Does military spending stimulate growth? An empirical investigation in Italy

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31 August 2014

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Abstract

This paper investigates the effect of military burden on economic growth and extends previous works on the optimal size of government expenditure by exploring how external threat affects the preferences of the households and, in turn, economic growth. Post World War II Italian data are used to estimate non-linear growth models using time-series semi-parametric methods. The estimates show that total government and civilian burdens are productive, whereas military burden has significant effects on economic growth through the expenditure for peacekeeping missions which reduces the insecurity in the home country. This may justify economically the current not negligible budget devoted to peacekeeping and humanitarian missions.

Keywords: Military burden, Italian defense sector, endogenous growth models, Non-linear time series

JEL Classification: H50, O41, O47

1. Introduction

The debate on the relationship between military spending and economic growth is largely inconclusive for either the sign or the magnitude of these effects. The heterogeneity depends on the contrasting outcomes that changes in military spending bring through several transmission channels identified from the literature. In fact, military sector providing a variety of public infrastructures (e.g., dams, communication networks, roads, airports, highways, and other transportation networks) may help a country to increase the physical capital, other than enhances human capital through education, nutrition, medical care, and training. In addition, to R&D experiences, military spending may have a positive effect on growth through complementarity effects on the private production inputs. Shieh et al. (2002) also show that military spending may promote economic growth through internal and external security (Lipow & Antinori, 1995; Aizenman & Glick, 2006; Pieroni, 2008), by boosting private domestic investments and by attracting the foreign ones. On the other hand, Knight et al. (1996) and Looney (1997) show that military spending is a constraint for economic growth at least because it obstacles the use of government spending for civilian sector more productive in stimulating economic growth (peace dividend hypothesis).

From a neoclassical perspective, the effect of government spending mainly depends on the productivity of the sector compared to the civilian one and on the amount of resources allocated to it through taxes. These effects produce non-linearities in the relationship between public spending and economic growth. A large body of empirical literature, taking cue from Barro (1990) and Devarajan et al. (1996), has

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confirmed the existence of non-linearities when total government spending is analyzed (Devarajan et al., 1996; Mittnik & Neumann, 2003), even if Mittnik & Neumann (2003) show that it is not possible *a priori* to extend this result to the of components of government expenditure. Indeed, this condition holds only when the government component is productive, since in line with Barro (1990) and Devarajan et al. (1996), unproductive public expenditures only affect the welfare level of the representative household, but have no effect on economic growth. d'Agostino et al. (2011) apply this framework using post World War II U.S. data and find that military sector is "productive" and non-linear related to economic growth.

Taking cue from this literature, the present paper contributes to the endogenous growth literature by showing that when external security levels in a given country are not constant over time, military burden has a further positive impact on growth, independently from complementarities with the private productive sector. Military burden stimulates economic growth through a greater perception of security of consumers, which does not constraint consumption. The empirical analysis, drawn on a unique dataset from 1960 to 2009 for Italy, identifies external security by the amount of resources devoted by the defense sector to finance overseas peacekeeping and humanitarian missions.

The results indicate no complementary effects on private productive sector, although the reduction of the external threat seems to stimulate growth. We show that, especially after the end of the Cold War, Italian participation in terms of budget of government to the peacekeeping and humanitarian missions is positively linked to economic growth.

The organization of the paper is as follows. Section 2 sets up the analytical framework to analyze the relationship between military spending and economic growth, whereas an historical overview of the defense budget and sources for Italy are presented in Section 3. Section 4 provides the main findings of the analysis and Section 5 concludes the paper through the suggestion of policy implications.

2. Theoretical framework

In this section, we setup an endogenous growth model to characterize the relations among military sector and the rate of economic growth. The proposed model is an extension of the ones proposed by Barro (1990); Devarajan et al. (1996) and d'Agostino et al. (2011, 2012).

Consider an economy consisting of a representative household and government producing a single composite commodity which can be accumulated as capital, consumed or paid as an income tax. Government provides the entire amount of public spending, namely total government spending G_t. In turn, G_t can be decomposed into government spending functional components namely military spending g_{1t} and civilian spending g_{2t}. Total government spending and its functional components are linked by the following rule:

$$G_t = g_{1t} + g_{2t} \tag{1}$$

which states that government allocates public sources to each sector in such a way to maintain budget constraint, and any change in the allocation mechanism in one sector also influences the amount of resources to the other ones (from now on additivity Assumption).

