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Economic versus Strategic Constraints: *the Asymmetric Behaviour of Defense Spending in France*

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Abstract
This article examines the main drivers of French defense expenditure between 1960 and 2010. France has to balance with two contradictory issues: strategic constraint and budgetary process. We assume that nonlinear approach is suitable to evaluate the demand function. Our results support latter assumption and we use time trend as transition function. Economic factors play a major role and considering the nonlinear pattern, we show that, before 1983, economic growth is inversely related to defense expenditure whereas the opposite arises after this threshold. Strategic considerations exert a little impact.

Keywords: Military expenditure - France - Demand function - LSTR modelling

Titre
Contraintes économiques vs contraintes stratégiques : le comportement asymétrique des dépenses de défense en France

Résumé
Cet article étudie les principaux déterminants des dépenses de défense françaises entre 1960 et 2010. La France doit faire face à deux difficultés contradictoires : la contrainte stratégique et la procédure budgétaire. Nous faisons l'hypothèse qu'une approche non-linéaire est appropriée pour évaluer la fonction de demande. Nos résultats confirment cette hypothèse avec la tendance linéaire comme variable de transition. Les facteurs économiques jouent un rôle primordial et étant donné la structure non-linéaire, nous montrons qu'avant 1983, la croissance économique est inversement reliée aux dépenses de défense alors que l'opposé survient après ce seuil. Les facteurs stratégiques n'ont que peu d'impact.

Mots-clés : Dépenses militaires - France - Fonction de demande - Modélisation LSTR

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1 Introduction

Recent events show that the current French defense policy has to cope with a double constraint: on the one hand, strategic factors involve substantial changes in the armed forces organization in order to face new threats, whereas on the other hand, the current economic crisis increases budgetary pressures. Such duality is in the core of the current trade-off in resources allocated to defense policy.

Historically, French defense policy has been characterized by the term "Grandeur policy" (Fontanel and Hébert, 1997). This expression means: development of nuclear deterrence, high level of defense spending - especially when it is compared to other developed countries -, development of a national and independent defense industry and arms exports. We then may wonder about the relevance of such a policy in the current global context. More particularly, we discuss the relevance of possible tensions in the current French defense policy.

The ambitious strategy of France is inherited from the spirit of "Grandeur policy". Indeed, in a recent past, France has been involved in many peacekeeping interventions in Afghanistan, Ivory Coast and Libya (2011), in Mali (January 2013), Central African Republic (Novembre 2013).

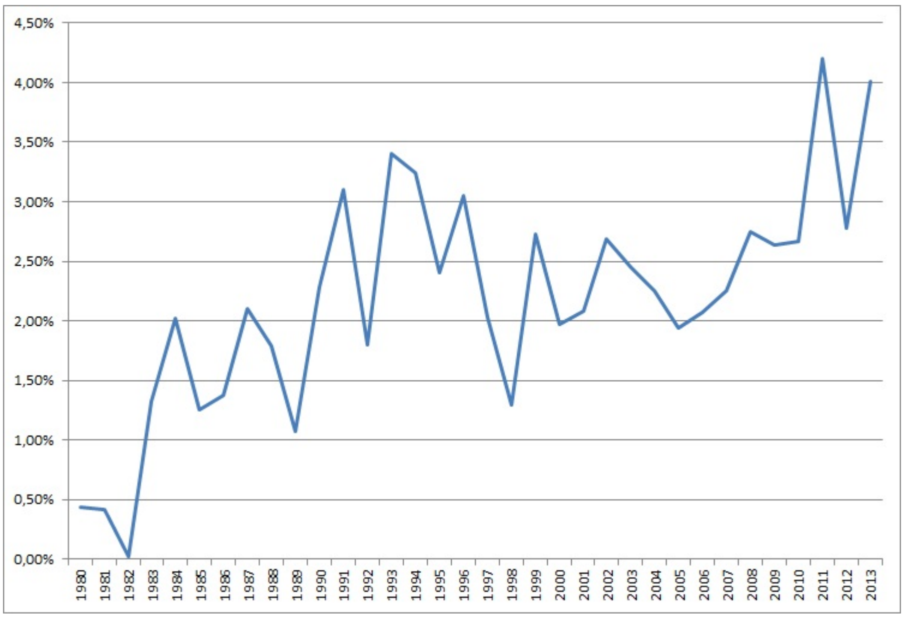

Figure 1: Share of overseas operations costs in defense budget

Figure (1) represents the share of overseas operations costs in defense budget from 1980 to 2013. Data are provided by Hébert from 1980 to 2008 and by several defense yearbooks from 2009 to 2013. In this figure, we note an upward trend, meaning that overseas operations generate a burden on defense budget. This burden is under-estimated by budget bills and leads to tension in defense budget outturn. In particular, several parliamentary reports point out that over-costs associated with overseas operations cause delays and cancellations in defense equipment spending.

The New White Book on Defense and Security - published in April 2013 - mainly focuses on possible path to cope with both strategic constraint and economic one. Recently, a new Military Program Law (MPL) has been introduced. It covers the years 2014-2019 period and defines both objectives and means devoted to the French Defense Ministry. Specifically, this MPL plans future budgets in line with the conclusions of the White Paper on Defense and Security (2013). The 2014-2019 MPL includes a total of credits that represents about 190 billions of current euros. The defense budget will stay constant between 2014 and 2017. In 2018, it should increase about 1% per year in volume. In this MPL, the amount of credits allocated to defense equipment is about 103 billion of current euros with an average amount of 17 billion of current euros per year during the period. Economies are expected on the non-equipment part of the budget.

