if } \tau_t < \tau^* \\ \alpha_2 + \beta_2 \Delta\tau_t + \sigma_2 \epsilon_t & \text{if } \tau_t \geq \tau^* \end{cases} \quad (11)$$

$$\tau_t = \tau_0 + \sum_{j=1}^t \Delta\tau_j, \quad \epsilon_t \text{ IID } N(0, 1).$$

This is a typical two-regime switching regression model in which the switching is governed by the observable (and exogenous) variable  $\tau_t$ . Estimation and inference in this type of models has been studied by Goldfeld and Quandt (1973). Details on the numerical procedure we use for estimation and inference are provided in Appendix A.

Similarly, we estimate a four-regime switching regression to test the version of the model with side payments, which is a straightforward extension of the two-regime framework.

For the sake of comparison, we shall also report OLS estimates of a simple regression that ignores the regime switch, such as

$$e_t = \alpha + \delta \Delta\tau_t + \epsilon_t$$

and include possible nonlinear terms in  $\Delta\tau_t$ .<sup>20</sup>

## 5.2 Indicators of political tension

For the purpose of regression analysis, we coded the political information gathered through the criteria described in section 3.3 into daily figures for the the following variables:

- *civdeath*: number of civilians dead;
- *civwound*: number of civilians wounded;
- *mildeath*: number of military deaths;
- *milsup*: number of military officials (superior grade) dead;
- *attacks*: number of attacks;
- *agencies*: number of press agencies reporting the news.

---

<sup>19</sup>The model does not imply that estimated variances ought to be regime-dependent. However, working with excess stock returns, allowing the presence of regime-specific heteroskedasticity adds an indispensable degree of flexibility to the statistical model.

<sup>20</sup>Notice that this simpler (linear) model becomes a good approximation of the true process as  $\tau^*$  is either very small (so that  $X_{\tau < \tau^*} = 0$  for most of the sample) or very large (so that  $X_{\tau < \tau^*} = 1$  for most of the sample).

This last variable is meant to capture the preceptions of the media on how serious a given episode is. The other variables have been aggregated into single political tension indexes through principal components and principal factor analysis. In particular, in what follows we shall employ two aggregate tension indexes: *TensionPC* (the first principal component extracted from *civdeath*, *civwound*, *mildeath*, *milsup*, and *attacks*) and *TensionF* (the first principal factor extracted from the same variables). Appendix B reports details on our procedure, including the implied weights on the original variables.<sup>21</sup> Figure 12 reports the evolution over our sample period of these two indexes and of the variable *agencies*. As can be seen from the figure, all three reveal a high prevalence (and also a high variability) of tension.

[Insert Figure 12]

### 5.3 Econometric results

In this section we present our main regression results. As a reference point, it is useful to start with a simple linear regression in which the abnormal returns for each company are regressed on several indicators of political tension. Table 1 reports the estimated OLS coefficients and standard errors from such an exercise for the seven public companies in our sample that have diamond mining concessions in Angola.

[Insert Table 1]

In the top panel the dependent variables are “raw” indicators of political tension, and in particular: the number of civilians dead during an attack of Unita or of the government forced (*civdeath*), the number of civilians wounded (*civwound*), the number of soldiers dead on either side (*mildeath*), the number of high rank officials dead on either side (*milsup*), the number of attacks in that day (*attacks*), and the number of press agencies that report the fact (*agencies*). With almost no exception, the estimated coefficients are never statistically significant and sometimes also have the “wrong” sign, indicating that the naive hypothesis that civil war hurts these companies – or at least has a negative impact on their stocks – is not validated. In panel B we regress abnormal returns over our first aggregate index of political tension, *TensionPC*, which is extracted from the above variables (excluding *agencies*) through the method of principal components. We add a square and a cubic term to account for possible nonlinearities, but again no significant result

---

<sup>21</sup>We also extracted principal components and principal factors from the full set of variables (including the number of agencies), but in what follows prefer to keep the ‘factual’ and the ‘perception’ dimensions separate.

emerges. Panel C repeats a similar exercise using the aggregate index constructed with factor analysis, *TensionF*. Again, although the coefficient on *TensionF* is now invariably negative, the estimates are never statistically significant. We thus turn to alternative approaches to disentangle the more complex relationship between political tension and firms' value.

[Insert Table 2]

Table 2 reports a first set of estimates for the parameters of our two-regime switching regressions as presented in (11). We report *t*-ratio statistics in parenthesis. The political tension index employed is the first principal component, namely *TensionPC*. In all seven cases we find  $\beta_1 < 0$  and  $\beta_2 > 0$ , as predicted by the theory. Furthermore, the coefficient on the tension variable is statistically significant at conventional levels for all but one company in the low tension regime ( $\tau < \tau^*$ ), and for all but two in the high tension regime ( $\tau \geq \tau^*$ ). These results suggest that while increases in tension do induce lower abnormal returns when tension remains below the critical level  $\tau^*$ , once this threshold is passed, further political turmoil is perceived by the market as actually benefiting the company.

On the side, it is interesting to note that the time-varying political tension also strongly affects the volatility of abnormal returns for most of the companies in our sample. With one exception only (De Beers), stock returns not explained by the market model seem to be much less volatile in the high tension regime ( $\tau \geq \tau^*$ ) than in the low tension one. For some companies (e.g., Odebrecht and TransHex), volatility more than halves when tension exceeds some critical level, suggesting that in these conditions stock prices steadily drift up (given the behavior of the reference market portfolio).

[Insert Table 3]

Table 3 reports analogous estimates for the case in which political tension is measured through the factor index *TensionF*. The qualitative results are virtually unchanged.<sup>22</sup>

[Insert Table 4]

In Table 4 we turn to the four-regime switching regressions to test the relevance of side payments in the context of our model. Recall that when the side payments effect is strong enough, the model predicts that as  $\tau$  increases the slope coefficient

---

<sup>22</sup>We have also experimented with two more comprehensive indexes that include the number of press agencies, *TensionPC+ag* and *TensionF+ag*, as well as with the raw number of agencies used as tension variable. Results available upon request.

should change four times:  $\beta_1 > 0$ ,  $\beta_2 < 0$ ,  $\beta_3 > 0$ ,  $\beta_4 < 0$ . This is indeed the pattern that emerges from our estimates. In most cases the coefficients have the expected sign and are statistically significant at the 5 percent level or less (a partial exception is the second regime,  $\beta_2 < 0$ , for which the results are weaker). Only one coefficient is significant and with the “wrong” sign. The negative slope in the last regime is thus consistent with the results of our event study for Savimbi’s death.

[Insert Table 5]

Finally, Table 5 reports our estimates for the sample of diamond mining companies that do *not* have concessions in Angola, using both *TensionPC* and *TensionF*. It is comforting to see that in general we fail to find significant evidence of a regime switch, given that those companies should not be affected by political tension in Angola.

## 6 Concluding remarks

...  
to be written  
...

## References

- [1] Campbell, J., A., Lo, and C., MacKinlay (1997), *The Econometrics of Financial Markets*, Princeton University Press.
- [2] Cilliers, J. and C. Dietrich, eds., (2000), *Angola’s War Economy. The Role of Oil and Diamonds*, Pretoria: Institute for Security Studies.
- [3] Cochrane, J. (2001), *Asset Pricing*, Princeton University Press.
- [4] Collier, P. and A. Hoeffler (2000), “Greed and Grievance in Civil Wars”, World Bank Working Paper 2355.
- [5] Dietrich, C. (2000a), “Inventory of Formal Diamond Mining in Angola”, in Cilliers and C. Dietrich (eds.), op. cit., ch. 7.
- [6] \_\_\_\_\_ (2000b), “Power Struggles in the Diamond Fields”, in Cilliers and C. Dietrich (eds.), op. cit., ch. 8.
- [7] \_\_\_\_\_ (2000c), “Unita’s Diamond Mining and Exporting Capacity”, in Cilliers and C. Dietrich (eds.), op. cit., ch. 13.