Let us assume that military spending enters into both the representative household utility function and into the production function, whereas civilian spending enters only into the production function. Shieh et al. (2002) argue that when the households set his preferences in such a way to maximize his utility, also security needs which depend on his perception of the internal and external threat levels in the country will be taken into account. Therefore, in the maximization process he will need a given amount of military spending which guarantees to the household its maximum utility. However, as argued by Barro (1990), military sector may also show complementary effects to private investments through *R&D*, infrastructures, and human capital. Since military sector may have a doubled impact on economic growth, depending on whether it is introduced into the production or in the utility function, we include in the model the assumption that household's preferences are affected by security. Formally:

A1: Let us assume that internal threat is constant. We identify the external threat by the inverse of military spending in overseas peacekeeping and humanitarian missions. This implies that security of households is inversely linked to external threat.

The assumption is in accordance with the findings by Polachek & Seiglie (2007) in which the stability of neighboring countries becomes crucial for the economic performance of the home country. In the Italian context the perception of security becomes more marked given the persistent instability and conflicts of many countries in the Mediterranean region, such as Bosnia-Herzegovina (1995-2002), Yugoslavia (1992-1995) or, more recently, Egypt, Libya and Tunisia.

2.1. The household maximization framework

Given the structure of government, the representative household derives his utility from private consumption per worker c_t and military spending g_{1t}. By using a CES utility function of the form $U(c_t, g_{1t}) = \left[(c_t g_{1t}^{\eta})^{1-\sigma} - 1\right] / 1-\sigma$, the objective of the household is to maximize the discounted sum of future instantaneous utilities:

$$U = \int_0^{\infty} \frac{\left[(c_t g_{1t}^{\eta})^{1-\sigma} - 1\right]}{1-\sigma} e^{-\rho t} \tag{2}$$

where $c_t = C_t/L_t$ is the consumption rate per-worker and ρ is the subjective discount rate. In (Shieh et al., 2002), η measures the impact of government services on the welfare of the household even if, alternatively, it can measure the effectiveness of services provided by the government (d'Agostino et al., 2011); σ describes the inverse of the elasticity of intertemporal substitution between private consumption and military spending.

The representative household is bounded at any instant of time by a private capital accumulation constraint, which is a function of private capital per-worker, k_t, military spending, g_{1t} and civilian spending, g_{2t} and is given by:

$$\dot{k} = (1-\tau) A k_t^{1-\alpha-\beta} g_{1t}^{\alpha} g_{1t}^{\beta} - c \tag{3}$$

where τ describes the tax rate. The production function, characterized by a Cobb-Douglas functional form, is given by:

$$y_t = A k_t^{1-\alpha-\beta} g_{1t}^{\alpha} g_{1t}^{\beta} \tag{4}$$

where y_t is the output per-worker. In such framework, the government is assumed to collect income tax revenues τy_t to finance total spending G_t, distributing them among military and civilian sectors. Denoting by θ and $1-\theta$ the fraction of resources devoted to each public sector, we have that:

$$G_t = \tau y_t = g_{1t} + g_{2t} \tag{5}$$

$$\frac{\dot{g}_1}{g_1} = \theta G_t = \theta\tau\frac{y_t}{g_{1t}} \tag{6}$$

$$\frac{\dot{g}_2}{g_2} = (1-\theta)G_t = (1-\theta)\tau\frac{y_t}{g_{2t}} \tag{7}$$

where equation 5 states the government budget constraint which is balanced by the government at any instant of time, and equations 6 and 7 describe the linkage between military and civilian spending and the amount of resources devoted to each public sector. Equations 6 and 7 allow for an accumulation process of public resources in each public sector, and it is proportional to production output y_t. This model formulation differs from the ones proposed by Barro (1990) and Devarajan et al. (1996) since these models suppose that all the allocated spending must be consumed at the end of each period, not allowing for an accumulation process of public resources in each sector. On the contrary, this model formulation is in line with Shieh et al. (2002) since, using equations 6 and 7 with $g_{10}/g_{20} = \theta/1-\theta$, we have the following relation between g_{1t} and g_{2t}:

$$\frac{g_{1t}}{g_{2t}} = \frac{\theta}{1-\theta} \tag{8}$$

2.2. The market solution

Given the previous framework, the representative household chooses private consumption so as to maximize the discounted sum of utilities (2), subject to (3), given initial private capital k_0. We only look the market solution of the household optimization process. This means that the household is not able to choose the optimal amount of public goods to consume or to use within the entrepreneurial activity, but to consider them as given. The resultant growth equation is then given by:

$$\gamma = \frac{\dot{c}}{c} = \frac{1}{\sigma}\left[(1-\sigma)\eta g_{1t} + (1-\tau)(1-\alpha-\beta)\frac{y_t}{k_t} - \rho\right] \tag{9}$$

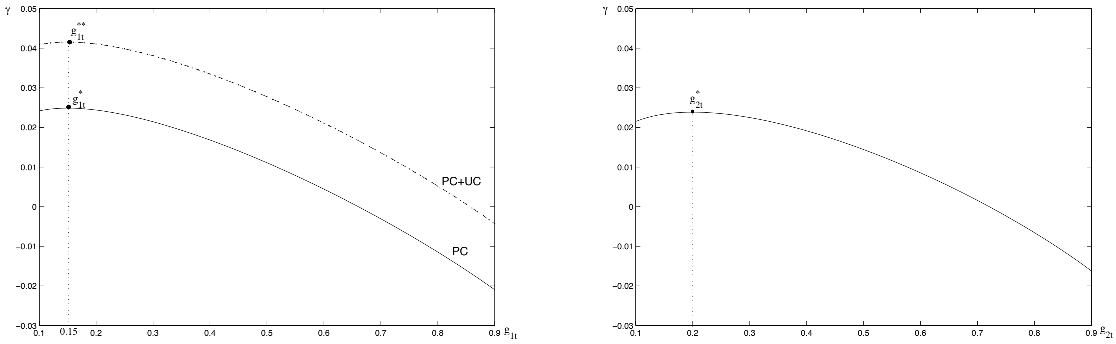
Equation (9)[1] is composed by two different parts: i) $(1-\sigma)\eta g_{1t}$ which accounts for the impact of military spending through the utility function, and ii) $(1-\tau)(1-\alpha-\beta)\frac{y_t}{k_t}$ describing the link among g_{1t} and g_{2t} and private capital k_t in the production function y_t. In more detail, the first part of equation (9) describes the linear link between military spending and economic growth performance depending on the household security perception. As it is clear from the equation, when the inverse of the elasticity of intertemporal substitution between private consumption and military spending σ is equal to 1, this term becomes zero. The restricted model can be written when external threat in a given country remains constant over time, and consequently the representative household will be indifferent to consuming an additional unit of military spending or private consumption. When this hypothesis holds, this model

[1]From a mathematical point of view, the first part of equation 9 is obtained by using equations 6 and 8.

formulation converges to the one proposed by d'Agostino et al. (2011, 2012); that is:

$$\gamma = \frac{\dot{c}}{c} = \frac{1}{\sigma}\left[(1-\tau)(1-\alpha-\beta)\frac{y_t}{k_t} - \rho\right] \tag{10}$$

Figure 1: Specification of the endogenous growth models



Notes: Notes: the graph adopts: $\rho = 0.02, A^{1/\beta} = 0.113, \alpha = 0.75, \beta = 0.75$, and $\sigma = 0.7$. In left panel, the dash line describes growth rate behavior from the proposed model (9) for g_{1t} following equation (10). On the right panel, it is described growth rate behavior for g_{2t}.

Figure 1 describes the behavior of the growth equations (9) and (10) for different amounts of resources devoted to military (g_{1t}) and civilian (g_{2t}) sectors. In the left panel, the dash line describes the growth rate behavior of the model (9), whereas the continuous line accounts for the ones in 10. Since civilian spending does not enter into the utility function, the right panel shows only its link with the growth rate in the production function which coincides in (9) and (10). From the Figure, we depict two important considerations. First, the models predict a non linear relationship between military (civilian) spending and economic growth, allowing either for positive or negative links. In particular, if the relative shares of public expenditure devoted to each good are below their relative output elasticities, shifts in the mix toward a given good increase the economy long-run growth, whereas the relationship is negative in the opposite case. Second, as showed in the left panel, the linear effect of military spending increases growth rate from g^*_{1t} to g^{**}_{1t}, given by the reduction of external insecurity when government spends on military activities.

