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NATO Defense Expenditures:

Common Goals or Diverging Interests?

A Structural Analysis

Jomana Amara

By testing for structural breaks in defense expenditures, we determine the dates of change in the pattern of defense expenditures for the NATO allies. If NATO members are responding to a common threat, we expect to see similar breaks, in both direction and dates, for defense expenditures. The breaks should occur during major NATO strategy shifts such as the change from mutual assured destruction (MAD) to the doctrine of flexible response, and finally to the end of the cold war. We analyze whether NATO ally behavior is influenced by regional or alliance concerns.

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NATO Defense Expenditures: Common Goals or Diverging Interests? A Structural Analysis

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By testing for structural breaks in defense expenditures, we determine the dates of change in the pattern of defense expenditures for the NATO allies. If NATO members are responding to a common threat, we expect to see similar breaks, in both direction and dates, for defense expenditures. The breaks should occur during major NATO strategy shifts such as the change from mutual assured destruction (MAD) to the doctrine of flexible response, and finally to the end of the cold war. We analyze whether NATO ally behavior is influenced by regional or alliance concerns.

Keywords: Defense expenditures; NATO; Multiple structural changes; Defense Burden;

JEL Code: C22, H56, H77

INTRODUCTION

Changes in defense expenditures have been used to analyze the response of NATO members to doctrine transformation and the behavior of NATO as an international alliance. The distribution of defense expenditures among NATO members raises questions about each nation's role in the collective defense effort that is the raison d'être of a military alliance. Since its inception in 1949, NATO has adopted three distinct defense doctrines, Mutually Assured Destruction (MAD), flexible response, and crisis management. These distinct defense strategies should have influenced the level and distribution of contributions to the common defense.

The allies adopted a doctrine of mutual assured destruction in the early years between 1949 and 1966. This doctrine essentially relied on US superiority in strategic nuclear weapons as a credible deterrent and automatic threat to counter any Soviet territorial expansion. The reliance on strategic nuclear weapons meant that NATO's security rested primarily with the US forces and as such, the US was responsible for a disproportionate share of NATO defense.

As the Soviet Union began to build its strategic forces in the late 1960s and early 1970s, NATO changed its doctrine to that of flexible response allowing for a measured response to aggression that would avoid an immediate nuclear exchange. The allies prepared to defend themselves against conventional forces. As a result, the allies supplemented strategic forces with tactical and conventional forces to allow for a response that is commensurate to acts of aggression and NATO could escalate the response if needed. In addition, NATO allies began to build up their conventional forces and support US troops and military installations in Europe. This change implied that NATO members would shoulder a greater share of NATO defense and would decrease reliance on US forces.

With the fall of the Berlin Wall in 1989 and the end of the Cold War, NATO no longer faced a common threat. NATO's roles and responsibilities evolved during this period. Security concerns extended beyond NATO's boundaries and new strategic doctrines were developed by the allies to deal with the emerging threats. The perceived challenges included managing crisis such as civil wars, disputes over natural resources, natural disasters, peacekeeping missions, and nuclear, biological, and chemical arms control. The allies began downsizing to take advantage of a peace dividend.

This study will address two issues by examining the ally's defense expenditure patterns from 1949 to 2005. The first issue is to ascertain if the three major changes in NATO doctrine are reflected in each ally's policy. The second is to determine whether the allies are acting as members of an alliance in a cooperative and common way, or whether the allies are pursuing their specific defense agendas. We do this by testing for breaks in the mean function of the defense expenditure growth process. A statistically significant shift, or structural break, indicates a change in defense expenditure patterns in response to policy changes. A positive break is indicative of an increase in the growth process of defense expenditures. A higher growth after a break indicates an expansion of the military. An expenditure growth after the break that is positive but less than the growth before the break represents a slowdown in rate of growth of military expenditures. A downsizing in the growth of military expenditures is a negative break in the mean function of expenditure growth. To address the first issue, we examine the date of the structural breaks in defense expenditures to determine if they correspond to the period of NATO policy change. To answer the second issue, if NATO nations are behaving as members of an alliance and responding in a collective manner to threats, then the break dates (change points in defense expenditures) and direction of the breaks should be similar for the allies. The

breaks in this study are determined using multiple structural change tests developed by Bai and Perron (1998, 2003). These tests determine the break date endogenously and allow up to a maximum of five structural shifts in the model. The newer members of the alliance, Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia, and Spain will not be included in the study since there are insufficient data to test.

With a few exceptions, the study provides no empirical evidence to suggest that NATO allies modified their behavior in any way to correspond to the three NATO doctrines. In addition, there is no evidence to suggest that NATO members are responding in a joint and concerted manner to threats. Structural breaks in defense expenditures for nearly every one of the NATO allies are associated with an ally specific defense agenda.

The remainder of the paper is structured as follows. In the next section, we discuss the theory of alliances and NATO. We, then, review the empirical tests and data to be analyzed. The last section presents the results, concludes, and offers policy advice.

Theory of Alliances

Military alliances are formed based on the logic of collective action. Allies need to prepare for action collectively and respond to threats collectively. Olson and Zeckhauser (1966) develop a model of organizations that are formed by nations to further their collective interests. They illustrate that larger nation members of organizations bear a disproportionate share of the financial responsibility for the collective organization. Such behavior threatens the independence of the organization and results in concern for the financial well being of the organization. In providing a good or service, an international organization, produces a public

good for the members of the organization. All members of the organization automatically benefit from the public good and the good can be made available to other members of the organization at little or no marginal cost. The public good is non-rival and non-excludable. NATO's proclaimed purpose is to protect its member nations from aggression, with aggression against one of its members considered an aggression against the collective.[1] The public good produced by NATO, deterring aggression, would be available to all its members and NATO should be able to expand its membership at little or no marginal cost. To test their theory that alliances provide public benefits, Olson and Zeuckhauser, find a significant positive correlation between GDP and military expenditures as a percentage of GDP for 1964 and conclude that GDP has a positive effect on military expenditures indicating that the larger NATO allies are shouldering the smaller allies defense burdens. These results are descriptive of the doctrine of MAD, characteristic of NATO between 1949 and the late 1960s when the reliance on strategic weapons meant that NATO's security rested primarily with the US strategic forces.[2]

In the late 1960s and the 1970s, NATO moved from the doctrine of mutual assured destruction to that of flexible response, which envisioned a measured response to acts of aggression and, if necessary, allowed for an escalation. The result was a shift from strategic to a combination of strategic, tactical, and conventional weapons. The public goods model no longer applied to NATO. The defense burden seemed to be shared more evenly between the larger and smaller allies, who were expected to maintain their conventional forces and defend themselves in the European theater. Researchers use the joint products model, which allows military expenditures to provide both public and private goods, to describe this period. Sandler and Forbes (1980) describe a continuum of alliances with a purely deterrent on one extreme and a purely protective on the other. The closer an alliance is to the purely protective, the greater is

the proportion of excludable benefits. The joint products model describes an alliance that is closer to the purely protective. They include both ability to pay and benefits received measures to an analyze behavior within an international organization. The proxies for ability to pay are military expenditure share of GDP, a measure of the internal burden of defense, and each allies' share of total NATO defense expenditures, a measure of the external burden of defense. The benefit proxies are the allies' shares of overall population, GDP, and exposed borders. They find that the dependence between GDP and ratio of defense expenditures to GDP supports a public goods model between 1960 and 1966. After 1967, the correlation between the two variables is weak indicating a shift from a deterrent alliance towards a more conventional cooperative alliance. In addition, they find a shift of defense expenditures from the US to the European allies.

The flexible response era can be divided into two distinct periods, 1967 to 1980 and 1981 to 1990 (Sandler and Murdoch, 2000). While a joint products model characterizes the first period, a joint products model with some public benefits best describes the second period. The years from 1981 to 1990 were defined by the Reagan procurement and strategic build up and the upgrading and modernizing of the British and French strategic forces. Khanna and Sandler (1996) and Sandler and Murdoch (2000) extend the analysis of NATO alliance behavior to include data covering the 1981 to 1990 period. They conclude that exploitation of the larger allies by the smaller allies increased due to the Reagan, British, and French strategic forces build up in the first half of the 1980s. The correlation between benefits received and defense burdens indicate a degree of cooperation in the alliance. However, the remainder of the period indicates NATO allies allocating defense spending based on nation specific concerns.

The 1990s to the present are characterized by the end of the cold war. NATO allies no longer faced a common threat from the Warsaw Pact. The allies reduced defense expenditures to take advantage of a peace dividend. NATO's strategic doctrine changed to reflect the new realities. NATO allies identified the threat from rogue nations, ethnic conflicts, peacekeeping, and the non-proliferation of weapons of mass destruction as its priorities. Even though this period is still best characterized by a joint products model, more elements of public goods are appearing and the defense burden of the larger allies could increase. Sandler and Murdoch (2000) analyze NATO alliance behavior to include data up to 1999 and find insignificant correlation between economic size and defense burdens and a match between defense burdens and proxy measures of defense benefits. This match is less significant for 1999, which is indicative of the increasing share of public benefits.