- [8] Fisman, R. (2001), “Estimating the Value of Political Connections”, *American Economic Review*, 91, 1095-1102.
- [9] Global Witness (1998), *A Rough Trade. The Role of Diamond Companies and Governments in the Angolan Conflict*. Global Witness Report, London.
- [10] Goldfeld, S., and R., Quandt (1973), “The Estimation of Structural Shifts by Switching Regressions”, *Annals of Economic and Social Measurement*, 23, 475-485.
- [11] Heinkel, R., and A., Kraus (1988), “Measuring Event Impacts in Thinly Traded Stocks”, *Journal of Financial and Quantitative Analysis*, 23, 71-88.
- [12] Johnson, S. and T. Mitton (2001), “Cronyism and Capital Controls: Evidence from Malaysia”, mimeo, MIT.
- [13] Klare, M.T. (2001), *Natural Resource Wars: The New Landscape of Global Conflict*, New York: Metropolitan Books.
- [14] Pindyck, R. (1991), Investment under uncertainty...
- [15] Ramalho, R. (2002), “The Effects of an Anti-Corruption Campaign: Evidence from the 1992 Presidential Impeachment in Brazil”, mimeo, MIT.
- [16] Roberts, B.E. (1990), “A Dead Senator Tells No Lies: Seniority and the Distribution of Federal Benefits”, *American Journal of Political Science*, 34(1), 31-58.
- [17] Sachs, J.D. and A.M. Warner (1995), “Natural Resource Abundance and Economic Growth”, NBER Working Paper 5398.

## Appendix A - Estimation and inference in the switching regression framework

We follow Goldfeld and Quandt (1973) in assuming that the law governing the regime switching depends on a set of parameters to be estimated. In our case these parameters are called  $\tau_0$ ,  $\tau^*$  (already introduced in the text) and  $\delta$  (to be introduced below).

We start from a time series of political events, such as the number of civilian vs. military casualties in each day, the number of attacks, etc., and aggregate it into a single indicator  $\{x_t\}$ . This indicator in turn affects our tension variable  $\tau_t$ .

We parameterize the variance of the political tension index through a parameter  $\delta$  in the following way:

$$\begin{aligned}\tau_t &= \tau_{t-1} + \frac{x_t - x_{t-1}}{\delta N} \\ \Delta\tau_t &= \frac{\Delta x_t}{\delta N} \quad (x_0 = \tau_0).\end{aligned}\tag{12}$$

with  $t = 1, \dots, N$  indicating the period (day). A small  $\delta$  corresponds to a highly volatile tension index; for instance,  $\delta = N^{-1}$  implies that  $\tau_t = x_t$ . Notice that  $\delta$  is another parameter to be estimated; in our estimates, we consider  $\delta \in [\frac{1}{2}, 2]$ .

Under our distributional assumption on the error terms, the log-likelihood function for model (11) may be written as:

$$\begin{aligned}\ell(\{\alpha_i\}_{i=1,2}, \{\beta_i\}_{i=1,2}, \{\sigma_i\}_{i=1,2}, \tau_0, \tau^*, \delta) &\propto -N(1 - X_{\tau \geq \tau^*}) \ln \sigma_1 + \\ - \sum_{t=1}^N (1 - X_{\tau \geq \tau^*}) \frac{(e_t - \alpha_1 - \beta_1 \Delta\tau_t)^2}{2\sigma_1^2} &- NX_{\tau \geq \tau^*} \ln \sigma_2 - \sum_{t=1}^N X_{\tau \geq \tau^*} \frac{(e_t - \alpha_2 - \beta_2 \Delta\tau_t)^2}{2\sigma_2^2}.\end{aligned}$$

Standard MLE estimates may be obtained by numerically solving the following program:

$$\begin{aligned}\max_{\{\alpha_i\}, \{\beta_i\}, \tau_0, \tau^*, \delta} &\ell(\{\alpha_i\}_{i=1,2}, \{\beta_i\}_{i=1,2}, \{\sigma_i\}_{i=1,2}, \tau_0, \tau^*, \delta) \\ \text{s.t. } &\sigma_i > 0 \quad \forall i \quad \delta \in \left[\frac{1}{2}, 2\right] \quad \tau_0 > 0 \quad \tau^* \in (0, \max_t \{\tau_t\}].\end{aligned}\tag{13}$$

The solution of (13) may be broken down as the following iterative process:<sup>23</sup>

1. Start with some initial guess for  $\tau_0, \tau^*$ , and  $\delta$ . Use (12) to build  $\{\tau_t\}_{t=1}^N$ , hence  $\{X_{t \geq \tau^*}\}_{t=1}^N$ .
2. Given the two times series of indicator variables, calculate the standard, closed-form MLE estimates

$$\begin{aligned}\hat{\beta}_i(\tau_0, \tau^*, \delta) &= \frac{\sum_{t=1}^N I_{it} \left( e_t - \frac{\sum_{t=1}^N I_{it} e_t}{\sum_{t=1}^N I_{it}} \right) \left( \Delta\tau_t - \frac{\sum_{t=1}^N I_{it} \Delta\tau_t}{\sum_{t=1}^N I_{it}} \right)}{\sum_{t=1}^N I_{it} \left( \Delta\tau_t - \frac{\sum_{t=1}^N I_{it} \Delta\tau_t}{\sum_{t=1}^N I_{it}} \right)^2} \\ \hat{\alpha}_i(\tau_0, \tau^*, \delta) &= \frac{\sum_{t=1}^N I_{it} e_t}{\sum_{t=1}^N I_{it}} - \hat{\beta}_i \frac{\sum_{t=1}^N I_{it} \Delta\tau_t}{\sum_{t=1}^N I_{it}}\end{aligned}$$

---

<sup>23</sup> As observed by Hamilton (1994, p. 689) this is a special case of the EM algorithm.

$$\hat{\sigma}_i^2(\tau_0, \tau^*, \delta) = \left( \sum_{t=1}^N I_{it} \right)^{-1} \sum_{t=1}^N I_{it} \left( e_t - \hat{\alpha}_i + \hat{\beta}_i \Delta \tau_t \right)^2.$$

where  $\{I_{it}\}_{t=1}^N$  corresponds to the indicator variable appropriate for regime  $i = 1, 2$ .

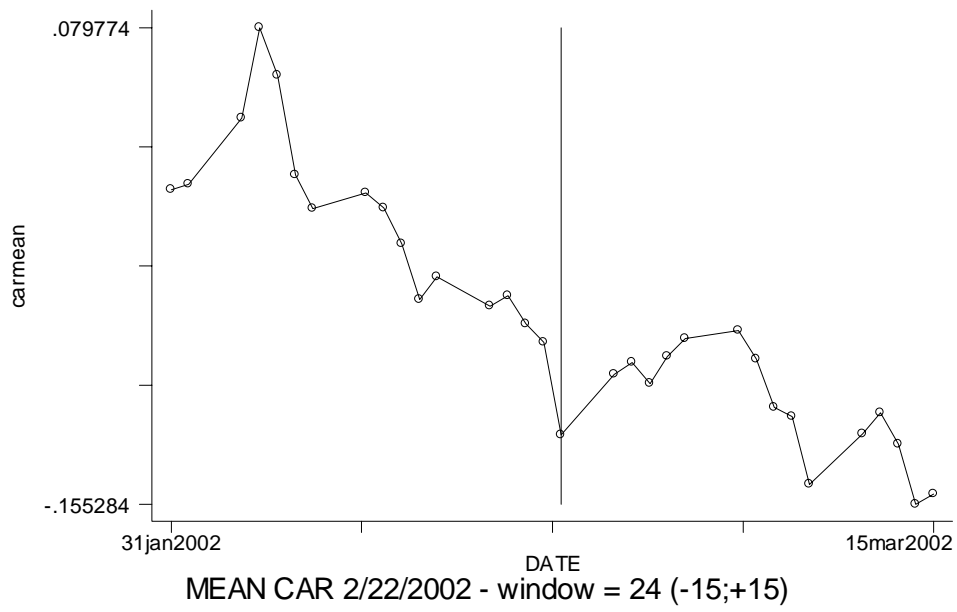
3. Maximize  $\ell(\{\hat{\alpha}_i\}_{i=1,2}, \{\hat{\beta}_i\}_{i=1,2}, \{\hat{\sigma}_i^2\}_{i=1,2}, \tau_0, \tau^*, \delta)$  by choosing  $\tau_0, \tau^*$ , and  $\delta$  subject to the constraints in (13) (which is relatively straightforward, being a three-variate problem. Call the resulting minimizers  $\hat{\tau}_0, \hat{\tau}^*, \hat{\delta}$ .
4. Repeat steps 2 - 3 until convergence of the estimates.