Finally, when we restrict the proposed model to determine the optimum allocation of total government spending allocated among public sectors, it converges to the Barro's (1990) endogenous growth model. When the share of government spending on the GDP growth rate is found to be at the optimum, this becomes the whole amount of resources to be allocated around military and civilian sectors. Formally:

$$\gamma = \frac{\dot{c}}{c} = \frac{1}{\sigma}\left[(1-\tau)\left(\frac{G_t}{k_t}\right)^{\alpha} - \rho\right]. \tag{11}$$

Following this model formulation the optimal amount of total government spending G_t is now a function of its relative share compared to private capital and of its productivity level.

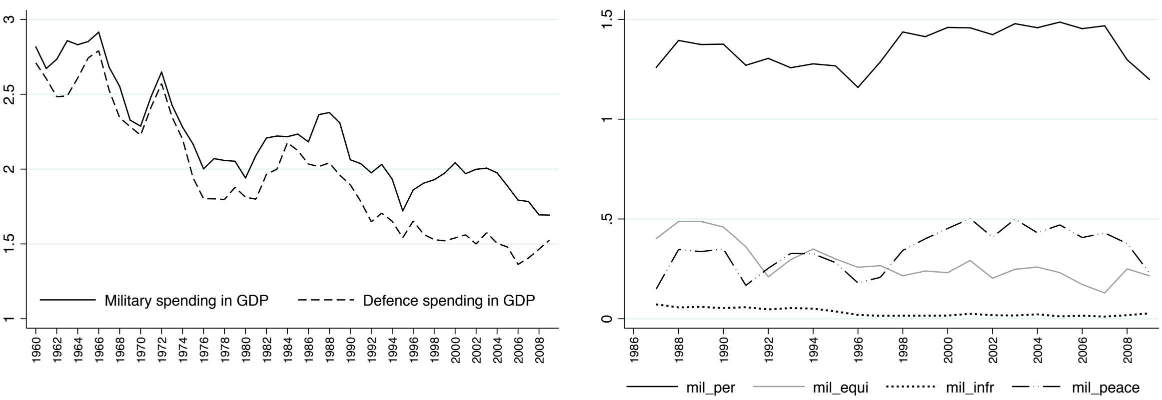
3. Data

3.1. Concepts, definitions and patterns of military sector in Italy.

In Italy, competences and expenditures in the military sector are shared among Defense Ministry, Ministry of Economy and Ministry of Economic Development. This has determined different classifications of the defense function (Nascia & Pianta, 2009). In particular, one is built according to the NATO definition, while another is based on the Italian Defense ministry. The first classification includes all current and capital expenditure on armed forces, peacekeeping forces, Defense Ministry and other government agencies engaged in defense projects, paramilitary forces available for military operations and military space activities[2]. Instead, the classification of the Italian Defense ministry budget does not include the expenses for peacekeeping missions relative to interdepartmental programs and some of the costs of the paramilitary forces used for public security as police forces.

Following these classifications, we define military spending in the first case and extract data from the annual compendium of financial, personnel and economic data published by NATO whereas we define defense spending in the second case and extract data from the Annual General Report of Italian Government.

Figure 2: Patterns of military and defense burdens and their functional components



Notes: Military spending is extracted by the annual compendium of financial, personnel and economic data published by NATO whereas, defense spending is extracted by the Italian Government General Report of Cash Flow, 1960-2009. Both these variables are expressed as ratio of per-capita GDP. The right panel of the graph reports the percentage shares on GDP of military equipment (mil_equi), infrastructure (mil_infr), personal (mil_per) and peacekeeping missions (mil_peace). The variables are extracted by the annual compendium of financial, personnel and economic data published by NATO.