In France, defense expenditure can be divided into equipment expenditures and non-equipment expenditures. One key decision of the last White Paper has been to increase equipment expenditures at the expense of non-equipment expenditures (especially wage bill). The main purpose of such a policy consists in adapting armed forces to new threats and jointly saving money.

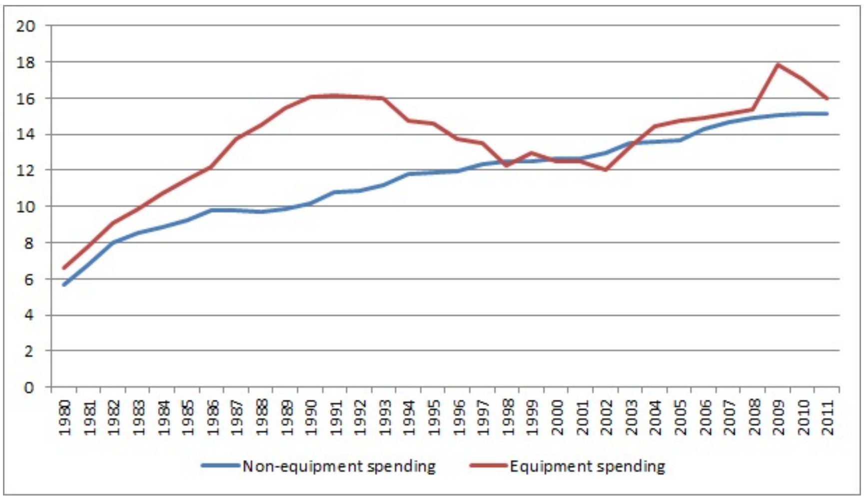

Figure 2: Evolution of defense equipment and non equipement expenditures

Figure (2) plots the evolution of equipment and non-equipment expenditures from 1980 to 2011 in constant euros. Non-equipment spending exhibits linear trend whereas equipment spending appears to be more volatile. Moreover, the preference for equipment is clear for the 80's decade whereas during the 90's decade, non-equipment is more prevalent. Strategic and geopolitical changes that occur since 2001 generate a budget quite fairly divided between both parts of defense spending.

France is torn between the need for adapting its army model to new threats and financial constraints that limit available budgetary resources. It is then relevant to evaluate the main drivers of French defense expenditure in order to identify to what extent economic or strategic factors do influence the evolution of the defense burden.

A quick look on the literature review does not provide a recent answer to this question. The last paper that explicitly examines the determinants of French defense spending has been written by Schmidt, Pilandon and Aben (1990). Some recent contributions have been published but with no specific concern to the case of France (see for instance Nikolaidou, 2008). The recent transformations in the strategic and economic environments require new empirical evidence.

Beyond the originality of the case study, our approach is also original because of its non-linear modelling. To the best of our knowledge, there is no application of non-linear models in the literature. We believe that there is an asymmetric behaviour of defense spending. In line with this, many scholars argue that individual determinant of defense spending exerts a non-linear impact; for instance, Murdoch and Sandler (1984) explain how doctrinal changes among allies in NATO may lead to structural change. Moreover, demand functions suffer instability and one possible way to deal with this weakness is to consider a non-linear approach. Consequently, estimating the demand function requires to check the linear hypothesis because this hypothesis generates many constraints both at theoretical and empirical levels.

We empirically estimate the French defense expenditure demand function for the 1960-2010 period. The model includes bureaucratic, strategic and economic factors. We then estimate both linear and non-linear models to check whether the latter outperforms in econometrics terms the former. Based on several criteria, we show the superiority of non-linear modelling.

The article is organized as follows. In the second section, we provide a literature review with a focus on the case of France. In the third section, we present the model and data, the non-linear approach and the possible causes of non-linearities. Then, in the fourth section, we examine the results obtained with both linear and non-linear approaches. The fifth section concludes the paper.

2 Literature review

The determinants of defense spending have been the focus of many studies. Indeed, many variables have been used, leading to a diversity in results. As indicated by Smith (1989), it is possible to distinguish two broad classes of factors influencing military expenditure: external and internal factors.

Concerning the external forces, three variables are candidate. First, arms conflicts influence directly defense expenditure, with an obvious link. Second, following Richardson (1960), arms races may arise between rivals. However, it is worth noting that latter representation receives less empirical evidence (Sandler and Hartley, 1995, p. 106). Third, alliances have been widely tested since the seminal study of Olson and Zeckhauser (1966) driving to a wide literature[1].

Regarding the internal influences, three factors may occur. First, economic factors have to be considered. Such factors are for example income, growth rate or prices. They describe the financial environment, in particular,the constraints for affordable defense spending. Second, bureaucratic influences model the bargaining over the budgetary process. In this kind of models, lagged values play an important role in the determination of military expenditure. Third, one has also to point out the influence of political factors, such as elections or governmental popularity.