Inference may be based on the fact that under the assumption of strict stationarity,

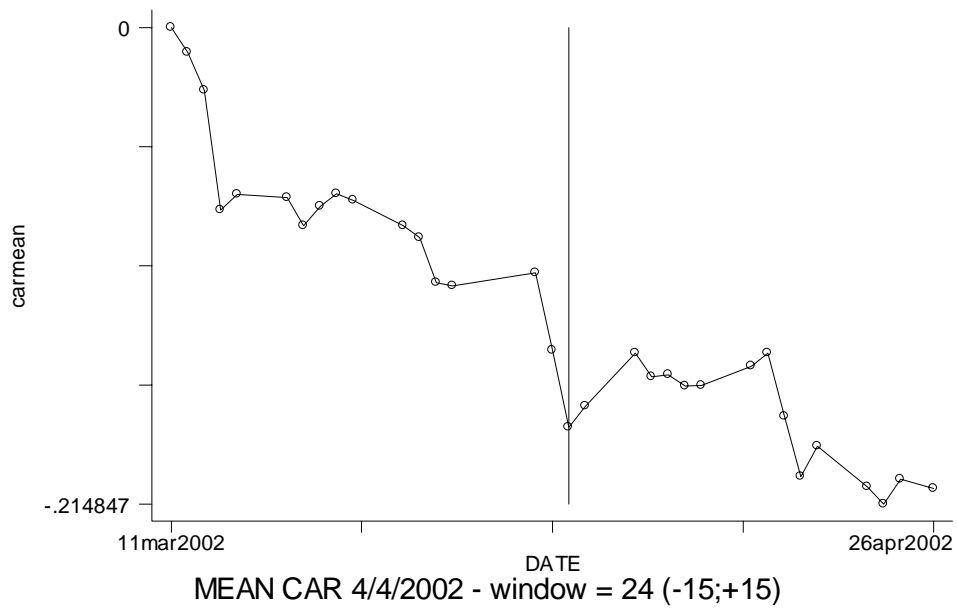
$$\hat{\boldsymbol{\theta}} \xrightarrow{D} N(\boldsymbol{\theta}_0, \mathfrak{S}^{-1})$$

where  $\boldsymbol{\theta} \equiv [\{\alpha_i\}_{i=1,2}, \{\beta_i\}_{i=1,2}, \{\sigma_i\}_{i=1,2}, \tau_0, \tau^*, \delta]'$ , and  $\mathfrak{S}$  denotes the information matrix. In practice three numerical estimates of  $\mathfrak{S}$  are normally calculated:

$$\begin{aligned} \hat{\mathfrak{S}}_H &\equiv \frac{\partial \ell(\boldsymbol{\theta})}{\partial \boldsymbol{\theta} \partial \boldsymbol{\theta}'} \Big|_{\boldsymbol{\theta}=\hat{\boldsymbol{\theta}}} \\ \hat{\mathfrak{S}}_{OP} &\equiv \sum_{t=1}^T \mathbf{h}(\hat{\boldsymbol{\theta}}) \mathbf{h}(\hat{\boldsymbol{\theta}})' & \mathbf{h}(\hat{\boldsymbol{\theta}}) &\equiv \frac{\partial \ell(\boldsymbol{\theta})}{\partial \boldsymbol{\theta}} \Big|_{\boldsymbol{\theta}=\hat{\boldsymbol{\theta}}} \\ \hat{\mathfrak{S}}_{HAC} &\equiv \hat{\mathfrak{S}}_H^{-1} \hat{\mathfrak{S}}_{OP} \hat{\mathfrak{S}}_H^{-1} \end{aligned}$$