Amara (2006) studies the long run behavior of the NATO allies from 1949 to 2002 and concludes that despite the US defense burden being the largest in absolute value, Turkey and Greece are the two countries that have steadily increased their defense burdens. Even though the concept of a military alliance would imply that NATO should have an integrated response over the long run to defense issues, it appears regional issues are the main drivers of military expenditures. Turkey and Greece are on the upper end of the defense burden and are clearly responding to defense concerns that are not shared by the remaining allies.

NATO

The North Atlantic Treaty signed in 1949, by Belgium, Canada, Denmark, France, Greece, Italy, Iceland,[3] Luxemburg, Netherlands, Norway, Portugal, US, and the UK, established NATO as a cooperative defense organization with each ally contributing a share to the defense of

the collective. However, with most of its members still recovering from the devastation of World War II, the burden of NATO defense fell on the United States with the expectation that the allies would gradually increase their contribution. Greece and Turkey joined NATO in 1952, West Germany in 1955, Spain in 1982, Czech Republic, Hungary, and Poland in 1999 and Bulgaria, Estonia, Latvia, Lithuania, Romania, Slovakia, and Slovenia in 2004.

NATO has undergone a rapid expansion during the last decade with a significant redrawing of the NATO border to the east. From an economic standpoint, the alliance should be expanded if the benefits of expansion are greater than the costs. When the new allies joined NATO it was assumed that they would eventually contribute to the security of the alliance and share in the costs of defense burden[4]. The costs of expansion include the costs of modernizing the new member's forces, the cost of intelligence, equipment, training, the cost of projecting NATO power to the new borders, and the cost of communication and control. While these additional costs are to be picked up by the new and current members, it is highly unlikely that the economies of the new members will allow them to undergo this tremendous investment. Their defense budgets are small, their economies are fragile and in transition and their populations do not appear to support an increase in the proportion of government spending devoted to defense. They are not in a position to increase their military budgets to meet NATO's military requirements. Quite likely, the wealthier NATO allies will underwrite the costs. Instead of the new alliance members fully integrating into NATO, proposals have been made where each NATO member would specialize and provide a niche capability. However, it appears that NATO is leaning toward integrating new members into its structure.

Tables 1, 2, and 3 identify defining events during the three major periods of NATO doctrine that are of concern to NATO and may have influenced allies to respond jointly or may have influenced their defense policy in any way[5].

EMPIRICAL TESTS

We use a structural change test to explain NATO defense expenditures over time. Structural changes result from a discreet change in the population regression coefficients from one period to another. Recent research on structural change in time series econometrics enables us to be explicit about the timing and the significance of the changes or breaks. A statistically significant break in the mean function of defense expenditures reflects a change in defense expenditure patterns in response to policy changes. The mean shifts can be negative indicating a downsizing in expenditure growth. A positive mean shift is indicative of an increase in the growth of defense expenditures. If the NATO nations are behaving as members of an alliance and responding in a collective manner to threats and to major changes in NATO doctrine and policy, then the break dates (change in the defense expenditure growth process) and direction of the mean shifts should be similar for the allies. The breaks in this study are determined using multiple structural change tests developed by Bai and Perron (1998, 2003).[6] These tests allow for multiple breaks and determine the break points endogenously. We use three tests to draw our conclusions. The first test identifies the number of breaks and the break dates sequentially. The second two tests are double maximum tests that test the null hypothesis of no breaks against the alternative of an unknown number of breaks. The sequential test is run at each possible break point and the sum of squared residuals calculated for the divided data sample. The first break

point is selected based on the minimization of the sum of squared residuals for the sub-samples. Once the first break point is identified, the data is divided into two sub-samples separated by the first estimated break. For each sub-sample, a one-break model is estimated and the second break point is chosen for the greatest reduction in the sum of squared residuals. The sample is then repartitioned in three regimes and the third point is selected as the estimate from three estimated one break models that allows the greatest reduction in the sum of squared residuals. This process is continued until the maximum number of break point is reached. The test is a sup Wald type test and is labeled sup $F_T(l+1|l)$. The sup F_T statistic is a generalization of the sup F statistic considered by Andrews (1993) and others for the case of one structural change. It considers a null hypothesis of l breaks against the alternative hypothesis that an additional break exists, $l+1$. The sup F_T statistic is obtained by maximizing the difference between the sum of squared residual for the null and alternative hypothesis. For a model with l breaks, the estimated break points are obtained by a minimization of the sum of squared residuals. The null hypothesis of l breaks is rejected in favor of the model with $l+1$ breaks if the overall minimal value of the sum of squared residuals for the alternative model is sufficiently smaller than the sum of squared residuals from the l break model. The break date selected is the one associated with the overall minimum.[7] Bai and Peron (1998, 2001) report the critical values for the test.

The sup $F_T(l+1|l)$ test requires the specification of a number of breaks for the null. Bai and Perron (1998) develop two tests where the number of breaks does not need to be pre-determined. The double maximum tests consider a null hypothesis of no structural break against an unknown number of breaks given some upper bound of breaks.[8] The two double maximum tests differ in their use of weights for the breaks. The weights reflect the imposition of prior conditions on the likelihood of various number of breaks. The first test, the equal weighted

double maximum test UD*max*F_T, gives equal weights of unity to all the breaks. The second, the weighted double maximum test WD*max*F_T, recognizes that as the maximum number of breaks increases, a fixed sample of data becomes less informative about the tested hypothesis since the critical values decrease leading to a test with low power. The WD*max*F_T alleviates this problem by adding weights to each break. The weights applied are such that the marginal p-values are equal across values of *m*. This implies that the weights are dependent on the significance level and the number of covariates. There are no theoretical guidelines about the best choice of double maximum tests.

We allow up to a maximum of five breaks and use a trimming of $\varepsilon = 0.15$[9]. The test allow for serial correlation and different variances in the residuals across the segments resulting from the breaks. We follow the strategy recommended by Bai and Perron (2003) by first examining both double maximum tests to determine if at least one break is present. If these two tests are significant and indicate the presence of at least one structural break, we determine the number of breaks by a sequential examination of the sup-$F_T(l + 1|l)$ statistics ignoring the sequential sup-$F_T(1|0)$ test. If the sup$F_T(l + 1|l)$ are insignificant and the double maximum tests are significant, the results indicate the presence of one structural break. If the sequential procedure fails to reject the null hypothesis when the number of breaks is low but is able to reject the alternative for a larger number of breaks, we choose the larger number of breaks because of the low power of the test in detecting smaller number of breaks when numerous breaks exist.

Data

NATO figures on military spending are highly reliable and use a common definition for defense. NATO has gone through the process of producing standardized figures that reflect

expenditures for comparable categories for each country. The attempt at standardization is to assist in the assignment of defense burden sharing among the member countries.

Data for NATO military expenditures are from *NATO Review*, which reports them in current year national currency. Military expenditure data are available from 1949-2004 for Belgium, Canada, Denmark, France, Greece, Italy, Luxemburg, Netherlands, Norway, Portugal, Turkey, UK and the US. Data for Germany is from 1953-2002. We use the CPI of each country as reported in the International Monetary Fund's *International Financial Statistics* May 2005 with 2000 as the base year to convert to real military expenditures. The data used is annual data expressed in logarithms

EMPIRICAL RESULTS

The two questions this study attempts to answer are whether the three major changes in NATO doctrine and policy are reflected in changes in defense expenditures, and whether allies pursued ally specific defense agendas or acted as members of an alliance in a cooperative and common way.

To answer the first question, we look for structural breaks in NATO defense expenditures that are descriptive of the theoretical underpinnings of the alliance behavior during the three periods. Therefore, we would expect two structural breaks for the allies. The first should occur around 1966/1967 with the transition from MAD to flexible response, and the second around 1989/1990 for the move from flexible response to crisis management The MAD period when the reliance on strategic weapons meant that NATO's security rested primarily with the US strategic forces, should be characterized by US military expenditures growth. The flexible response era should be a period of defense expenditure growth for all the NATO allies who were expected to

maintain their conventional forces and defend themselves in the European theater. The US should have either slower defense spending growth or no growth at all. The last period, crisis management, should be a period of either a slowdown or declining defense expenditure growth for all allies as they take advantage of the end of the cold war.

The results of the structural tests are summarized in Tables 4 to 6. Table 4 details the structural break dates for NATO defense expenditures and their significance levels. Table 5 gives the average annual defense expenditure growth rates before and after each break. Table 6 groups the breaks for each ally into the period in which they occur, MAD, flexible response, and crisis management. Figure 1 presents the allies annual defense expenditures and their changing means.

The answer to the first question of whether the three major changes in NATO doctrine and policy are reflected in changes in defense expenditures is quite weak. The allies exhibit little of the expected characteristics in moving between the three periods. If we examine each country's structural break, none appear to match the dates for the transitions between doctrines. There are some exceptions. An argument may be made for the break in 1965 for France. It is close to the end of MAD period and indicates positive growth in defense expenditures for France. Greece's break in 1968 and Norway's in 1967 are close to the beginning date for the flexible response period. However, both counties exhibit decreasing defense expenditure growth contrary to the expectations for the period. Finally, Belgium, Canada, France, Germany, Luxemburg, and the UK all have a break during the crisis management era. This last structural break is followed by either a slowdown or downsizing of expenditure growth. This is very consistent with the theoretical expectations for the period. However, only Belgium's break is

close enough to the beginning of the crisis management era to be interpreted as resulting from the fall of the Berlin Wall.