A large part of the empirical literature follows the pioneering approach of Smith[2]. Some studies deal with developed countries. For instance, Kollias and Paleologou (2003) give evidence for the Greek case and conclude that income, strategic variables and political colour have significant impact. Dunne, Nikolaidou and Mylondis (2003) argue that no clear pattern emerges from demand function for Greece, Portugal and Spain. More recently, Nikolaidou (2008) shows that both economic and strategic factors play significant role for EU15 countries but one has to pay attention to specific individual characteristics. Bernauer, Koubi and Ernst (2009) examine whether the Swiss neutrality makes a difference in terms of demand of defense spending and they conclude that the main driver is the external threat perceived by large NATO countries. For developing countries, Dunne, Perlo-Freeman and Smith (2008) insist in the importance of carefully defining hostility and capability.

France has a special status in terms of defense policy. Indeed, when de Gaulle came to power, the defense policy guidelines clearly were the importance of independence in

[1]See Sandler and Hartley (1995), chapter 2 or Murdoch (1995) for a literature review.

[2]The aim of this article is not to give an overall literature review. The interested reader can check Smith (1995).

terms of production of weapons and nuclear deterrence. This independence policy was reinforced when France withdrew from the integrated military command of NATO in 1966. The end of the Cold War led to a reorganization of the defense policy since it is no longer appropriate to new risks. As stated by Coulomb and Fontanel (2005, p. 299), even if the strategic ambitions are always reasserted, "the analysis of defense budget reveals that the means have not always followed the declared objectives." Fontanel and Hébert (1997) also point out that "policy of grandeur" is no longer adapted to the context. Such an affirmation led the authors to consider an Europeanization process of defense industry.

Considering these specificities, some studies deal with the explanation of French military expenditure. Schmidt, Pilandon and Aben (1990) indicate that defense spending are driven by economic factors through GDP and strategic factors through aggregate NATO expenditures. Lelièvre (1996) shows that the share of military expenditure in the government budget is declining with economic constraints over the period 1971-1995, showing that defense is an adjustment variable. This result has been confirmed by Coulomb and Fontanel (2005) with more recent data. The weight of financial constraints and income fluctuations has been pointed out by Jacques and Picavet (1994) within a cointegration framework.

This short literature review clearly shows the absence of recent evidence. Our purpose is to give new empirical evaluation of the demand function in the case of France since major changes occur in the past few years.

3 Model

In this section, we first present the estimated model. Then, we turn with the econometric method and finally provide some indications about the origins of non-linearities in the model.

3.1 Estimated equation

From existing literature, it appears that incorporating economic influences as explanatory variables for French military expenditure is crucial. Indeed, the literature teaches us that defense spending has often been used as an adjusting variable in the budgetary process (Lelievre, 1996 or Coulomb and Fontanel, 2005) and depends on economic conditions (Jacques and Picavet, 1994). So, with the growth rate of GDP[1], we take into account the economic influences on defense expenditure.

Bureaucratic influences model bargaining over the budgetary process. Rattinger (1975,p. 575) pointed out that:

> "the behavior of defense bureaucracies in the competition for funds corresponds to the organizational routine behavior of other government agencies. Specifically, this implies that-regardless of the threat posed by the international environment-cuts in the defense budget from one year to the next during the process of appropriation in administration and legislatures have to be avoided by all means."

This hypothesis is designed as "incrementalism" and reflects the fact that lagged values have an important role in the determination of military expenditure. As noted by Rattinger (1975), the bureaucratic influence is more probable when "high proportion of defense expenditures are programmed in advance and do not lend themselves to budgetary manoeuvres on short notice".

In France, incrementalism is likely to occur. Indeed, the budgetary process for defense expenditure is organized through MPL. There is "program approval" (*autorisation de programme*), defined for several years, generally five. Program approval constitutes the spending's upper limit allowed to engage. In order to finance these program approvals, the Parliament votes each year "crédit de paiement" which represents the share of budget devoted to defense spending. For these reasons, we integrate the lagged values of French military expenditure as an explanatory variable.

As noted by Coulomb and Fontanel (2005), political factors do not seem to have a significant impact on level of defense spending[2]. More recently, Foucault (2012) argues that there is no partisan effect: when we include a time dummy reflecting the government's political side, this variable is not significant. We exclude this kind of variable in our analysis.

[1]Note that we can not use the GDP (or GDP per capita) in order to model the economic influence because this variable is not stationary. Stationarity is a necessary condition in order to estimate STR models.

[2]They argue that "since the acceptance by the two main French political parties of the principle of nuclear deterrence, and then the abolition of conscription, military expenditures are no longer a subject of debate". pp. 303-304. This point of view may be qualified as simplistic since on the one hand, with the advent of new governments (1986, 1988, 1995), we have observed major changes in military programs. But, on the other hand, this argument also has the advantage to not overload the model with less crucial variables

Concerning external factors, in the French case, the influences of external factors appear to be difficult to evaluate. Since there is no avowed enemy, examining the arms race hypothesis through action-reaction model is not relevant.

Furthermore, the status of France in NATO is special. Indeed, even if independence has been erected as a principle of defense policy, several studies (Murdoch and Sandler, 1984, Smith, 1989, or Fontanel and Smith, 1990) indicate that French military expenditure responds to US military expenditure. Our model takes this element into account with the US defense burden. We expect little impact of this variable because independence balances the will to avoid free riding.