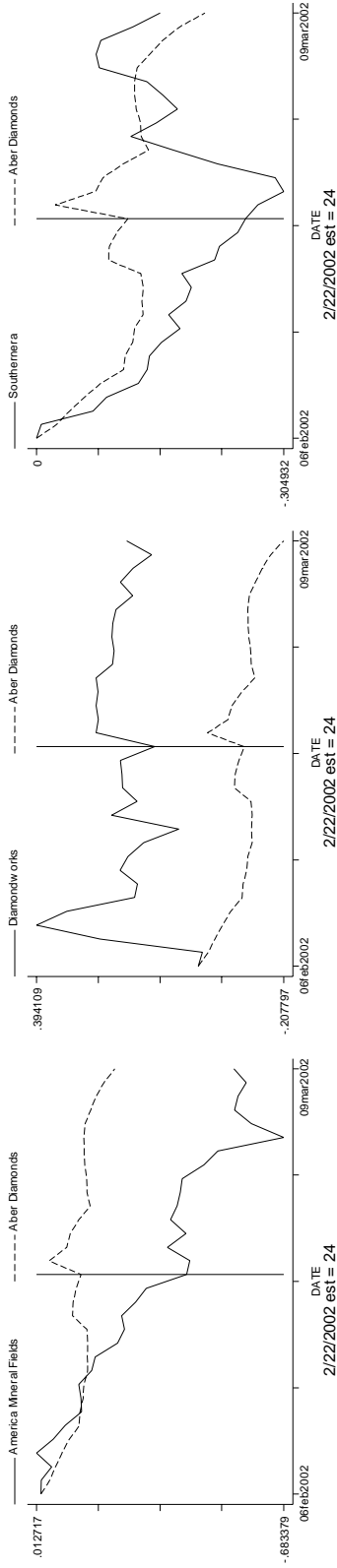


(a) Savimbi's death

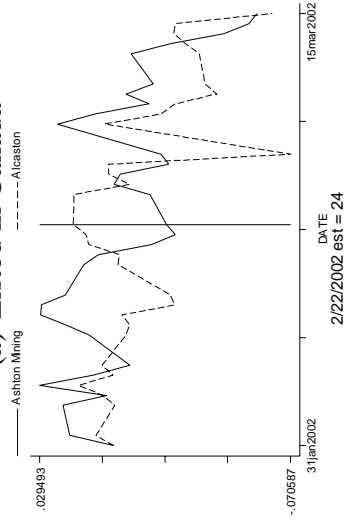


(b) Cease fire

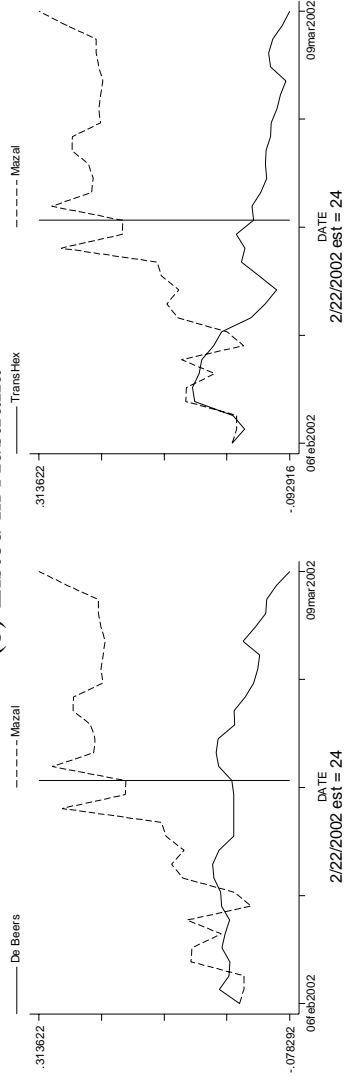
**Figure 1: End of conflict**



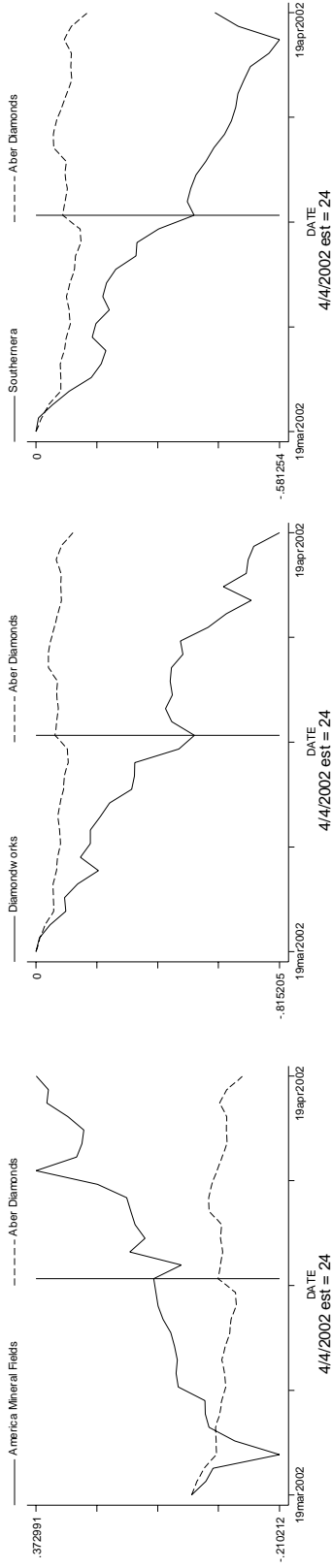
(a) Listed in Canada



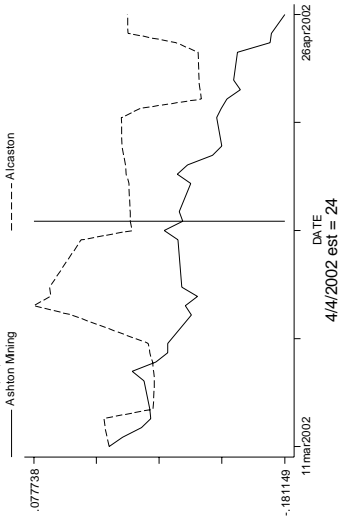
(b) Listed in Australia



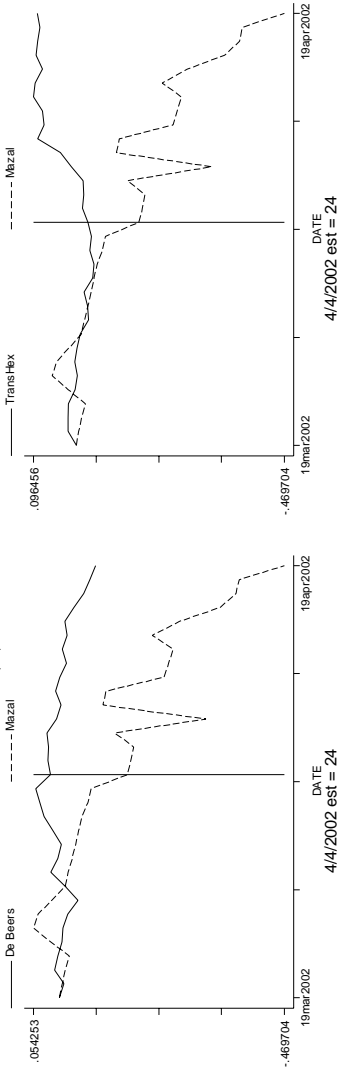
(c) Listed in South Africa  
**Figure 2: Savimbi's death: "Angolan" vs "non-Angolan"**



(a) Listed in Canada

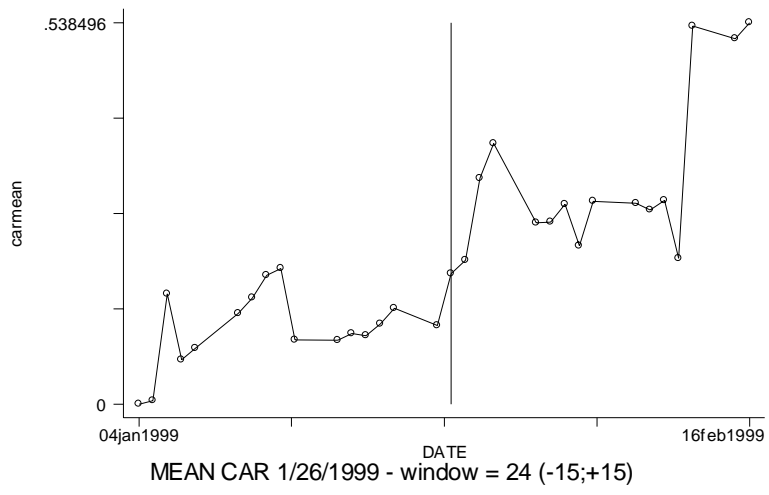


(b) Listed in Australia

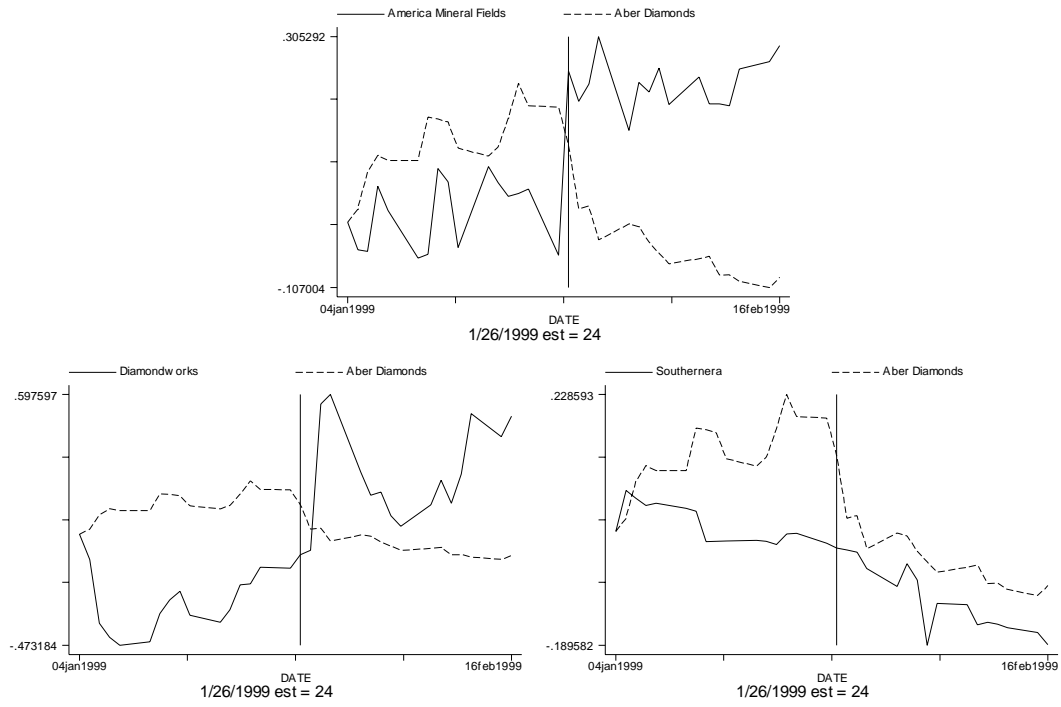


(c) Listed in South Africa

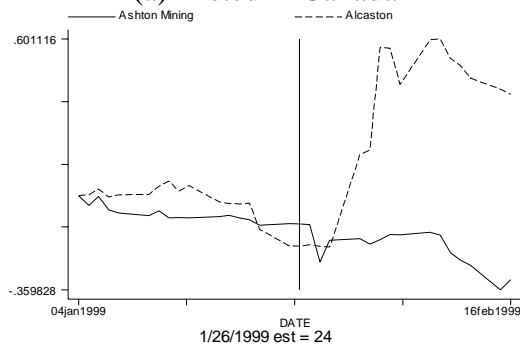
Figure 3: Cease fire: ‘Angolan’ vs ‘non-Angolan’