We address the second question in two parts. To respond to whether NATO countries acted as members of an alliance in a cooperative and common way, we look for commonalities in spending growth patterns and break dates that correspond to the timing of events of importance to NATO as summarized in Tables 1,2, and 3. There is little evidence to support the premise of cooperative and common behavior among the allies. One possible commonality is that all the allies, except Portugal, exhibit the highest rate of defense expenditure growth before their first structural break. This could be due to several factors such as the rebuilding efforts after World Was II, the strengthening economies, and the height of the Cold War. Another commonality in defense spending growth comes after the last break for all NATO allies regardless of when the break occurs. A majority of the allies, except Canada, Luxemburg, and Portugal, have a slowdown or downsizing in growth following the last break. In addition, Denmark, Germany, Italy, and the UK experience a reduction in expenditure growth in the mid 1970s. These reductions are clustered around the SALT I agreement of 1972.

If we attempt to explain the breaks and direction of defense expenditure growth using ally specific concerns, it appears that NATO members, in general, adjusted their defense spending according to economic imperatives, political issues, and ally specific defense agendas.

Both of Belgium's breaks signal a decrease in defense expenditure growth. The structural break for Belgium in 1969 marks the beginning of the constitutional change from a central to a federal government to accommodate the three major communities, Flemish, French, and German. The resulting decrease in defense expenditure growth is consistent with the literature

on decentralization that finds a decrease in defense expenditure growth resulting from increased decentralization.[10]

All of Canada's five breaks are preceded by a change in government. In addition to a change in government, the breaks in 1975 and 1982 follow changes in domestic economic conditions.

Denmark's structural break in 1974 followed a complete change in the political parties that comprise the structure of the government. The reason behind the break in 1961 is less evident.

France's break in 1956 could signal a decrease in expenditure growth following its defeat and withdrawal from Southeast Asia (Vietnam, Laos, and Cambodia) and the Suez Canal. The subsequent period is characterized by an increase in expenditure growth that could be the result of France's preoccupation with the Algerian war of independence. The third break, which signals an increase in defense expenditures, follows the election of the conservative government of Valery Giscard D'Estaing. The fourth break in 1984 follows the election of a socialist government.

Greece's break in 1968 follows the military coup d'etat in 1967 that established a military dictatorship. The break also follows a severe economic downturn.

Italy's break in 1973 came amid a period of political turmoil with several changes of government in 1972, 1973 and 1974. Italy also faced a severe economic crisis during this period that resulted in austerity measures and reductions in government expenditures.

Luxemburg's first break in 1975 follows the steel crisis that resulted from the world-wide decline of demand for steel. The decline precipitated an economic downturn given that the Luxemburg industrial structure was dominated by the steel industry. This economic downturn

resulted in a massive increase in welfare payments and social security benefits to households that reached 24% of GDP in 1981. The second break in 1986 marks the beginning of an economic recovery resulting from a boom in financial services, the stepping-up of the economic diversification policy, and a pay moderation policy, which helped to restore the cost-competitiveness of the Luxembourg economy.

The Netherlands, in 1963, turned over the western half of New Guinea to Indonesia, withdrew its forces, ending 300 years of Dutch presence in Asia. The break for the Netherlands in 1963 marks a decrease in defense expenditure growth.

Portugal's break and high defense spending growth in 1960 is reflective of its internal turmoil and preoccupation with its colonies in Africa. The second break in 1975 and its negative expenditure growth mark the conclusion of its commitment in Africa and the beginning of political reform following the coup in 1974. The break in 1987 coincides with improving economic conditions, admission to the European Union, and elections resulting in a strong single party government.

Turkey is notable in that the defense expenditure growth remains the highest among all NATO after its one break[11]. The break in 1978 follows the diffusion of tension between Turkey and Greece over Cyprus resulting from UN mediation.

The break for the UK in 1963 marks the transition in power from the conservatives to labor and the continued retreat from colonialism and a start of a period of economic stringency and inflation. The second break for the UK in 1973 coincides with the UK's entry into the EEC and the international oil crisis that was accompanied by a domestic coal crisis.

The USA's single break in 1956 comes at the end of massive increase in expenditure growth during the beginning of the cold war and end of the Korean War.

The reasons behind the breaks for the rest of the allies are less clear but are a combination of domestic economic issues and national security concerns. Canada, France, Luxemburg, and Portugal experience a mixture of downsizing and expansion in expenditure growth between the first and last structural break. The rest of the NATO allies exhibit steadily decreasing defense expenditure growth.

CONCLUSION

The North Atlantic Treaty establishing NATO specifies the principal purpose of the alliance in Article 5, which states, "an armed attack against one or more of them in *Europe* or North America shall be considered an attack against them all." This premise has never been seriously challenged until September 11, 2001 since no NATO member has suffered a direct attack necessitating a military response.[12] As such, one could conclude that NATO as an alliance has fulfilled its mission. Deterrence has worked. However, the policy of deterrence rests primarily with the US strategic forces and to a lesser extent with those of the larger allies such as the UK and France. A closer look at the behavior of even the three largest allies indicates a preoccupation with national issues over NATO issues.

The results of the structural analysis tests suggest that NATO allies do not have an integrated response to NATO specific defense issues. There is no evidence to suggest that NATO members are responding in a joint and concerted manner to threats or responding to the adoption of the three doctrine changes. There is no indication that the NATO allies attempted to create forces capable of defense after the adoption of the flexible response doctrine. In fact, it

appears that long before the formal end of the cold war, the allies were reducing the growth of defense expenditures. The last structural break for all the allies, no matter when it occurred, is followed either a slowdown or downsizing in defense expenditure growth.[13]

Further efforts to study NATO should attempt to examine force structure to determine if changes in alliance behavior can be explained by internal reconfigurations of forces in conjunction with changes in spending patterns.[14] In addition, alliance behavior can be analyzed by using temporal and spatial methods to explain its interactions. Finally, researchers should control for and isolate country specific effects. Instead of focusing on whether NATO members behave as allies, researchers should ascertain how much of their behavior is influenced by belonging to the alliance and in what manner. The question of interest becomes the issue of motivation. How do you motivate allies to conform and contribute to an alliance in a meaningful and productive way?

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[1] Article 5 of North Atlantic Treaty of 1949.
[2] See Khanna and Sandler (1996) and Sandler and Murdoch (2000) for a discussion on NATO doctrine.
[3] Iceland maintains no military but its strategic location allows it to host NATO bases.
[4] Congressional Budget Office (CBO), 2000.
[5] Dates and events are summarized from NATO update available online on http://www.nato.int/docu/update/index.htm
[6] The Bai and Perron formulation allows for general forms of serial correlation and heteroskedasticity in the errors. It also allows lagged dependent variables, trending regressors as well as different distributions for the errors and the regressors across data segments.
[7] Our interest is the presence of a structural change in the mean of the series. As such, we apply the following multiple linear regression with m breaks and m+1 regimes for a sample of T observations:

$$y_t = x_t'\beta + z_t'\delta_j + \mu \qquad t = T_{j-1} + 1,...,T_j$$

for $j = 1,...,m+1$ where y_t is the observed dependent variable at time t; x_t (p x 1) and z_t (q x 1) are vectors of covariates and β and δ_j are the corresponding vectors of coefficients; μ_t is the disturbance at time t. The break dates occur at $\{T_1,...,T_m\}$. For this study, $z_t = \{1\}$ and q=1, for the case of changes in the mean of a series and p=0 for a pure structural change model where all the coefficients are subject to change.
[8] The upper bound of breaks is set equal to that specified for the sequential procedure.

[9] Bai and Peron (1998) show in simulation experiments that a small value for trimming such as 5% can lead to tests with substantial size distortions when sample size is small and the variances of errors across the data segments are different or when serial correlation is permitted. This is because the researcher is trying to estimate quantities using very few observations and could end up estimating for some segments, values like the variance of the residuals, using only several observations. Bai and Perron recommend trimming values of 15% or higher in this case and a maximum number of breaks based on the trimming value, 5 breaks for a trimming value of 15%. The maximum number of breaks is set to $\text{int}[1/\varepsilon] - 2$ breaks where ε is the trimming size.

[10] Devarajan, Shantayanan, Vinaya Swaroop and Heng-fu Zou (1996) include a detailed discussion of the effects of decentralization on defense expenditures.

[11] See Amara (2006) for a discussion regarding the level of Turkey defense expenditures over time.

[12] Less than 24 hours after the attack on September 11, 2003, NATO invoked Article 5 for the first time. However, this was seen as a gesture of political support rather than a call for the allies to take collective military action. The alliance's military role and commitment has been minimal so far.

[13] The data used in this study does not extend beyond 2004. It is not yet apparent what the effects of the commitments by NATO allies to the wars in Iraq and Afghanistan may be.