Finally, France has participated to many conflicts and peacekeeping interventions. It seems far from obvious that these interventions have an influence on the importance of defense spending. The four first months of the French intervention in Mali (operation Serval) costed about 200 millions and, by the end of 2013, the total cost of the operation is expected to exceed 400 millions of euros. Finally, France has also sent troops in Central African Republic (operation Sangaris) (the cost of this recent operation has not been assessed yet).

Since 1960, we note that the participation of the French armed forces have been quite frequent. We model these events by a dummy variable which takes the value 1 during a conflict and 0 otherwise. Here is the list of these interventions:

- Algeria (1960-1962)
- Chad (1986)
- First Gulf war (1990-1991)
- Rwanda (1994)
- Kosovo (1999)
- Afghanistan - Lebanon - Ivory Coast (2002-2010)

As a consequence, we focus only on economic, bureaucratic and strategic factors to model the French military expenditure. The tested model takes the following form:

$$m_t = \sum_{i=1}^{n} m_{t-i} + \sum_{j=0}^{n} g_{t-j} + \sum_{k=0}^{n} usm_{t-k} + conflicts_t + \epsilon \qquad (1)$$

where m_t denotes the current French defense burden computed as the ratio defense spending to GDP, g_t the current real growth rate of GDP, usm_t the current US defense burden, $conflicts_t$ the current value of the conflict dummy and ϵ the error term.

3.2 Empirical model

In order to estimate the model, we use STR models, introduced by Teräsvirta (1994). The formulation is as follows (Teräsvirta, 2004):

$$\begin{aligned} y_t &= \phi' \mathbf{z}_t + \theta' \mathbf{z}_t G(\gamma, c, s_t) + \epsilon_t \qquad (2) \\ &= \{\phi + \theta G(\gamma, c, s_t)\}' \mathbf{z}_t + \epsilon_t \end{aligned}$$

where y_t is the dependent variable, $\mathbf{z}_t$ the vector of explanatory variables with $\mathbf{z}_t = (\mathbf{w}'_t, \mathbf{x}'_t)$, $\mathbf{w}'_t = (1, y_{t-1}, ..., y_{t-p})$, $\mathbf{x}'_t = (x_{1t}, ...x_{kt})'$ a vector of exogenous variables and $\epsilon_t \sim iid(0, \sigma^2)$.

$G(\gamma, c, s_t)$ denotes the transition function, it is a bounded function between 0 and 1 of the transition variable s_t. The transition variable may be endogenous and in this case $s_t = y_{t-d}$ where d is the delay parameter or an exogenous variable or even a linear trend. γ is the slope parameter and indicates the transition's speed between regimes. c is the threshold parameter. A general specification of $G(\gamma, c, s_t)$ is the general logistic function:

$$G(\gamma, c, s_t) = \left(1 + \exp\left\{\gamma \prod_{k=1}^{K} (s_t - c_t)\right\}\right)^{-1} \qquad (3)$$

With this function, we get a LSTR model[1]. K indicates the number of regimes. If $K = 1$ (LSTR1) there is one threshold so we get two regimes. In this case, parameters change monotonically as a function of s_t. The LSTR1 is appropriate for modelling asymmetric behavior, such as business cycle: the properties of expansions are different than those of recessions with smooth changes between both regimes. If $K = 2$, the model (LSTR2) has three regimes but both extreme regimes are similar (for small and large values of s_t).

An important feature is to test linearity. The test has been proposed by Luukkonen, Saikkonen and Teräsvirta (1988). The principle is that we approximate the transition function by a Taylor expansion with the null hypothesis $\gamma = 0$. The following auxiliary regression is given by:

$$y_t = \beta'_0 \mathbf{z}_t + \beta'_1 \tilde{\mathbf{z}}_t s_t + \beta'_2 \tilde{\mathbf{z}}_t s_t^2 + \beta'_3 \tilde{\mathbf{z}}_t s_t^3 + u_t^* \qquad (4)$$

where $u_t^* = u_t + R_3 G(\gamma, c, s_t) \theta' \mathbf{z}_t$, $R_3 G(\gamma, c, s_t)$ denotes the remainder term of the Taylor expansion. Under the null hypothesis where $\mathrm{H}_0 : \beta_1 = \beta_2 = \beta_3 = 0$, we assume that $R_3 G(\gamma, c, s_t) = 0$ and so $u_t^* = u_t$ so that the remainder term does not affect the errors' properties (see van Dijk, Teräsvirta and Franses (2002) for details)

[1] When the transition function is exponential, the resulting model is called ESTR

and asymptotic theory applies.

It is important to distinguish between LSTR1 and LSTR2 in the case of linearity rejection. Teräsvirta (2004) recommends to use the following sequential tests based on equation (4):

$$\begin{aligned} \mathrm{H}_{04} &: \quad \beta_3 = 0 \\ \mathrm{H}_{03} &: \quad \beta_2 = 0 \mid \beta_3 = 0 \\ \mathrm{H}_{02} &: \quad \beta_1 = 0 \mid \beta_2 = \beta_3 = 0 \end{aligned}$$

If the lowest p-value is associated with H_{03}, then the selected model is the LSTR2 one; otherwise the LSTR1 model is more appropriate. As all the tests can be simultaneously rejected, the strongest rejection determines the chosen model.