Figure 2a reports patterns of military (mil_t) and defense (def_t) spending as share in GDP between 1960 and 2009. As showed by the figure, it is possible to characterize the behavior of these two series by three main phases. The first, from 1974-1975, is determined by a change in public policy, producing a sharp decrease in military spending of 3.6%, due mainly to a reduction of military investments. The

[2]The areas of defense sector cover a large variety of expenditure including: i) personnel, relating to the costs incurred for salaries and allowances of military and civilian personnel, and for the treatment of provisional pensions of military personnel; ii) maintenance, relative to the costs necessary to ensure the functionality and efficiency of the military like training costs, preservation of materials and infrastructure; iii) investment, relative to the costs required to improve the effectiveness of the military, like expenses for modernisation and renewal of operational resources, technical support, logistics, infrastructure, research and development. This aggregation does not includes civil defense, current expenditure for previous military activities, veteran benefits, demobilization, conversion of arm production facilities and destruction of weapons.

rise in oil prices has justified an expansion of non-military public spending to reduce social emergencies generated by the World economic crisis, substituting the expenditures for military sector. The second phase, during the eighties, is characterized by a new cold war and a policy in line with the United States, which led to a new period of growth in military spending. Both military and civilian spending grow on average at a rate of 5.8% and 5.6 %, respectively, whereas, for the first time, armaments play a significant role in the composition of military spending. This phase ends with the fall of the Berlin wall in 1989 and the dissolution of the Soviet union in 1991, which caused the subsequent end of the Cold War and a substantial reduction in expenditure commitments. As a consequence, military expenditure, from 1989 to 1995, decreased on average at a rate of 2%, while public spending remained stable. Starting from 1995, the third phase is marked by an overall reduction of government spending and, particularly, of military spending (about -5.6%). The decrease of military spending is alleviated increasing expenditures in peacekeeping and humanitarian missions, starting with the Balkan war, with the Italian participation in NATO air strikes against Serbia and the international missions in Kosovo, Afghanistan and Iraq.

We summarize the trends in military and defense spending in Italy through two main futures. First, the composition of military (or defense) spending has not been stable along the period, with decreasing behaviors during the economic crises depicted, principally, by a reduction in armaments, without any significant variation in current expenditures (such as personnel spending). This predominance of current spending is showed in Figure 2b, where we report the percentage shares on GDP of military equipment (mil_equi), infrastructure (mil_infr), personal (mil_per) and peacekeeping missions (mil_peace). Second, the expenditure increases in peacekeeping and humanitarian missions generate in the recent period discrepancies between military and defense expenditures. In particular, these differences are important for Italy during the period 1996-2003 (on average 25% of military spending) when Italy has been involved in NATO and UN interventions[3].

3.2. Other variables

To complete the model, total government spending gov_t is extracted by the source "Italian Government Cash Flow". This variable includes all current expenditures for goods and services (including the compensation of employees). It also accounts for all the expenditures for government capital formation and on national defense and security, but excludes all the expenditures for interest rates on public debt. Two important remarks are necessary. gov_t considers the expenditures of the ministries and so its composition may slightly change during the considered time span. However, this aspect does not influence the results when we consider the aggregate variables. Secondly, since in 1975 gov_t includes also National Health Services, extended by law to all citizens and the amount of social pensions. This further accounting may produce a structural break in the series that have to be considered in the empirical analysis. For this purpose, we construct a shift dummy ($d1975$), which is equal to 1 from 1975 on, that accounts for an intercept shift due to National Health Services and the amount of social pensions. We also include in the model specification an impulse dummy variable to account for the effect of the 2008 economic crisis ($d2008$).

[3]Following the Stockholm Institute of Peace Research (SIPRI), Italy has been involved into 11 peacekeeping missions between 1948 and 1990, whereas they more than doubled between 1990-2010.

4. Econometric framework

This section provides a discussion of the empirical investigation from equations (9), (10) and (11). However, before presenting the mathematical derivation of these models, we illustrate the test for the presence of non-linearities into the proposed growth models.