[14] Thanks to Col. Michael Meese for bringing this explanation to my attention.

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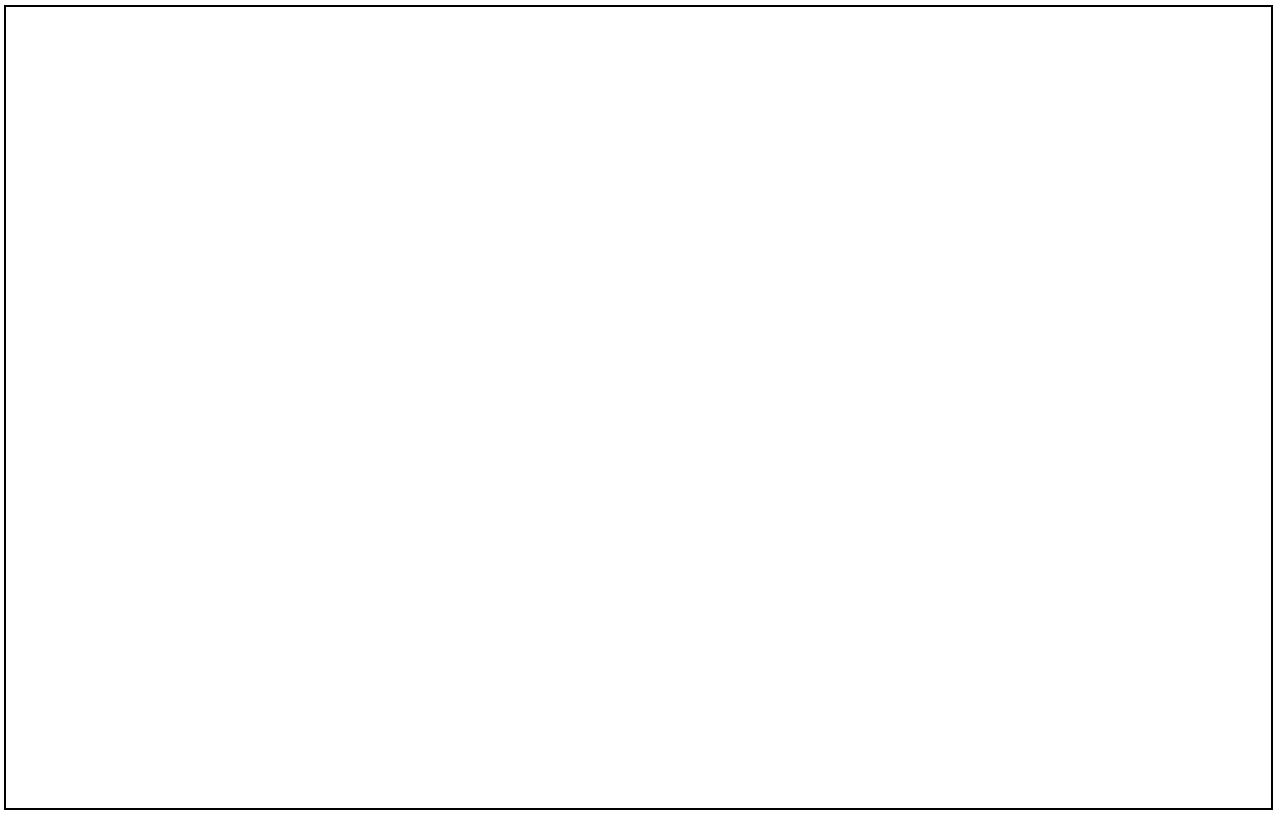
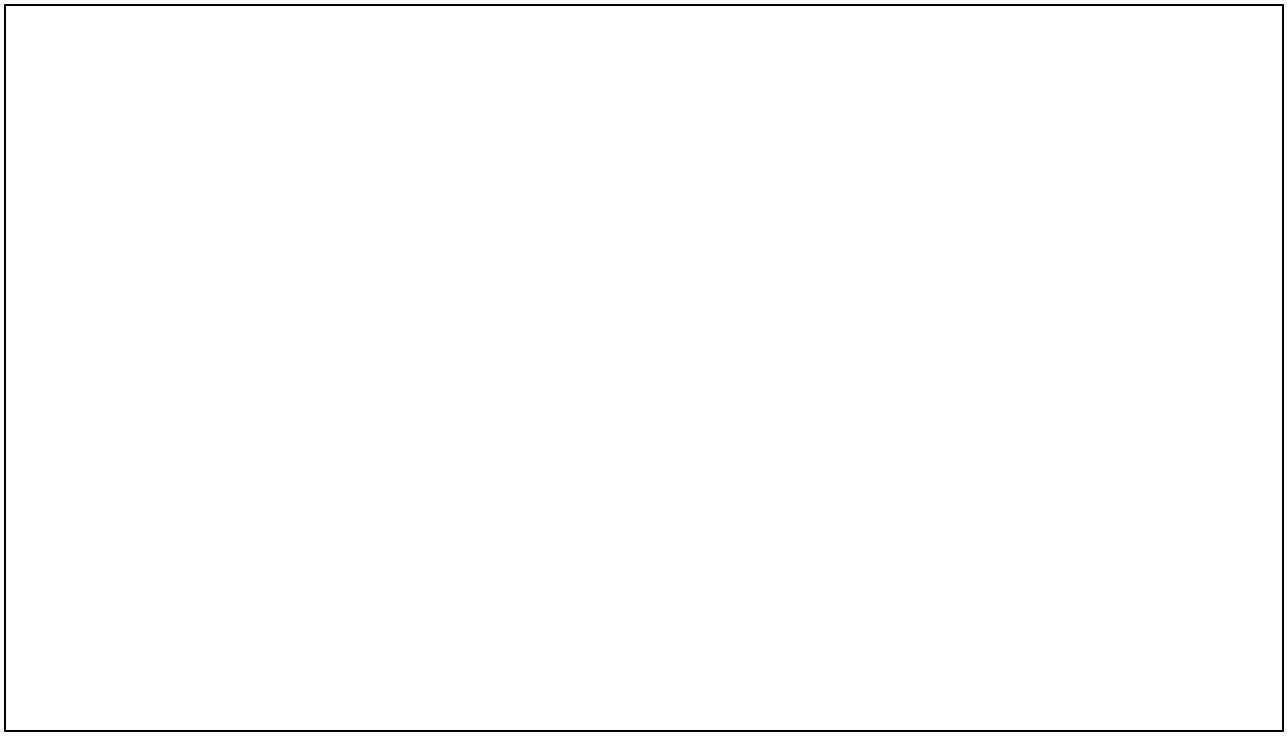
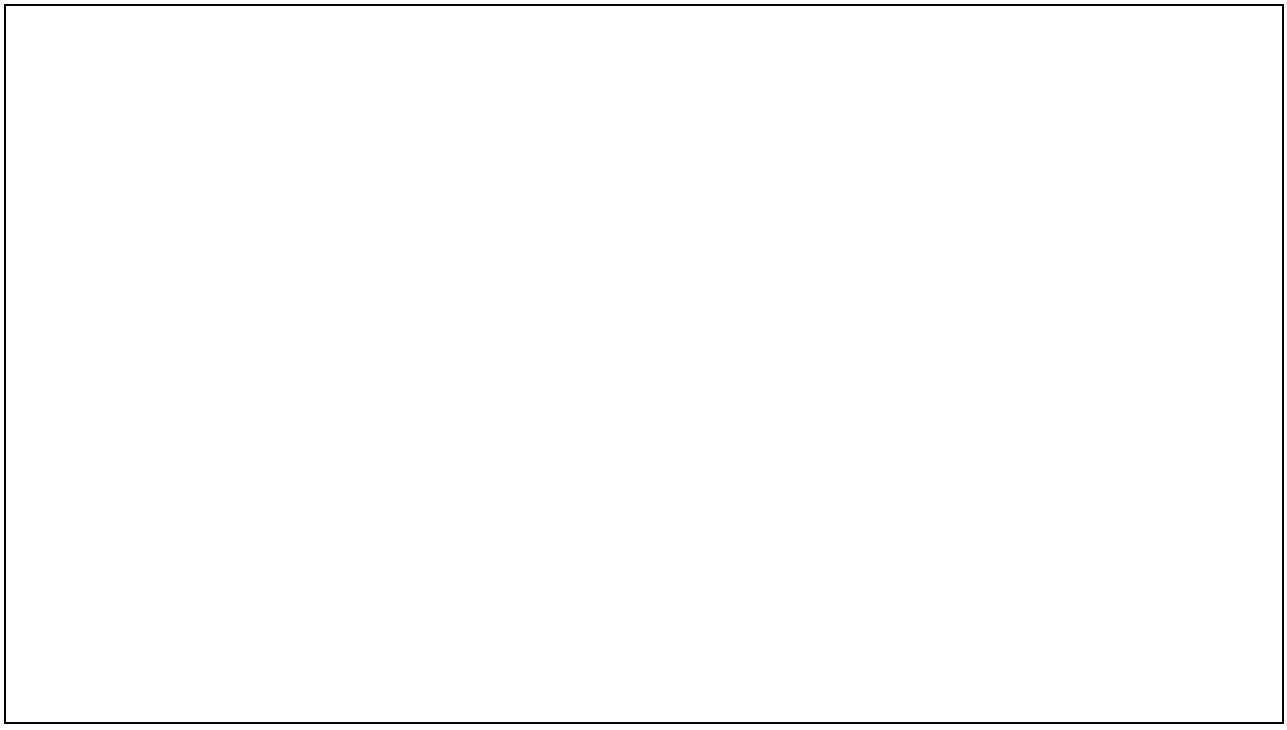
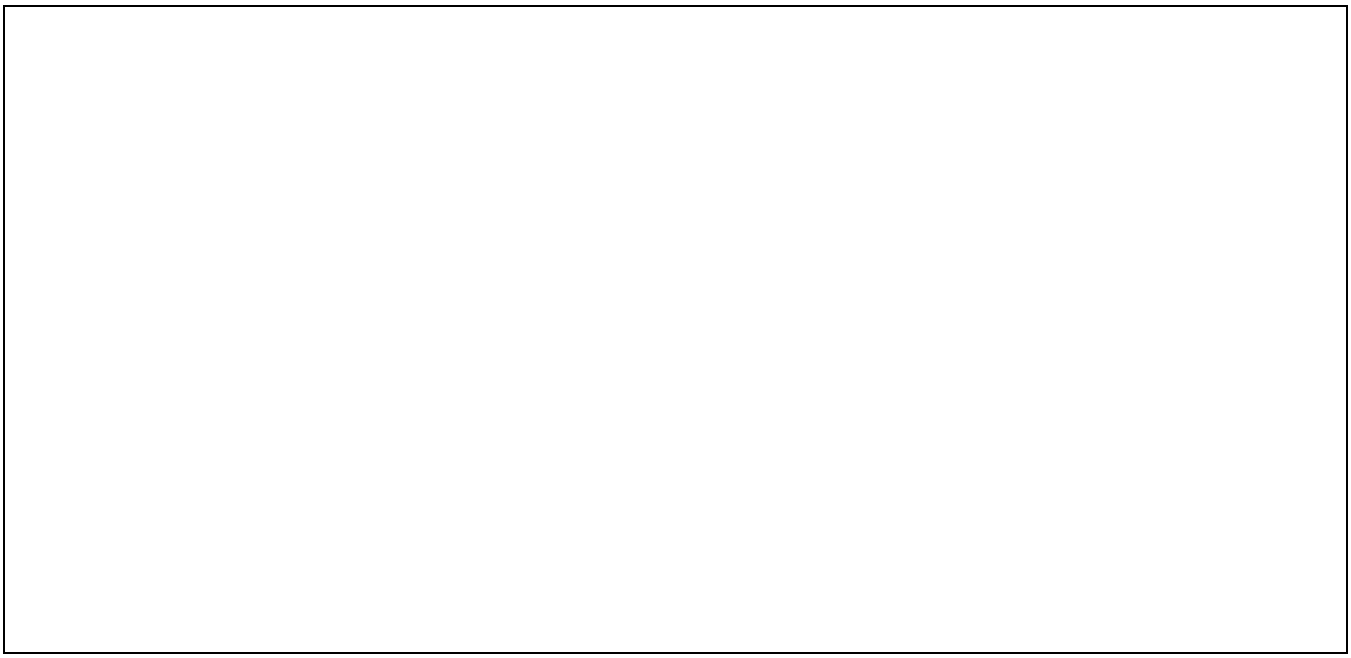
Figure Captions:

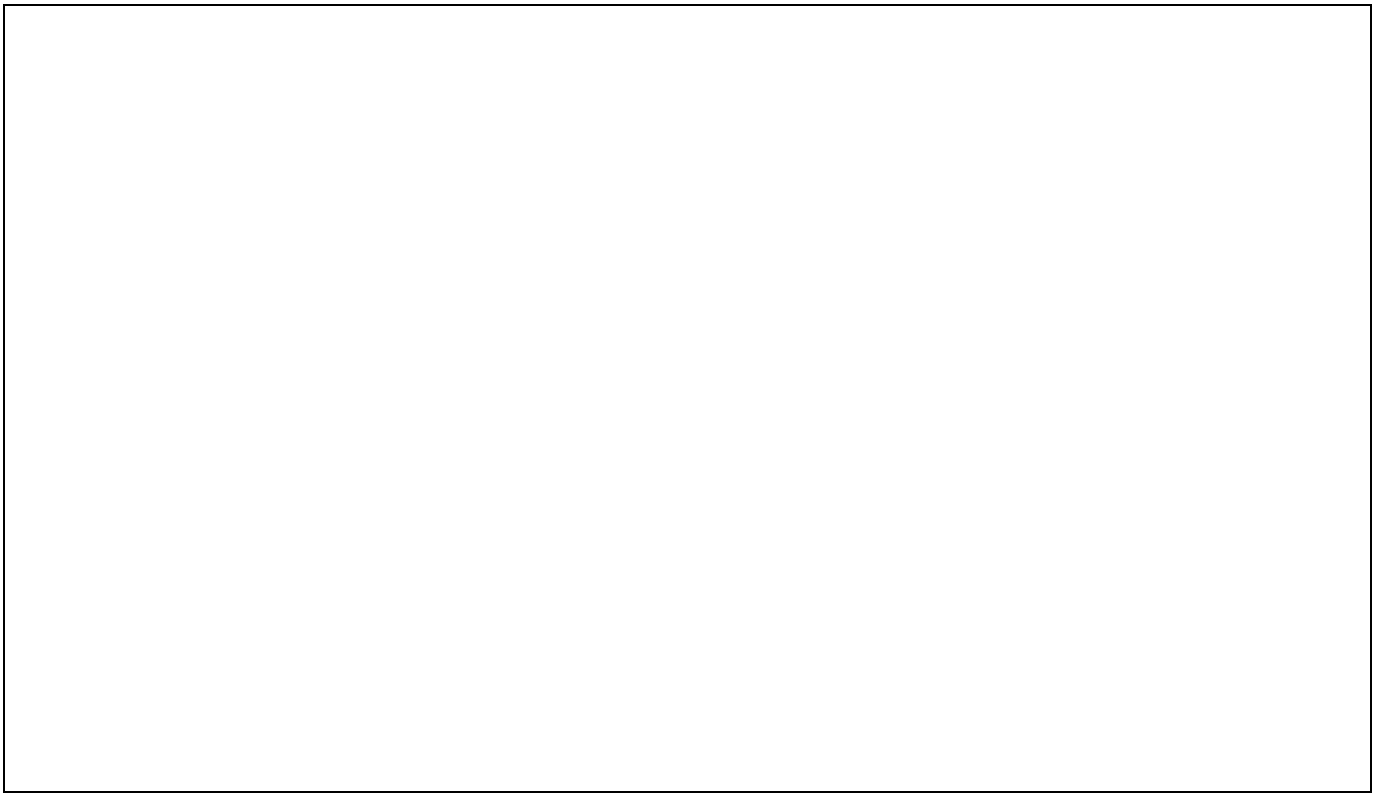
FIGURE 1: Natural logs of annual defense expenditures and their changing mean