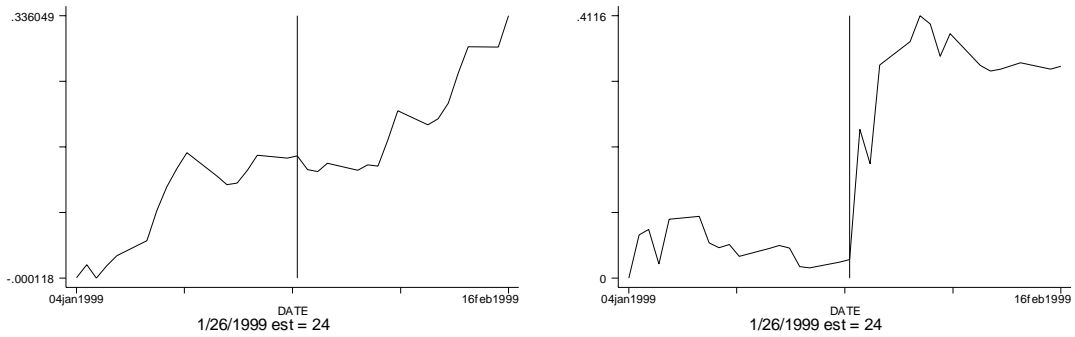
**Figure 4: Endiama director suspended**



(a) Listed in Canada

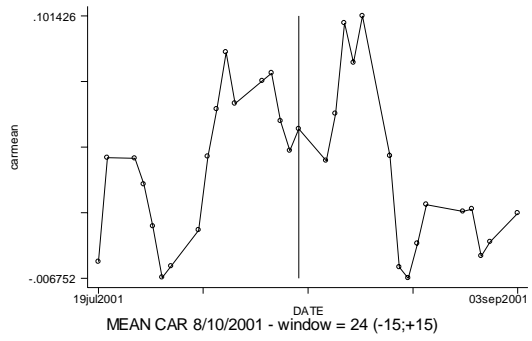
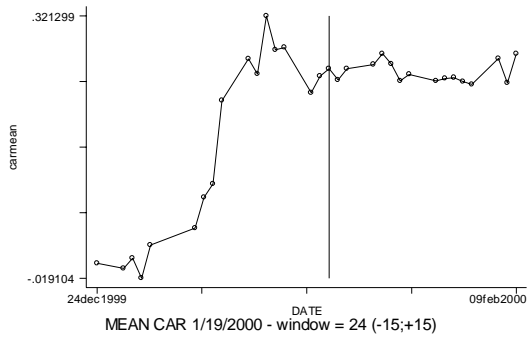
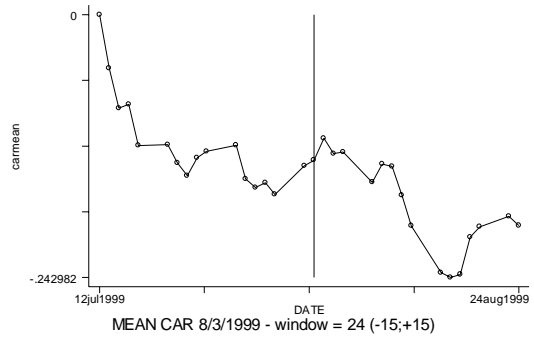
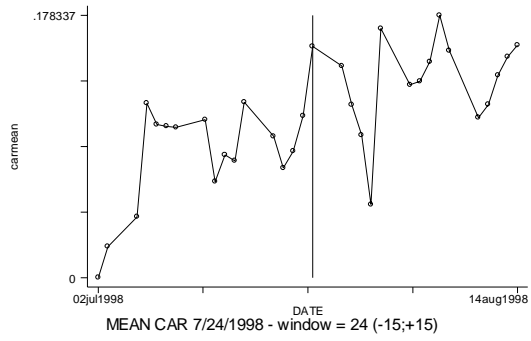


(b) Listed in Australia

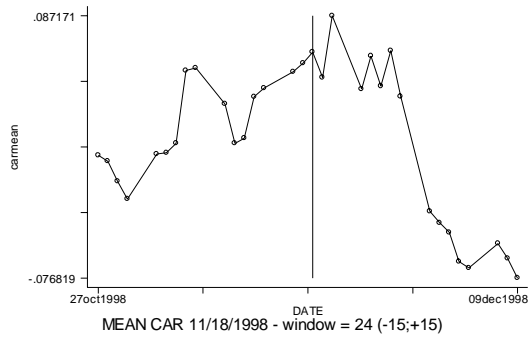


(c) Listed in South Africa

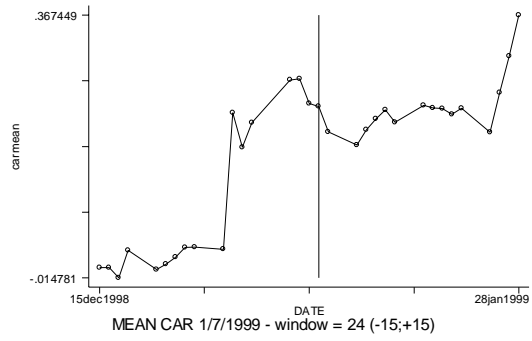
**Figure 5: Endiama director suspended, by company**



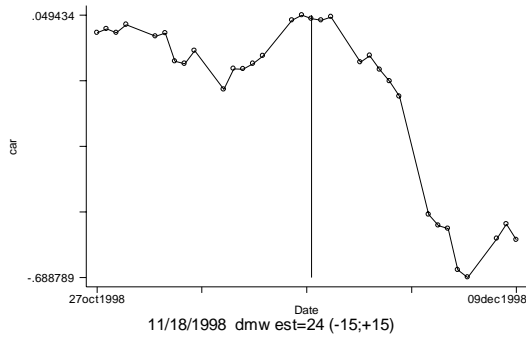
**Figure 6: Unita attacks on towns and civilians**



Average "Angolans"

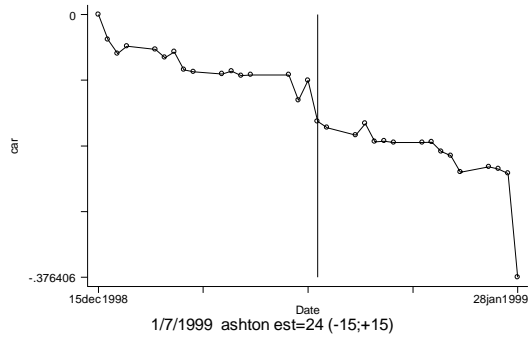


Average "Angolans"