After determining the transition variable, we have to estimate the model. This is done with algorithm for non-linear model which requires choosing good starting values (see Teräsvirta, 2004 for a detailed presentation of the estimation's method and associated problems). Several tests are also used in order to evaluate the model. Some of them are employed in a linear context, such as error autocorrelation, ARCH effects and normality. One test is particularly important in a non-linear context: no additive non-linearity. This test checks whether the STR model fits correctly the non-linearity in the data. This is done with an extra transition function[1] for which the identification problem is solved through a Taylor expansion. See van Dijk, Teräsvirta and Franses (2002) for a comprehensive explanation.

To sum up, in order to estimate STR model, we follow 5 steps: (*i*) estimate a linear model; (*ii*) test linearity against STR model; (*iii*) compute a search grid to determine the initial values; (*iiii*) estimate STR model; (iiiii) validation with the use of misspecification tests.

3.3 Origins of non-linearities

In this subsection, we explain the main reasons for adopting a non-linear model. The linear hypothesis imposes too many restrictions which are not in line with the instability associated with the demand function. For instance, Abu-Qarn et al (2013) show that the demand function for Egypt suffers functional form issues as indicated by Ramsey test. Even if the detection of a misspecification is quite easy, the diagnostics of the underlying disease are difficult to find. Our hypothesis is that a non-linear approach

[1] As a consequence, the model has the following form: $y_t = \phi' \mathbf{z}_t + \theta' \mathbf{z}_t G(\gamma_1, c_1, s_{1t}) + \psi' \mathbf{z}_t H(\gamma_2, c_2, s_{2t}) + \epsilon_t$, where $H(\gamma_2, c_2, s_{2t})$ is a transition function given by (3).

is suitable to capture the potential misspecification associated with demand function.
It has been argued that modern conflicts are different compared to those observed before Cold War. For instance military equipement embodied more and more costly technologies, development of asymetric and regional conflicts. More particularly, the increase in regional conflicts contributes to develop a projection forces paradigm, latter often involves costly logistic efforts. This change in the way of conducting war leads to another look on the importance of conflicts to explain French defense spending. France has been involved in many peacekeeping interventions over the 20 last years whereas previously only Algeria war (between 1960 and 1962) was the sole major conflict in the Cold War perid. However, given the empirical approach, it is not possible to use a dummy variable as a transition variable and then we do not consider this variable as a driving force for non-linearities.

Arms race may also explain the existence of non-linear behaviour. As pointed out by Sandler and Hartley (1995) or Murdoch (1995), the empirical tests lead to poor results. The reasons are numerous: theoretical misspecification, poor data quality, structural change and econometric issues. Considering these difficulties, some recent applied studies use non-linear model to evaluate the "action-reaction" hypothesis on a regional basis. For example, Smith et al (2000) demonstrate the appropriateness of the Markov Chain estimates for the Greece-Turkey rivalry. However, in our model, following the idea of no avowed enemy, we do not include any variable reflecting the existence of arms race phenomenon (see the recent survey made by Dunne and Smith (2007) for further information on on this topic.)

It has been argued in the defense literature that doctrinal changes have impact on the behaviour of government vis-à-vis the membership in an alliance. Murdoch and Sandler (1984) document this point for NATO countries. Their argument is simple: the burden sharing among NATO allies is consistent with free riding but not with the features of a pure public good model. Empirically, they show a shift in the parameters of the estimated equation and interpret this shift as a response to the new doctrine of flexible response. In our model, we reduce the membership to NATO to the US defense spending[1]. As a consequence, we consider it as a transition variable in order to capture any change of doctrine between NATO allies.

Considering internal factors, we don't think lagged defense spendig could be used as a transition variable. Indeed, budgetary rules remain unchanged over the sample period, with a military program laws defining objectives and means devoted to the Ministry of

[1]Note that empirically defense spillins are not significant whereas US defense spending is significant.

Defense for several years (often for 5 years). However, this statement does not mean that defense spending has not suffered from budgetary issue.

Growth rate of GDP is also a candidate for being the transition variable. This choice reflects the defense burden sensitivity to financial constraints. Because government budget is countercyclical, a low growth performance generates greater social expenditures and lower tax revenues and so a higher deficit. Under these circumstances, financing defense burden is more difficult, the few past years provide an example.

Finally, we also include time trend as potential transition variable. In defense literature (for instance Brauer, 2007), it has been argued that shocks may lead to affect parameters which tend to be unstable over time. As indicated by Hansen (1992, p. 517) "because a parametric econometric model is completely described by its parameters, model stability is equivalent to parameter stability". If time trend is the transition variable, the resulting thresholds are years.

Our approach is then less specific compared to previous papers that consider only one reason. Considering all variables as potential transition variable, we therefore check the multiple sources of non-linearity rather considering *a priori* one transition variable.

4 Data and results

4.1 Data

We first present the data used in our empirical analysis. The dependent variable is the ratio of military expenditure to GDP. It has been computed with data from the SIPRI database. US defense spending is also provided by SIPRI. In order to capture the economic factors, we employ the growth rate of GDP calculated as the difference between the log of real GDP less the log of real GDP of the previous year. Data come from the IFS database, published by IMF. Our analysis extends from 1960 to 2010.