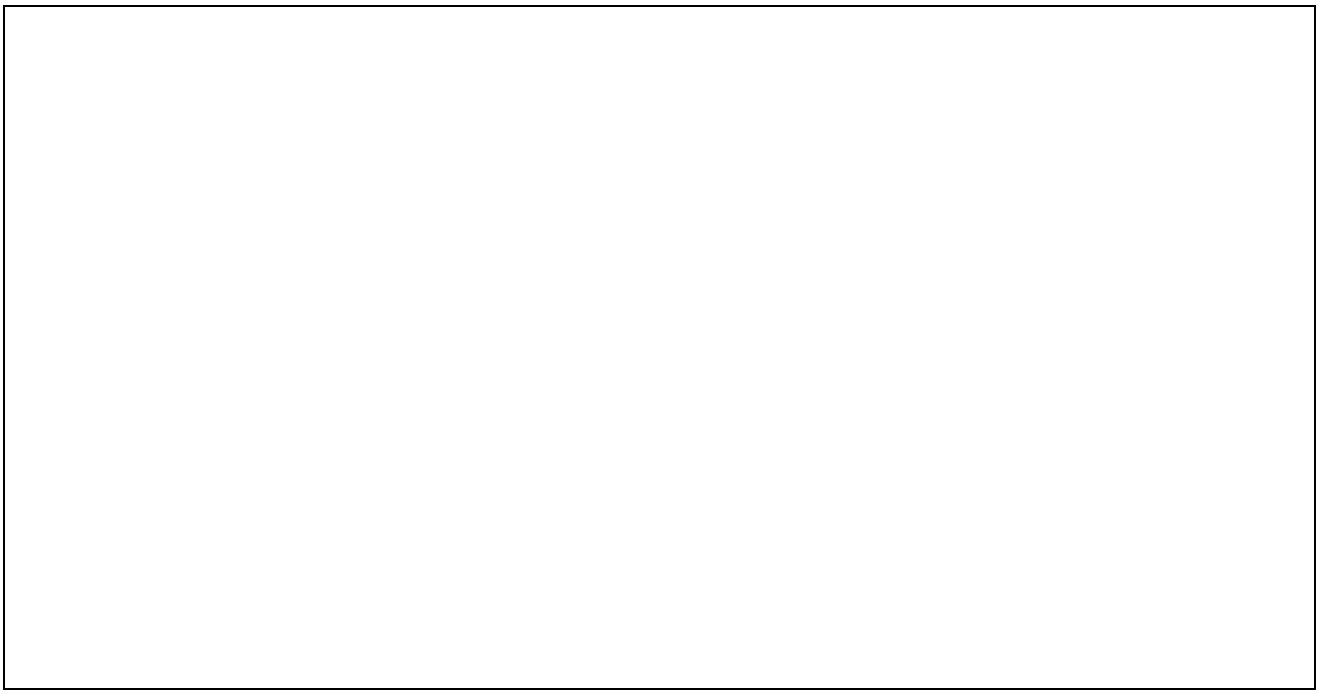


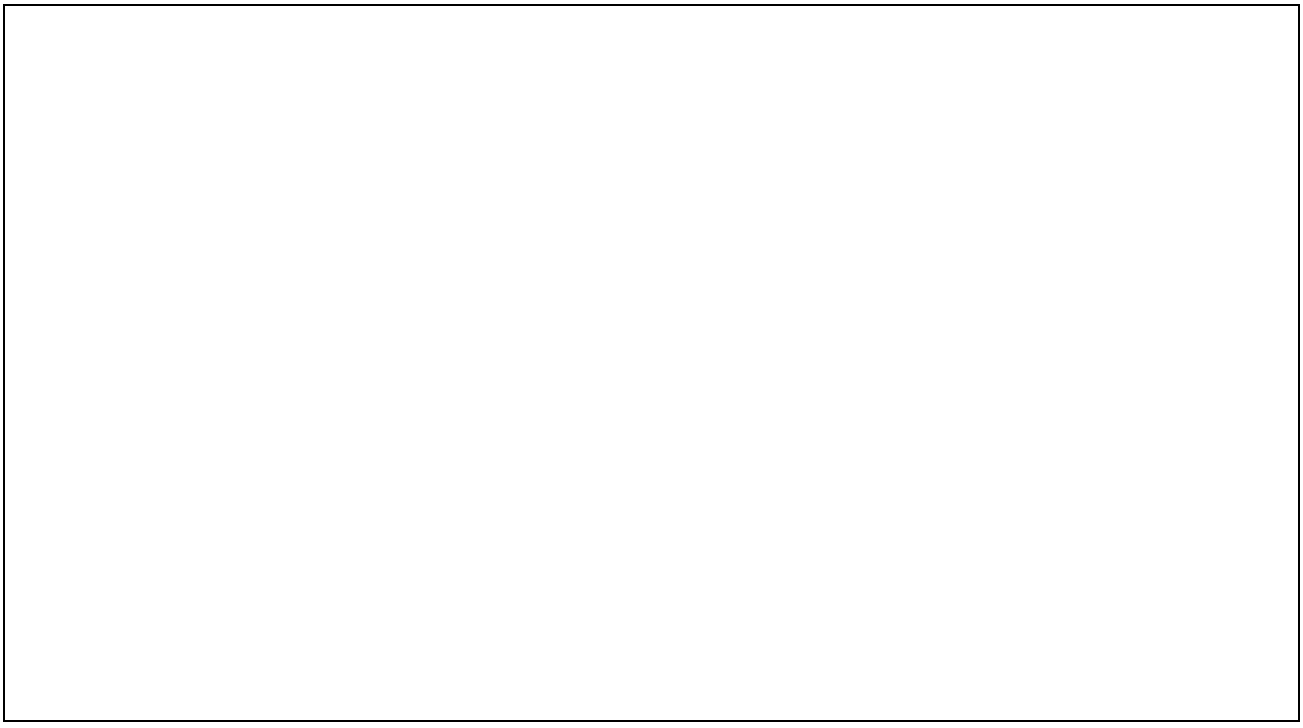


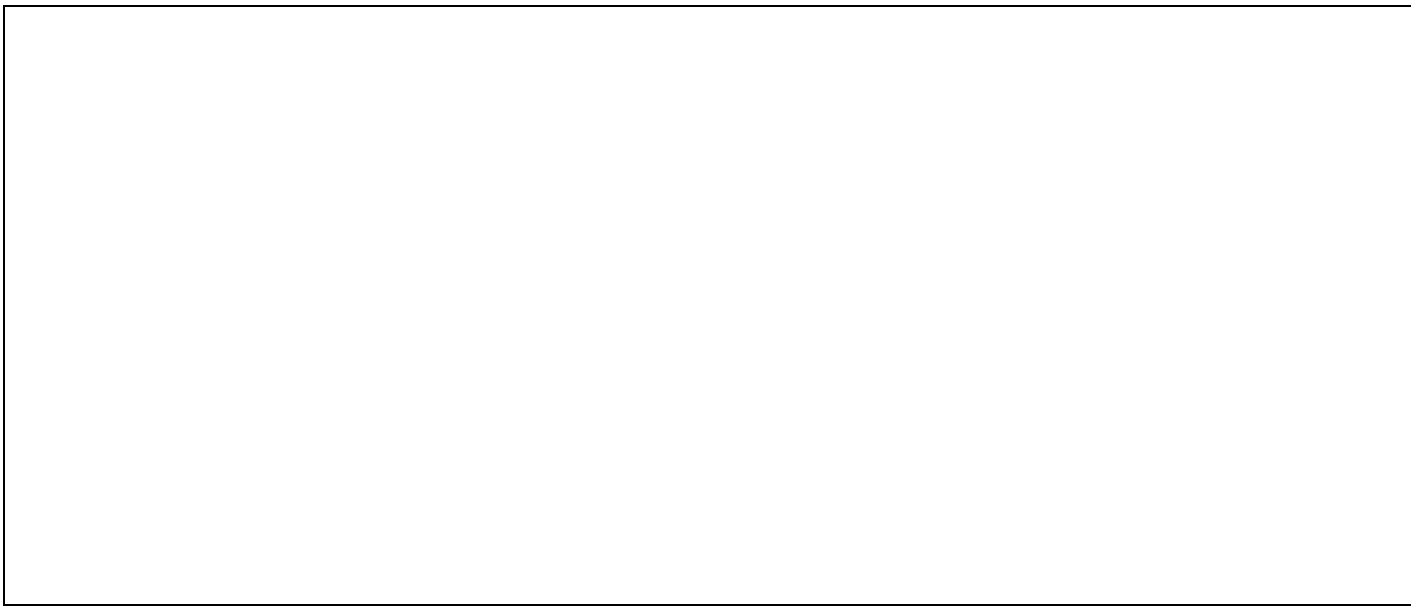


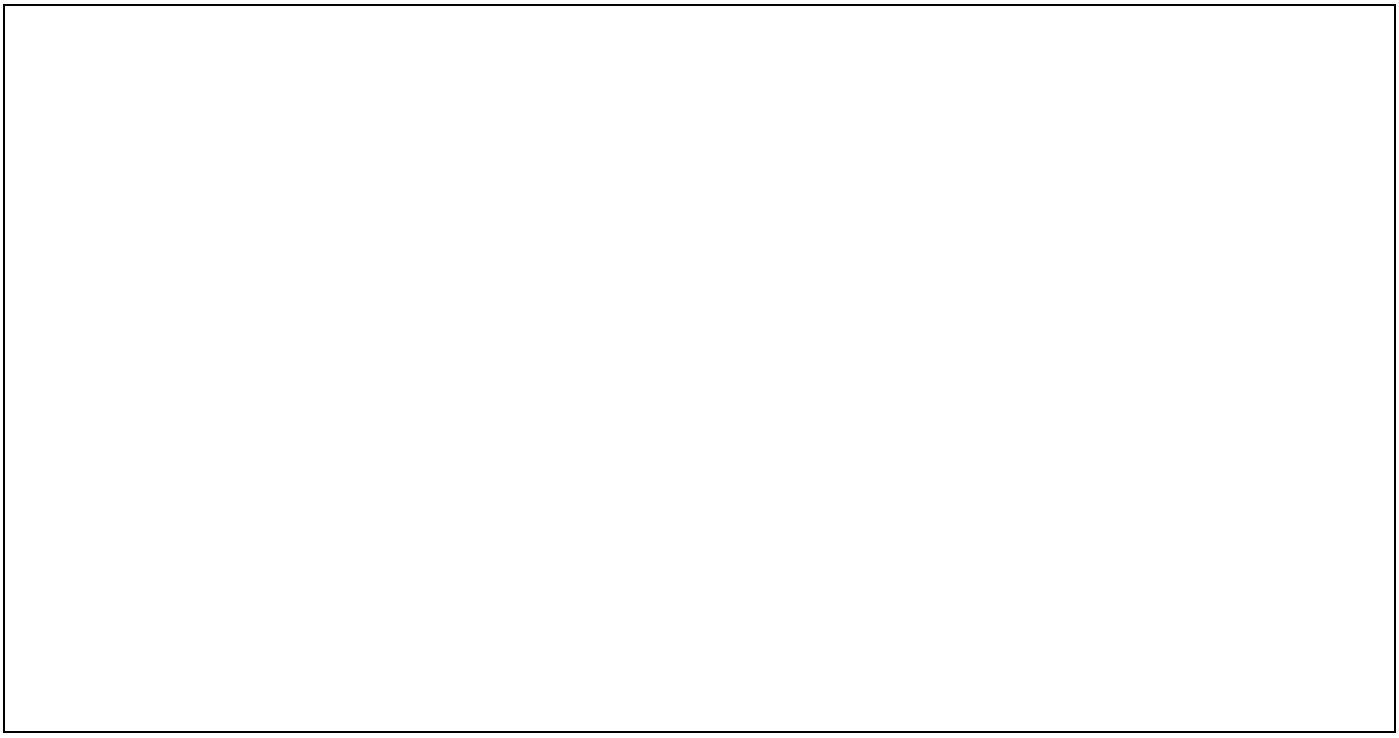


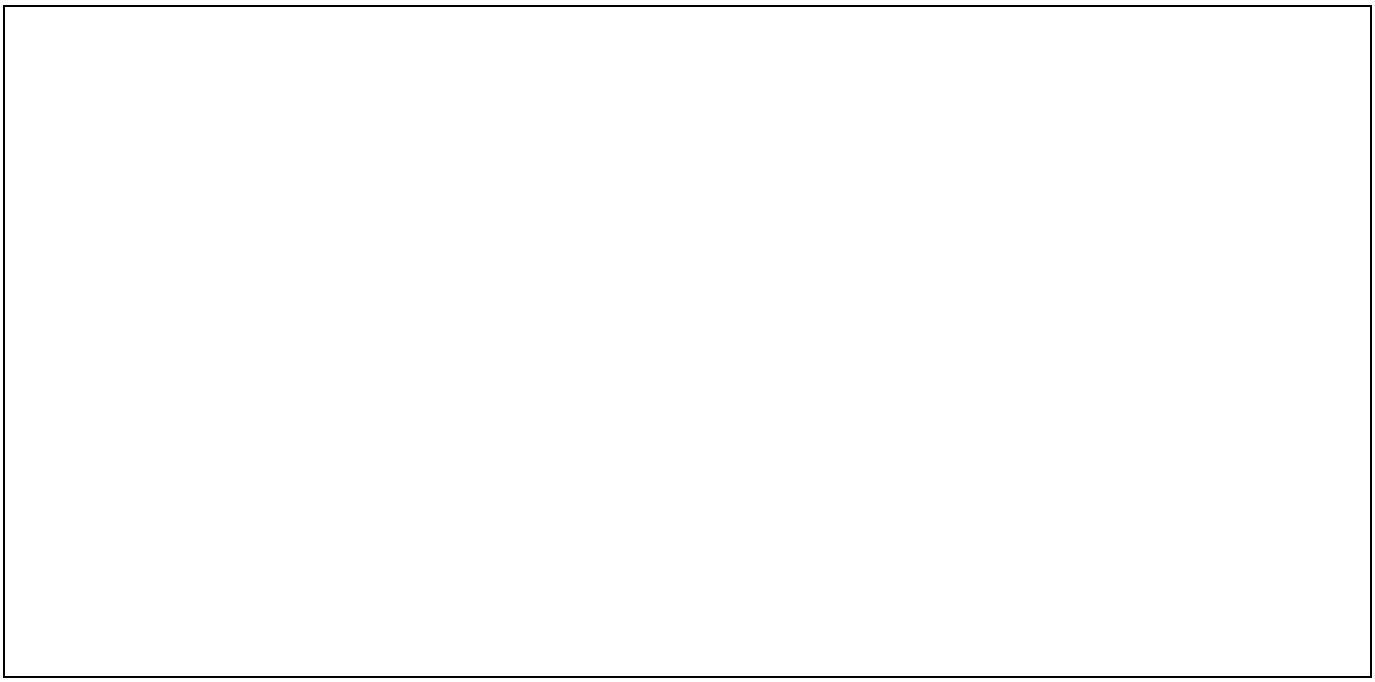


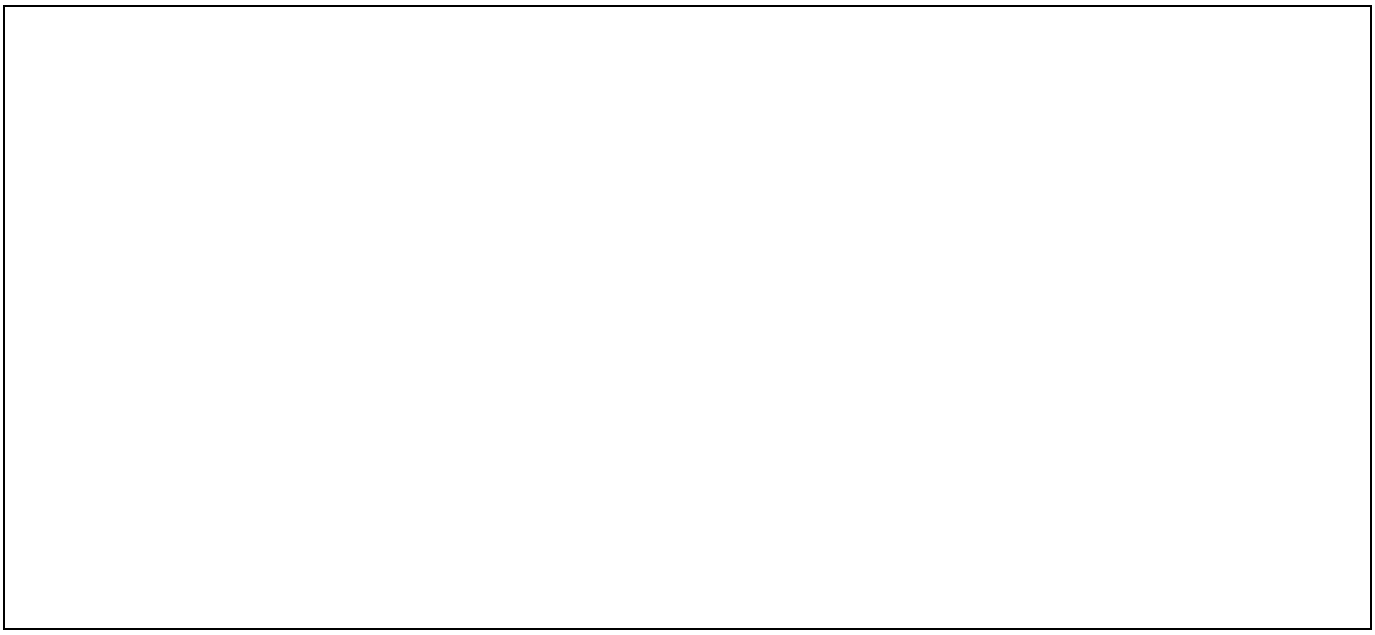












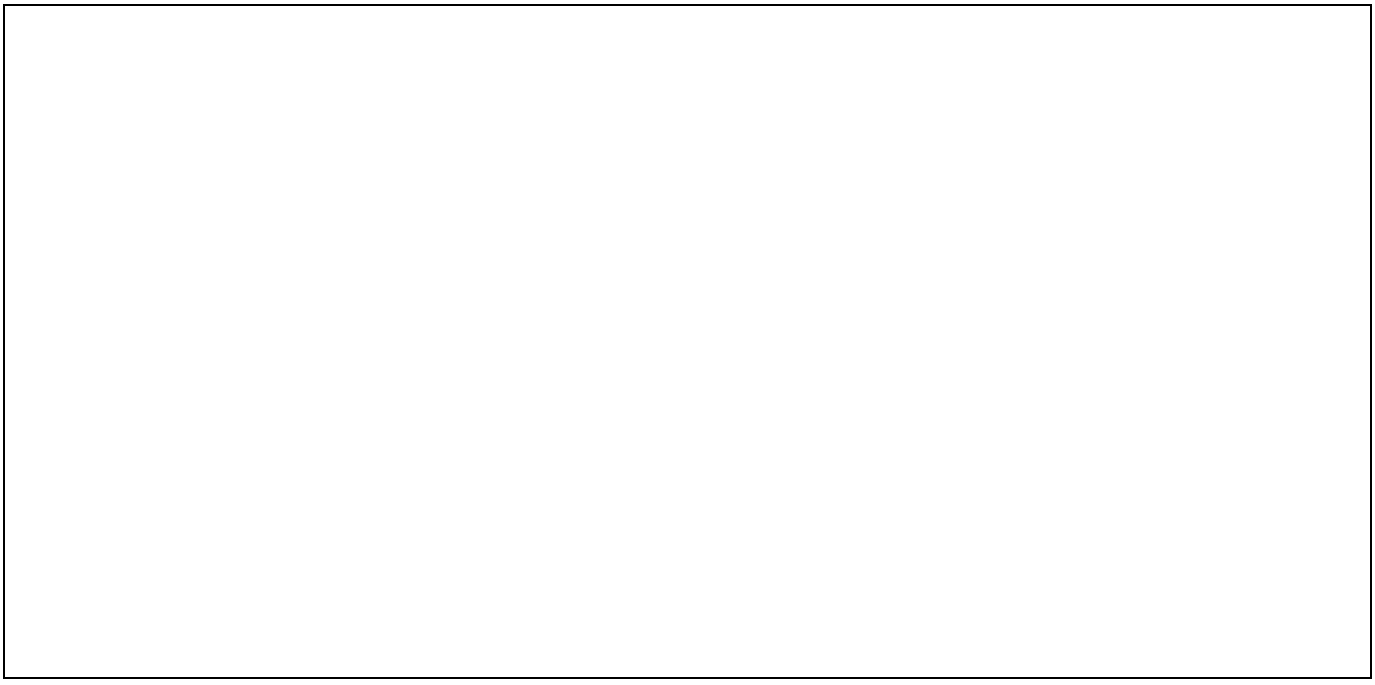


TABLE 1 MAD (1949-1966) dates and defining events

Date	*Defining Events*
1949	The ratification of the North Atlantic Treaty establishing NATO. The principal purpose of the alliance is specified in Article 5 which states that "an armed attack against one or more of them in Europe or North America shall be considered an attack against them all."
1952	In a meeting in Lisbon, NATO leaders agreed that the alliance needs capabilities equal to those of the Soviet Union and proposed that members specialize in providing certain services. In addition, Greece and Turkey acceded to NATO.
1953	Joseph Stalin, who had led the Soviet Union for almost 30 years, died and was succeeded by Nikita Khrushchev. These events seem to herald a thaw in East-West relations, particularly with the formulation of the Soviet policy of peaceful co-existence. Later that year, the USSR reveals its possession of the hydrogen bomb. Thus the United States loses its nuclear supremacy and with it the strong guarantee of Western security.
1954	The North Atlantic Council authorized NATO to use strategic weapons to counter any aggression.
1955	The Soviet Union concludes the Warsaw Treaty with Albania, Bulgaria, Czechoslovakia, East Germany, Hungary, Poland and Romania, and in December signs a treaty with the regime in East Germany transforming it into a State.
1956	The Hungary uprising is quickly suppressed by Soviet troops.
1961	East Germany begins building the Berlin Wall.
1962	The development of the Cuban missile crisis
1965	The North Atlantic Council meeting in Ministerial session in Paris accepts new procedures designed to improve the annual process of reviewing the defense efforts of member countries and agreeing upon their force contributions.

TABLE 2 Flexible Response (1967-1988) dates and defining events

Date	*Defining Events*
1967	The Harmel Report on the Future Tasks of the Alliance is finalized. NATO decides to adopt a revised strategic concept to replace the massive retaliation doctrine. The new strategy, flexible response, is based on a balanced range of responses involving the use of conventional as well as nuclear weapons.
1968	Czechoslovakia uprising suppressed by Soviets