Diamondworks

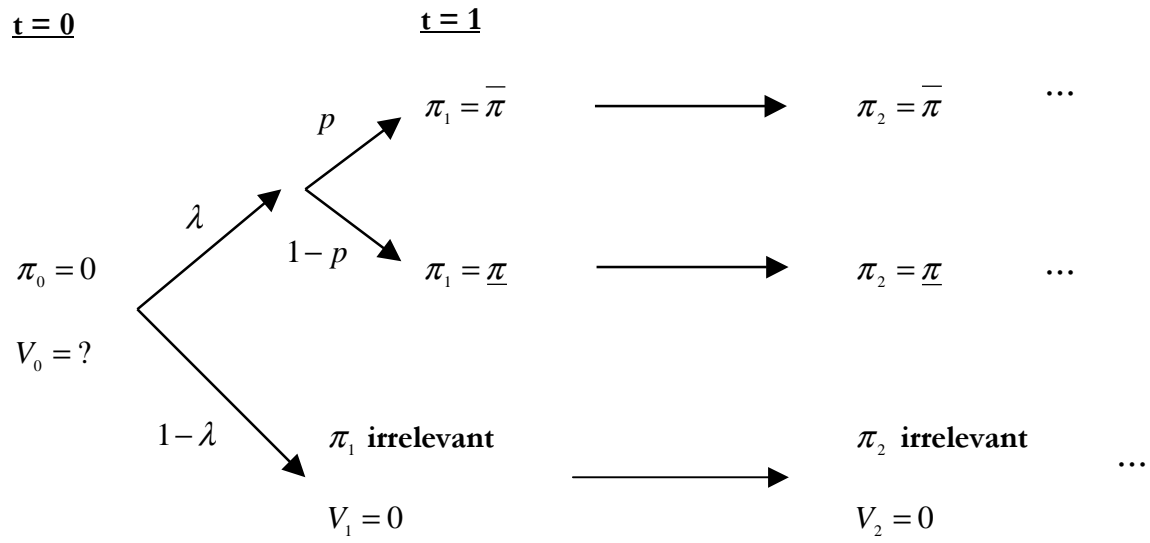
(a) Yetwene Mine



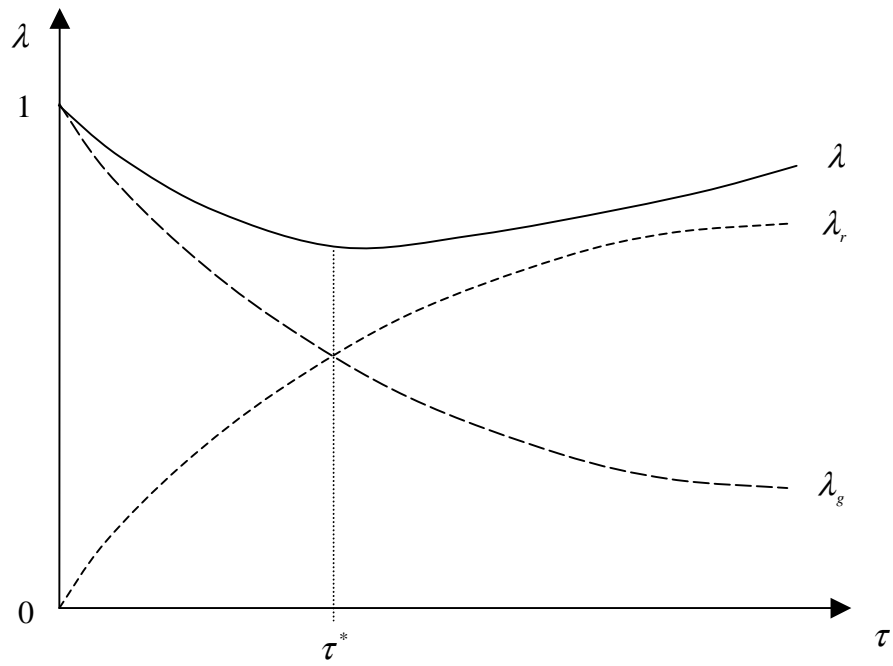
Ashton Mining

(b) Luzamba Mine

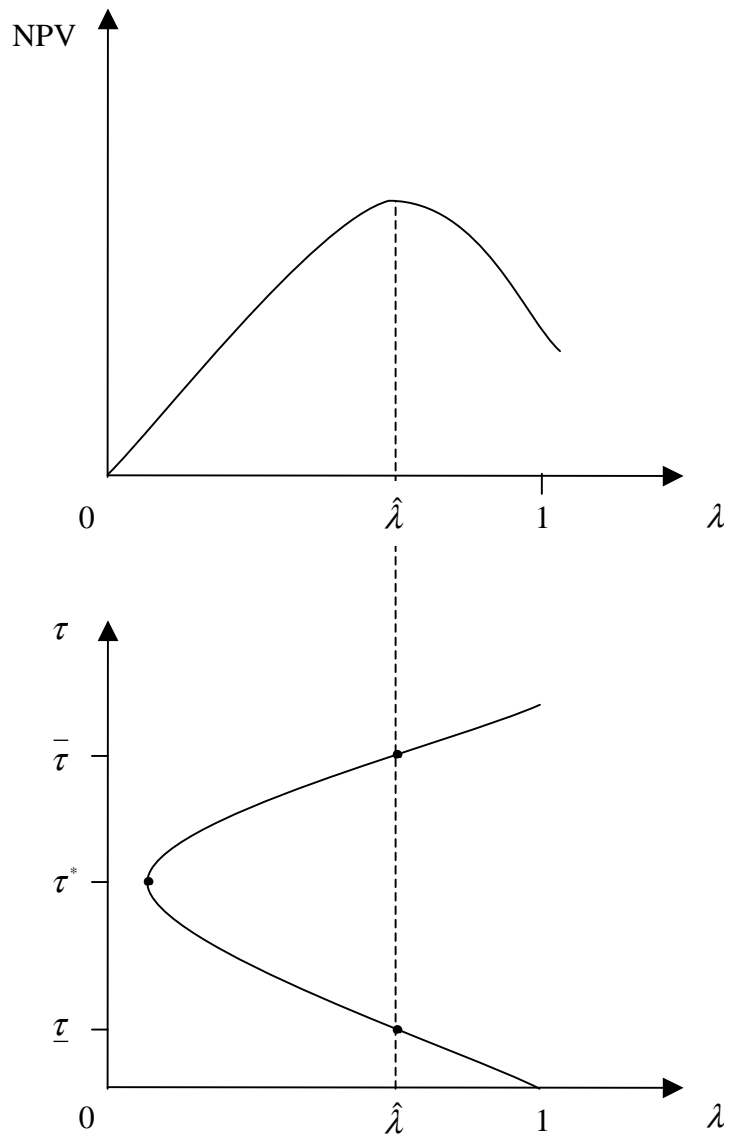
Figure 7: Unita attacks on mines



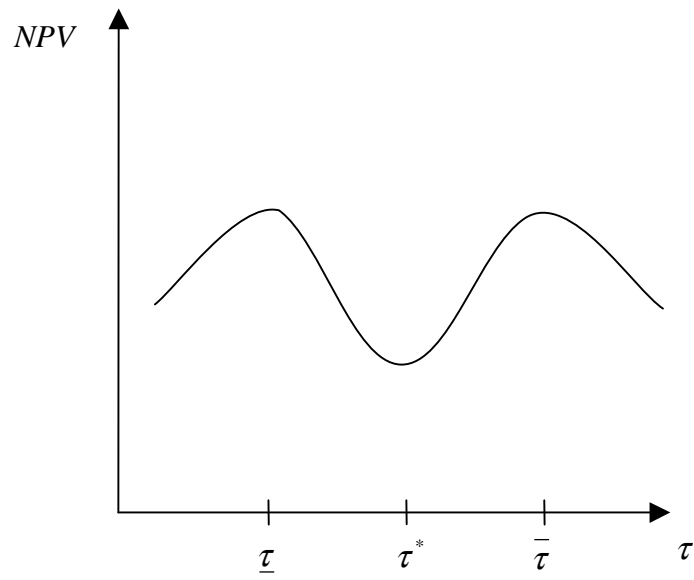
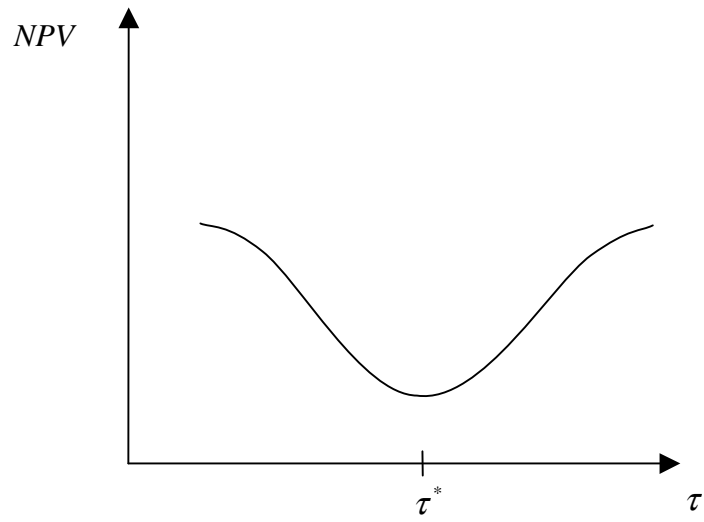
**Figure 8: Political and economic uncertainty**