Before turning to the results, it is important to check the properties of the series, because STR model requires stationary variables. To do so, we use the Augmented Dickey-Fuller (ADF) and Philipps Perron (PP) tests. We adopt here the strategy of Dickey and Pantula (1987). The results of these tests are presented in Table (**??**). As indicated in Table (**??**), both variables are stationary, so the estimation can be achieved directly.

Variable	ADF test	PP test
g_t	-5.6935	-5.6993
Δg_t	-10.1827	-14.9624
m_t	-5.0326	-4.1221
Δm_t	-2.6507	-4.0969
usm_t	-2.7722	-2.6475
Δusm_t	-3.8957	-3.7230

Table 1: ADF and PP tests

4.2 Linear model

In accordance with the steps presented above, we begin the sequence with a linear model estimation. We first estimate the most general model and then remove all the non-significant values. The resulting model has the following form:

$$m_t = \underset{(0.0628)}{0.0910} + \underset{(0.0388)}{0.9742} m_{t-1} - \underset{(0.0160)}{0.0456} g_t + \underset{(0.0328)}{0.1071} usm_t - \underset{(0.0330)}{0.0988} usm_{t-1} - \underset{(0.0274)}{0.0080} conflicts_t \tag{5}$$

Adjusted R^2=0.9897; $pARCH(1) = 0.2363$; $pARCH(2) = 0.4220$; $p_{AR}LM(1) = 0.2489$; $p_{AR}LM(2) = 0.1029$; $pJB = 0.1652$; $\hat{\sigma}_L = 0.1001$; AIC=-1.6456; SIC=-1.4094; HQ=-1.5567

where $pARCH(.)$ denotes the p-value associated with the ARCH test, the number in brackets referring to the test order; $p_{AR}LM(.)$ the p-value of the LM test for autocorrelation and pJB the p-value of the Jarque-Bera test. We can note that all the misspecification tests suggest that the errors have the good properties.

As widely documented in the literature, the linear model indicates that inertia effects are crucial in the determination of French military expenditure. This is coherent with the model developed previously. It is well known that bureaucratic arguments may arise for explaining defense expenditure. Note that only the first lag is significant.

Furthermore, we observe that the growth variable enters in the regression with a negative coefficient. This result, recently pointed out by Malizard (2013), indicates that defense expenditure has been used as a counter-cyclical instrument.

Finally, the coefficients associated with the U.S. military expenditure are very close but with opposite signs. We test the hypothesis that the sum of both coefficient is 0 with a Wald test, which proves that U.S. defense spending has no effect on French military expenditure. This is consistent with our expectations presented in the model.

The next step is to test linearity against STR model. In accordance with the origins of non-linearities, we check the linearity hypothesis for all the variables included in the model. We apply the strategy presented in the previous section. The results of the linearity test are presented in the Table (2). In this table, we report the p-value associated with each test presented in the previous section.

F denotes the null hypothesis H_0 of the auxiliary regression (equation 4), $F2$ the hypothesis H_{02} and so on for F3 and F4. From Table (2), we can note that both g_t and the trend reject the linearity hypothesis but the best candidate for the transition variable is the trend because the test reaches the lowest p-value compared to g_t. Both m_{t-1} and usm do not reject the hypothesis of linearity.

Transition variable	F	F4	F3	F2	Suggested model
m_{t-1}	0.3208	0.2201	0.6616	0.2516	Linear
g_t	0.0205	0.0704	0.5481	0.0105	LSTR1
usm_t	0.3079	0.8451	0.1559	0.1536	Linear
usm_{t-1}	0.3548	0.9760	0.1013	0.1963	Linear
Trend	0.0019	0.1363	0.1441	0.0006	LSTR1

Table 2: Linearity tests

As the lowest p-value is given for H_{02}, the suggested model is the LSTR1. The choice of trend as transition variable is not very surprising. It captures elements that are not modelled by other variables and more particularly exogenous factors such as political and international events (e.g. the end of the Cold war or periods of conflict). Latter elements enter only partially in our model, since defense spending and growth do not capture them globally. Considering that, the trend is justified and coherent with our hypothesis previously discussed.

4.3 Non-linear model

Now we compute the non-linear model. The results are given by:

$$\begin{aligned} m_t &= \underset{(0.1252)}{0.4892} + \underset{(0.0478)}{0.9871} m_{t-1} - \underset{(0.0155)}{0.0771} g_t + \underset{(0.0452)}{0.1027} usm_t - \underset{(0.0463)}{0.1372} usm_{t-1} + \underset{(0.1020)}{0.0209} conflicts_t \\ &+ \left[-\underset{(0.1873)}{0.6264} + \underset{(0.1107)}{0.7740} m_{t-1} + \underset{(0.0202)}{0.0443} g_t - \underset{(0.0863)}{0.0426} usm_t + \underset{(0.0975)}{0.0778} usm_{t-1} + \underset{(0.1107)}{0.032}\, conflicts_t \right] \times G(\gamma; c; (s \end{aligned}$$

where the transition function is given by:

$$G(\gamma; c; s_t) = \left(1 + \exp\left\{\underset{(13.3149)}{12.9277}\left(\text{trend} - \underset{(1.3961)}{20.3135}\right)\right\}\right)^{-1} \tag{7}$$

Adjusted R^2=0.9950; $pARCH(1) = 0.1064$; $pARCH(2) = 0.2356$; $p_{AR}LM(1) = 0.0140$; $p_{AR}LM(2) = 0.0449$; $pJB = 0.3601$; $\hat{\sigma}_{STR} = 0.0886$; $\hat{\sigma}_{STR}/\hat{\sigma}_L$=0.865; AIC=-4.6701; SIC=-4.2878; HQ=-4.5245

We also note that the γ parameter is not significant. Nonetheless, as indicated by Teräsvirta (2004, p. 229), "contrary to first intuition, the ensuing small value of the t ratio does not, in that case, suggest redundancy of the non-linear component". So, this argument does not provide any rejection of the non-linear perspective. Because γ is large, the transition between regimes is rapid. In this condition, determining the curvature of (3) requires many observations in the neighbourhood of c and this is not the case in our sample.