1970	The US and the Soviet Union, having reached nuclear parity, seek to impose limitations on their respective nuclear arsenals. In 1970, the nuclear Non-Proliferation Treaty comes into force.
1972	An interim agreement on strategic arms limitations (SALT 1) and an anti-ballistic missile systems (the ABM Treaty) are both signed. Allied Ministers had agreed to begin multilateral talks in preparation for a Conference on Security and Cooperation in Europe.
1973	The Allies propose a common ceiling on the two sides' ground forces
1976	Allies express concern at the growth in the Warsaw Treaty's military strength, review national force contributions and agree to the need for further strengthening of NATO conventional defenses.
1978	NATO leaders agree to raise real defense spending by three percent annually to and adopt the Long Term Defense Program to ensure that the ability of the alliance to meet future needs.
1979	The SALT II agreement to curtail the manufacture of strategic nuclear weapons is signed.
1981	France and the UK begin to modernize their strategic nuclear forces and the Reagan administration embarks on a significant build up of the US military forces. The US accuses allies of not contributing fair share to collective security and US Senate threatens to reduce defense spending if the allies do not increase European defense
1989	The Berlin wall falls marking the end of the Cold War.

TABLE 3 Crisis Management (1990 to the present) dates and defining events

Date	*Defining Events*
1991	During the Rome summit, the allies determine that NATO must assume responsibility for security challenges both within and beyond NATO boundaries. Gulf War is fought and the Communist regimes in Europe start to collapse.
1992	At the Oslo summit, peacekeeping is added as part of NATO's new strategic crisis management doctrine
1994	NATO broadens strategic doctrine to include the policing for the non proliferation of nuclear and other weapons of mass destruction.
1995	NATO peacekeepers deployed in Bosnia.
1999	NATO peacekeepers deployed in Kosovo.
2003	Iraq war starts.

TABLE 4 Structural Break Dates for NATO Defense Expenditures

Country	Breaks	Break Year	supF(2|1)	supF(3|2)	supF(4|3)	supF(5|4)	WDmax	Udmax
Belgium	2	1969, 1991	8.54*	5.6	0.02	1.41	79.96***	31.94***
Canada	5	1956, 1964, 1975, 1983, 1994	0.18	9.65*	4.64	11.33*	64.00***	26.65***
Denmark	2	1961,1974	26.16***	0.004	0.004	5.19	45.86***	22.29***
France	5	1956,1965, 1976, 1984,1994	3.25	0.52	0.37	21.29***	57.98***	35.67***
Germany	3	1960, 1971, 2001	1.18	134.93***	6.65	2.17	136.28***	56.27***
Greece	1	1968	0.6	1.05	0.24	2.43	175.75***	111.56***