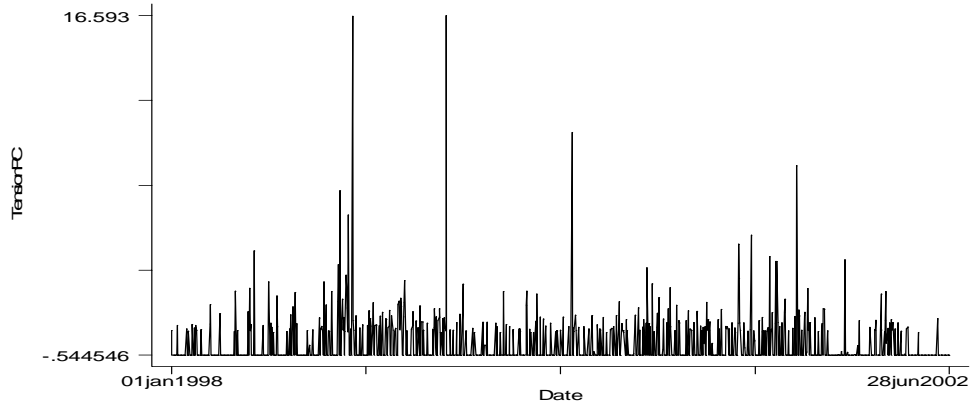
**Figure 9: Political tension and conflict outcome**



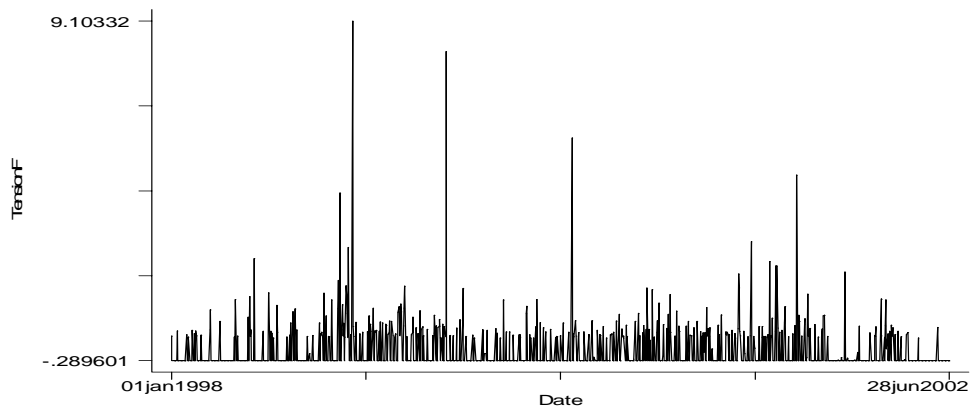
**Figure 10: Political tension with side payments**



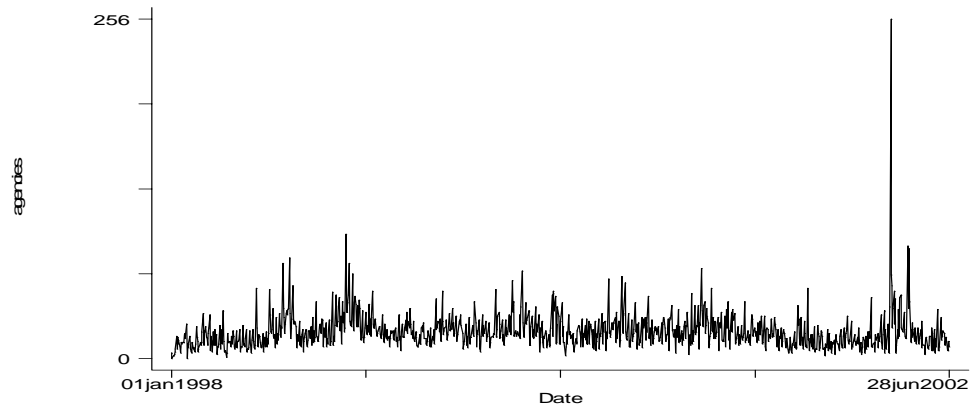
**Figure 11: Regimes**



(a) TensionPC



(b) TensionF



(c) Agencies

**Figure 12: Political tension indexes**

**Tab 1: OLS regressions**

	America Mineral Fields	Ashton Mining Limited	De Beers	Diamond Works	Odebrecht	Southernera	Trans Hex
civdeath	.033 (.067)	-.002 (.023)	.008 (.015)	-.012 (.089)	-.006 (.097)	.034 (.033)	.017 (.039)
civwound	.193 (.177)	.007 (.058)	-.081** (.040)	-.004 (.231)	.061 (.274)	.004 (.085)	.036 (.102)
mildeath	-.057 (.065)	-.003 (.021)	.003 (.014)	-.030 (.088)	-.018 (.138)	.007 (.032)	.017 (.038)
milsup	-4.431 (7.509)	6.41 (2.588)	-1.528 (1.719)	10.300 (16.582)	14.794 (18.482)	-2.418 (3.767)	1.261 (4.542)
attacks	-1.496 (5.566)	-.825 (1.875)	-.955 (1.508)	-7.233 (7.857)	6.868 (9.131)	-2.302 (2.771)	-2.201 (3.963)
agencies	-.255 (.208)	.009 (.067)	.037 (.046)	.043 (.029)	-.443 (.472)	-.129 (.102)	.026 (.121)
constant	5.296 (4.902)	.079 (1.608)	-.165 (1.096)	.869 (6.787)	6.831 (10.486)	.003 (2.400)	-.317 (2.885)
Nobs	1077	1168	1099	969	633	1128	1108
R <sup>2</sup>	.004	.005	.006	.001	.003	.003	.001
<hr/>							
<i>TensionPC</i>	.0001 (4.298)	.007 (1.401)	-.734 (1.016)	-7.124 (6.031)	-2.790 (7.492)	-.797 (2.095)	-1.483 (2.572)
<i>TensionPC</i> <sup>2</sup>	-1.237 (1.712)	.040 (.530)	-.014 (.459)	1.807 (2.176)	2.908 (2.929)	.058 (.780)	.958 (1.049)
<i>TensionPC</i> <sup>3</sup>	.096 (3.074)	.002 (.029)	-.0006 (.025)	-.087 (.120)	-.162 (.162)	.001 (.043)	-.050 (.058)
constant	.944 (3.074)	.220 (1.008)	.062 (.721)	-2.023 (4.331)	-1.941 (5.465)	-.041 (1.499)	-.898 (1.834)
Nobs	1077	1170	1099	969	633	1128	1108
R <sup>2</sup>	.002	0	.003	.001	.002	.0003	.001
<hr/>							
<i>TensionF</i>	-.259 (7.944)	-.174 (2.596)	-1.784 (1.870)	-13.292 (11.165)	-2.657 (13.781)	-1.559 (3.879)	-2.635 (4.752)
<i>TensionF</i> <sup>2</sup>	-3.810 (5.975)	.234 (1.850)	.538 (1.591)	6.085 (7.518)	6.465 (9.754)	.426 (2.719)	3.334 (3.644)
<i>TensionF</i> <sup>3</sup>	.580 (.630)	-.022 (.195)	-.071 (.166)	-.544 (.786)	-.661 (1.023)	-.020 (.286)	.334 (.380)
Constant	.801 (3.054)	.199 (1.002)	-.073 (.715)	-1.941 (4.301)	-1.059 (5.395)	-.084 (1.490)	-.869 (1.821)
Nobs	1077	1170	1099	969	633	1128	1108
R <sup>2</sup>	.003	0	.003	.001	.001	.0002	.001

Note: Standard errors in parenthesis. Coefficients and standard errors multiplied by 10<sup>3</sup>

Tab 2: Two-regime switching regressions, Political tension index = Tension PC

	America Mineral Fields	Ashton Mining Limited	De Beers	Diamond Works	Odebrecht	Southernera	Trans Hex
$\tau < \tau^*$							
Constant ( $\alpha_1$ ) <sup>(a)</sup>	-0.002 (.716)	-0.63 (2.343)	.001 (9.847)	.003 (5.308)	-0.002 (2.411)	-0.067 (.534)	-0.0002 (1.358)
Tension ( $\beta_1$ )	-0.466 (3.266)	-1.117 (1.748)	-0.978 (7.193)	-0.913 (1.746)	-1.194 (8.628)	-0.145 (1.181)	-0.462 (4.888)
Volatility ( $\sigma_1$ )	.088 (480.28)	.030 (519.95)	.021 (420.99)	.126 (373.16)	.136 (279.03)	.044 (503.11)	.052 (488.74)
$\tau \geq \tau^*$							
Constant ( $\alpha_2$ )	.034 (2.830)	-0.18 (4.814)	-0.003 (12.430)	-0.011 (15.703)	.033 (12.242)	-0.017 (2.018)	.001 (2.792)
Tension ( $\beta_2$ )	.883 (1.058)	1.893 (5.767)	1.231 (4.954)	1.656 (4.884)	.365 (3.045)	1.164 (1.273)	.819 (8.876)
Volatility ( $\sigma_2$ )	.060 (21.360)	.010 (10.676)	.041 (252.37)	.088 (221.04)	.058 (44.972)	.029 (24.210)	.021 (84.185)
$\tau^*$	1.0039	1.0039	.9996	1.0003	1.0019	1.0031	1.0008
Nobs	1076	1166	1101	970	632	1127	1109
Log-Likelihood	1092.30	2423.66	2506.37	721.24	379.80	1914.79	1723.90
R <sup>2</sup>	0:11%	0:02%	0:41%	0:22%	0:42%	0:10%	0:06%

Notes: (a) Coefficients for Ashton Mining and Southernera are multiplied by 10<sup>3</sup>.