The relative gain of using a non-linear model is given by the ratio $\hat{\sigma}_{STR}/\hat{\sigma}_L$. This gain is relatively low, probably due to the fact that non-linearity is not strongly rejected.

The misspecification tests show that the errors suffer ARCH effects and autocorrelation. Normality is accepted. This regression has bad properties, so it is important to improve it. Furthermore, except for m_{t-1}, we note that the coefficients of g_t, usm_t and usm_{t-1} are close in both linear and non-linear parts but have opposite signs. It is perhaps suitable to impose a restriction such as: $\phi = -\theta$. The resulting regression is:

$$\begin{aligned} m_t &= \underset{(0.2136)}{0.5793} + \underset{(0.0399)}{0.9496} m_{t-1} - \underset{(0.0143)}{0.0578} g_t + \underset{(0.0439)}{0.1031} usm_t - \underset{(0.0426)}{0.1270} usm_{t-1} + \underset{(0.0683)}{0.0595} conflicts_t \\ &+ \left[+ \underset{(2.1127)}{0.4131} + \underset{(0.0797)}{0.7675} m_{t-1} + \underset{(0.0143)}{0.0578} g_t - \underset{(0.0439)}{0.1031} usm_t + \underset{(0.0426)}{0.1270} usm_{t-1} + \underset{(0.2930)}{0.0644} conflicts_t \right] \times G(\gamma; c; s \end{aligned}$$

Where the transition function is given by:

$$G(\gamma; c; s_t) = \left(1 + \exp\left\{\underset{(0.9469)}{1.2837}\left(\text{trend} - \underset{(3.9222)}{22.6371}\right)\right\}\right)^{-1} \tag{9}$$

Adjusted R^2=0.9948; $pARCH(1) = 0.1931$; $pARCH(2) = 0.21749$; $p_{AR}LM(1) = 0.2121$; $p_{AR}LM(2) = 0.3681$; $pJB = 0.9714$; $\hat{\sigma}_{STR} = 0.0823$; $\hat{\sigma}_{STR}/\hat{\sigma}_L$=0.822; AIC=-4.8030; SIC=-4.3823; HQ=-4.6428

Several indicators support this last specification. Firstly, the regression given by equations (8) and (9) minimizes the information criteria. Secondly, the misspecification tests are greatly improved with the last specification, in particular ARCH effects and no autocorrelation. Finally, the significance of the coefficients is also better, in particular in the non-linear part. For the rest of this article, we use the specification (**??**)-(**??**). Before turning to the interpretations, we now present the relevant test in the non-linear context. Table (3) shows the results of the test of no remaining non-linearity. In Table (3), the figures are the p-values associated with each test. Notations are the same as previously. We note that there is no problem of remaining non-linearity since each p-value is greater than 5%.

Transition variable	F	F4	F3	F2
m_{t-1}	0.1385	0.0471	0.6201	0.5006
g_t	0.1711	0.0435	0.7449	0.5711
usm_t	0.2556	0.2335	0.2086	0.6599
usm_{t-1}	0.1855	0.1609	0.1457	0.8106

Table 3: Test of no remaining non-linearity

Since we have determined that the LSTR model has good properties, let's now turn to interpretations. We begin by commenting the results obtained with the linear part. We can note that the inertia effect is still very effective. Once again, the growth rate of GDP is significantly negative. So, the conclusions formulated for the linear model are still valid for the linear part of LSTR model. The coefficients associated with the US military expenditure confirms the relative neutrality in terms of response of French defense spending. Furthermore, the coefficients are very close between linear model and linear part of non-linear model, confirming the idea that the interpretation is the same. Our regression indicates that the threshold is 1983, so these conclusions are valid only before this date.

After 1983, the model turns to be non-linear. The conclusion are diametrically opposed. Indeed, the inertia effect is still effective, but the coefficient is lower, from 0.99 to 0.75. This result can be explained by several arguments. First, the "incrementalist" hypothesis is less pertinent for the recent years, as already noted by Jacques and Picavet (1994). Second, this result confirms the idea that military programs have been non-executed. The "comb" picture, presented in Figure (3), illustrates this idea. More specifically, in such a picture, executed programmes would represent the "handle" of the comb whereas "teeth" would represent non executed programmes.