Italy	1	1973	3.5	1.09	2.52	2.52	626.87***	259.07***
Luxemburg	3	1975, 1986, 1996	4.23	26.69***	0.07	0.21	133.25***	53.24***
Netherlands	1	1963	0.4	3.75	1.05	0.016	103.02***	50.07***
Norway	1	1967	4.27	3.69	3.69	2.36	30.40***	19.30***
Portugal	3	1960, 1975, 1987	0.61	36.28***	0.01	0.01	227.94***	14.68***
Turkey	1	1978	2.18	3.4	5.49	5.49	19.55***	7.81*
UK	3	1963, 1973, 1992	42.52***	11.56**	2.57	0	95.43***	48.07***
USA	1	1956	0.27	0.81	0.85	0.11	31.38***	15.80***

*, **, *** indicates significance at the 10%, 5%, and 1% levels respectively

TABLE 5 Prebreak and Postbreak Average Annual Defense Expenditure Growth Rates

Country	1	2	3	4	5	6
Belgium		*1969*	*1991*			
	6.23%	1.54%	-2.44%			
Canada		*1956*	*1964*	*1975*	*1983*	*1994*
	28.94%	-2.08%	-0.40%	3.32%	0.90%	0.37%
Denmark		*1961*	*1974*			
	7.40%	3.70%	0.46%			
France		*1956*	*1965*	*1976*	*1984*	*1994*
	12.40%	1.55%	1.87%	2.63%	0.34%	-0.40%
Germany		*1960*	*1971*	*2001*		
	10.90%	4.47%	0.52%	0.33%		
Greece		*1968*				
	6.56%	2.91%				
Italy		*1973*				
	4.63%	0.53%				
Luxemburg		*1975*	*1986*	*1996*		
	6.88%	3.90%	4.10%	3.99%		
Netherlands		*1963*				
	5.60%	0.49%				
Norway		*1967*				
	6.17%	1.39%				
Portugal		*1960*	*1975*	*1987*		
	6.27%	7.07%	-0.84%	0.97%		
Turkey		*1978*				
	20.26%	13.11%				
UK		*1963*	*1973*	*1992*		
	3.54%	1.57%	0.50%	-1.16%		
USA		*1956*				
	20.95%	1.17%				

Note: The entry in column 1 is the average annual defense growth rate before the first break.
The entries in columns 2 through 6 are the average annual defense expenditure growth after the break.
The break dates are in italics.

TABLE 6 NATO Allies Structural breaks by period

Country	MAD (1949-1966)	Flexible Response (1967-1989)	Crisis Management (1990- 2004)
Belgium		69 +↓	91 −↓
Canada	56 −↓ 64 −↓	75 +↑ 83 +↓	94 −↓
Denmark	61 +↓	74 +↓	
France	56 +↓ 65 +↑	76 +↑ 84 +↓	94 −↓
Germany	60 +↓	71 +↓	1 +↓
Greece		68 +↓	
Italy		73 +↓	
Luxemburg		75 +↓ 86 +↑	96 +↓
Netherlands	63 +↓		
Norway		67 +↓	
Portugal	60 +↑	75 −↓ 87 +↑	
Turkey		78 +↓	
UK	63 +↓	73 +↓	92 −↓
USA	56 +↓		

The arrow below each date indicates the direction of the mean growth rate after the break
A +↓ below the year indicates a positive growth in average annual defense expenditures that is less than the average before the prebreak year
A +? below the year indicates a positive growth in average annual defense expenditures that is greater than the average before prebreak year
A -↓ below a year indicates a negative growth in average annual defense expenditures that is less than the average before the prebreak year