T-ratio statistics in parenthesis.

**Tab 3: Two-regime switching regressions, Political tension index = TensionF**

	America Mineral Fields	Ashton Mining Limited	De Beers	Diamond Works	Odebrecht	Southernera	Trans Hex
$\tau < \tau^*$							
Constant ( $\alpha_1$ ) <sup>(a)</sup>	-0.0002 (.655)	.070 (.846)	.045 (.564)	.020 (.051)	-0.0005 (.791)	-0.084 (.672)	-0.079 (.530)
Tension ( $\beta_1$ )	-0.145 (1.824)	.203 (1.702)	-0.221 (3.693)	-1.385 (2.445)	-1.538 (3.479)	-0.431 (2.771)	-1.761 (7.179)
Volatility ( $\sigma_1$ )	.088 (480.30)	.030 (518.32)	.028 (491.64)	.118 (432.66)	.135 (281.70)	.044 (502.88)	.052 (495.03)
$\tau \geq \tau^*$							
Constant ( $\alpha_2$ )	.040 (3.019)	-0.004 (1.919)	-0.041 (5.582)	-0.012 (5.057)	.057 (3.367)	-0.012 (2.758)	.013 (6.271)
Tension ( $\beta_2$ )	1.164 (.432)	1.063 (1.853)	1.680 (3.145)	.931 (1.777)	-0.801 (.603)	1.842 (2.266)	.461 (1.094)
Volatility ( $\sigma_2$ )	.061 (259.36)	.010 (24.95)	.020 (13.962)	.013 (21.639)	.060 (21.639)	.028 (33.685)	.012 (19.290)
$\tau^*$	1.0016	1.001	1.0036	1.0013	1.0030	1.0016	1.0013
Nobs	1076	1166	1101	970	632	1127	1109
Log-Likelihood	1092.26	2424.12	2393.94	707.84	373.68	1914.94	1712.27
R <sup>2</sup>	0.10%	0.0%	0.14%	0.01%	0.11%	0.07%	0.07

Notes: (a) Coefficients for Ashton Mining, Southernera, Transhex, DeBeers, Diamondworks are multiplied by 10<sup>3</sup>.  
T-ratio statistics in parenthesis.

**Tab 4: Four-regime switching regressions, Political Tension Index = TensionPC**

	AMF	Ashton	De Beers	Diamond Works	Odebrecht	Southernera	Trans Hex
$\tau < \tau_0$							
Constant ( $\alpha_1$ )	.001 (3.268)		.001 (15.25)	.005 (9.849)	-.001 (1.775)	.0005 (3.135)	.0004 (2.038)
Tension ( $\beta_1$ )	1.200 (9.624)		1.072 (9.154)	1.902 (10.76)	-.158 (.413)	1.583 (7.251)	1.673 (5.782)
Volatility ( $\sigma_1$ )	.084 (410.0)		.021 (419.2)	.126 (239.5)	.143 (239.52)	.045 (432.38)	.057 (523.5)
$\tau_0 \leq \tau < \tau^*$							
Constant ( $\alpha_1$ )	.018 (139.2)		.005 (13.67)	-.011 (15.19)	.005 (4.351)	-.0002 (.591)	.013 (20.939)
Tension ( $\beta_1$ )	-.271 (.314)		-.940 (.112)	-1.094 (5.420)	.472 (1.082)	-.650 (1.920)	1.555 (.527)
Volatility ( $\sigma_1$ )	.121 (160.2)		.021 (53.27)	.086 (190.6)	.103 (127.47)	.043 (238.60)	.026 (46.75)
$\tau^* \leq \tau < \tau_1$							
Constant ( $\alpha_1$ )	-.018 (24.11)		-.004 (12.27)	.006 (1.989)	-.019 (2.892)	-.005 (2.892)	-.002 (7.250)
Tension ( $\beta_1$ )	1.230 (6.446)		1.528 (4.424)	.754 (1.312)	-.064 (.062)	-.668 (.709)	1.858 (6.214)
Volatility ( $\sigma_1$ )	.075 (174.1)		.044 (222.4)	.100 (67.65)	.141 (67.647)	.051 (75.108)	.034 (244.9)
$\tau \geq \tau_1$							
Constant ( $\alpha_1$ )	.009 (5.817)		.002 (4.644)	.003 (.848)	.043 (12.139)	.012 (15.307)	.004 (5.884)
Tension ( $\beta_1$ )	-.436 (2.978)		-1.489 (7.944)	-.348 (1.708)	-1.295 (3.677)	-1.310 (6.914)	.673 (3.066)
Volatility ( $\sigma_1$ )	.066 (85.5)		.026 (123.2)	.079 (56.67)	.058 (24.870)	.021 (62.503)	.021 (65.67)
$\tau_0$	.9995		1.0004	1.0012	1.0007	.9704	1.0002
$\tau^*$	1.0019		1.0006	1.0032	1.0026	.9713	1.0004
$\tau_1$	1.0044		1.0014	1.0066	1.0044	.9719	1.0017
N.obs.	1076		1101	970	632	1127	1109
LogLikelihood	1119.0		2518.1	723.2	387.19	1119.04	1766.4
R <sup>2</sup>	.99%		.51%	.50%	.28%	.14%	.11%

Notes: T-ratio statistics in parenthesis.

**Tab 5: Two-regime switching regressions, ‘non-Angolan’ companies**

	TensionPC			TensionF		
	Aber Diamonds	Mazal	Thabex	Aber Diamonds	Mazal	Thabex
$\tau < \tau^*$						
Constant ( $\alpha_1$ )	-0.0004 (3.761)	-0.0001 (.338)	.001 (1.829)	-0.0003 (3.084)	.0001 (.222)	-0.002 (4.300)
Tension ( $\beta_1$ )	-1.071 (1.771)	1.372 (3.723)	3.046 (18.626)	-1.209 (1.652)	12.642 (1.342)	.719 (.539)
Volatility ( $\sigma_1$ )	.029 (432.00)	.106 (356.92)	.212 (486.54)	.029 (432.26)	.106 (356.42)	.185 (480.76)
$\tau \geq \tau^*$						
Constant ( $\alpha_2$ )	-0.0002 (1.135)	.032 (4.887)	.004 (1.886)	-0.0004 (1.982)	-0.006 (2.765)	.059 (99.794)
Tension ( $\beta_2$ )	-.386 (.715)	-.438 (.500)	-.940 (7.743)	-.410 (.624)	8.837 (.975)	.632 (.129)
Volatility ( $\sigma_2$ )	.028 (259.54)	.034 (22.836)	.070 (72.652)	.028 (184.06)	.028 (35.785)	.520 (99.794)
$\tau^*$	1	1.0022	1.0045	1	1.0054	.9835
Nobs	1127	801	1100	1127	801	1100
Log-Likelihood	2398.50	667.97	173.40	2398.54	672.66	247.81
R <sup>2</sup>	0.33%	0.06%	0.31%	0.29%	0.31%	0.35%

Notes: T-ratio statistics in parenthesis.