The non-execution has been pointed out by several French deputies. For instance, it is interesting to note that during a parliamentary debate, Mr Boyon states that the real execution rate is 80% over the period 1989-1993. More recently, in a report, Mr Bouvard (2009) states that concerning the military program over 2003-2008: "implementation of military planning law that ended last year has experienced severe difficulties as regards

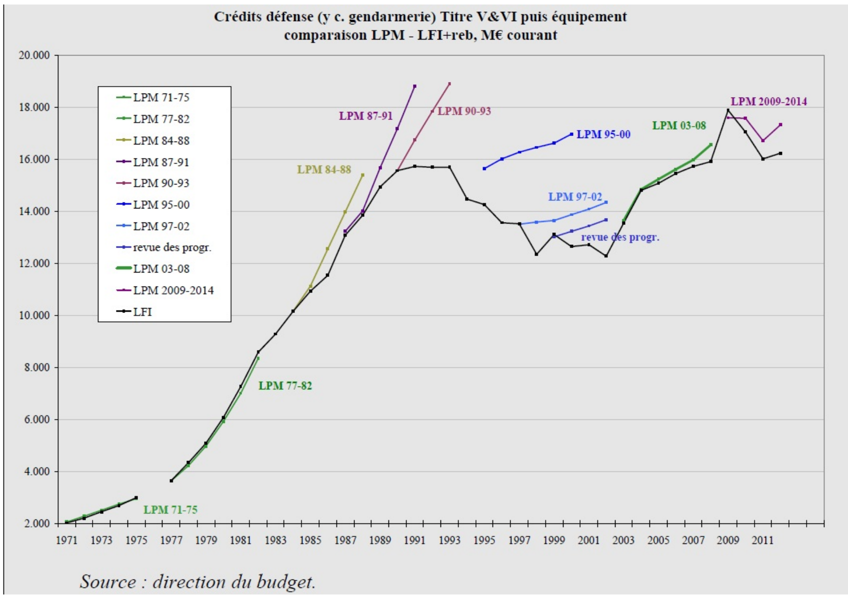

Figure 3: Voted budgest and executed budgets.

Source: Fromion and Rouillard (2013)

as its execution (p.26)".

In the non-linear part, we can also note that the sign of g_t is reversed. This result reflects the fact that military expenditure is more dependant of the conjuncture than before 1983. Our results confirm the shift concerning the explanatory variable of French military expenditure: if bureaucratic factors have significant explanatory power before 1983, the economic factors tend to have more influence in the explanation of defense spending after this threshold. This is not surprising, since economic crisis modify the priority of economic policy, in favour of social policies (Lelièvre, 1996). Thus, the weight of defense spending is decreasing over time (except for the period 1977-1982). This is in line with the recent literature about the French case (Lelievre, 1996 or Coulomb and Fontanel, 2005).

The year 1983 is a break in French defense spending and this 1983 threshold can be subject to several alternative interpretations. Firstly, it marks the end of the 4th MPL. This program (1977-1982) reveals a rise of military expenditure due to the "euromissile crisis". Thereafter, with the anticipated end of this crisis, the next MPL planned reductions in defense budget. Secondly, this reduction can also be attributed to the fail of President Mitterand's boost which started with his election in 1981 and adopted an economic policy based on budgetary rigour, a reorientation called "tournant de la rigueur" or "rigour switching". Finally, the threshold has already been noticed previously by some scholars: Lelièvre (1996, pp. 73-74) indicates that "if in 1982, military expenditure is less affected by the rigour than civilian public expenditure, it undergoes the consequences of the economic decline... Voted military spending is judged too important and during the budget execution, some are cancelled."

5 Conclusion

This article provides new empirical insights on the main drivers of French defense expenditures. More specifically, we have empirically studied how the French government balances a double constraint: the will to have important strategic ambitions (1) and the budgetary process (2).

Following the first constraint, the defense budget should increase in order to face new threats. However, such a mechanism is obviously limited by the budget constraint of the country. Indeed with the budgetary crisis, the French defense budget only remains constant in nominal terms.

Following the Smith's (1989) pioneering model of demand for defense expenditures, we use several variables in order to take into account bureaucratic, economic and strategic drivers. Our empirical framework is original in the literature since with the use a nonlinear econometric approach based on LSTR model (Teräsvirta, 1994). Thus, we identify several reasons to justify a non-linear pattern of the French defense demand function. Because linear approaches impose many constraints , relaxing the linearity hypothesis permits a more thorough analysis in the data exploitation. Several criteria confirm the usefulness of LSTR model compared to linear model.

Our results show that economic factors play a major role in the French defense behaviour. More particularly, we show a shift concerning the explanatory variable of French defense expenditures. Bureaucratic factors have significant explanatory power before 1983, but after this threshold, economic factors tend to have more influence in explaining the demand for defense expenditures. The year 1983 can be interpreted as a break in French defense spending.

Moreover, strategic factors exert little influence. Conflicts have no significant impact and the influence of US military spending is low. Consequently, even if bureaucratic factors play a major role to explain what drives the defense burden, economic factors tend to be more prevalent over time and especially during the 1983 - 2010 period.

The rise of economic factors may be explained by two main reasons. First, the positive sign associated with economic growth after 1983 confirms the defense burden's sensitivity to funding opportunity: policy makers have to cope with a rising public debt and previous political choices showed a preference for non-military public spending. Second, military costs rose in procurement cost, manpower cost and equipment support cost (especially in Maintenance, Repair and Overhaul).

This study is the first attempt to provide empirical evidence on the defense spending's driver using non-linear model. The assumption of asymmetrical behaviour of defense spending is confirmed and future research may check this assumption for other countries.

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