4.1. The non-linearity test

We start considering a non linear AR(p) model where we allow both for $I(0)$ and $I(1)$ time series x_t, $t = 1, ..., T$. Following Vogelsang (1998), we can apply a modified test statistic whose asymptotic null critical value are the same in both case. Harvey & Leybourne (2007) make empirically tractable the test by including non-linear functions $f(x_{t-1}, \theta)$ and $f(\Delta x_{t-1}, \theta)$. By considering a general case which allows AR(p) specification, the model is written as,

$$\begin{aligned} x_t &= \mu + v_t \\ v_t &= \lambda_1 v_{t-1} + \lambda_2 v_{t-1}^2 + \lambda_3 v_{t-1}^3 + \lambda_5 \Delta v_{t-1}^2 + \lambda_6 \Delta v_{t-1}^3 + \sum_{j=1}^{p} \lambda_{4,j} \Delta v_{t-j} + \varepsilon_t \end{aligned} \quad (12)$$

with $\varepsilon_t \sim IID(0, \sigma^2)$. As shown in Kapetanios et al. (2003), the reduced form of the non-linear model can be obtained recursively and written as,

$$x_t = \delta_0 + \delta_1 x_{t-1} + \delta_2 x_{t-1}^2 + \delta_3 x_{t-1}^3 + \delta_5 \Delta x_{t-1}^2 + \delta_6 \Delta x_{t-1}^3 + \sum_{j=1}^{p} \delta_{4,j} \Delta x_{t-j} + \varepsilon_t \quad (13)$$

where $\sum_{j=1}^{p} \beta_{4,j} \Delta x_{t-j}$ is the additional serial correlation that enters linearly in the equation (13). A Wald test under linearity is implemented from the residuals of this fitted model and the residuals obtained from the following restricted model,

$$x_t = \pi_0 + \pi_1 x_{t-1} + \sum_{j=1}^{p} \gamma_j \Delta x_{t-j} + \varepsilon_t. \quad (14)$$

As proved by Harvey & Leybourne (2007), we can also test the hypothesis of non-stationarity $\pi_1 = 1$ in the restricted model (14) by a t-statistic that is derived from a transformation of the Dickey Fuller statistic. A summary of the Harvey-Leybourne test is presented in Table 1.

Furthermore, under the hypothesis that government spending is nonlinear and stationary, we write a smooth transition autoregressive (STAR) model of the continuous transition variable s_t in order to estimate the effects of government spending components on economic growth. The general framework is given as,

$$y_t = \phi' z_t + \theta' z_t G(\eta, c, s_t) + u_t \quad with \quad u_t \sim iid(0, \sigma^2) \quad (15)$$

where z_t is a vector of explanatory variables and $\phi = (\phi_0, \phi_1 ...., \phi_m)'$ and $\theta = (\theta_0, \theta_1 ...., \theta_m)$ are $((m + 1)x1)$ parameter vectors of the linear and nonlinear part of the model, respectively. The transition function $G(.)$ is a bounded function of the continuous transition variable s_t, the slope parameter η and the vector of location parameters, $c = (c_1, ...c_k)$. Following Lutkepohl (2004), a sequential strategy

Table 1: Summary of hypotheses tests

Harvey-Leybourne test	
$H_1 : \delta_2, \delta_3, \delta_5, \delta_6 = 0$	Linear AR(p) process
$H_2 : \pi_1 = 1$	Stationary AR(p) process
Granger-Teräsvirta test	
$H_{01} : \beta_1 = \beta_2 = \beta_3 = 0$	Linear model selection.
$H_{02} : \beta_1 = 0 \vert \beta_2 = \beta_3 = 0$	$LSTR(1)$ with one transition variable and one regime change.
$H_{03} : \beta_1 = 0 \vert \beta_2 = 0$	$LSTR(2)$ with one transition variable and two regime changes.
$H_{04} : \beta_3 = 0$	$EXPAR$ where transition states are more than two.

Notes: The Harvey-Leybourne (2007) test has for H_1 is based on the Wald statistic, which has χ^2-distribution with four degrees of freedom. The stationarity hypothesis H_2 is based on a augmented Dickey-Fuller statistic (ADF-test), with t-distribution. The Granger-Teräsvirta (1993) test is based on F-statistic, with $3m$ and $T - 4m$ degrees of freedom.

for testing the non-linear function is derived using the logistic smooth transition (LSTR) model. A third-order Taylor expansion around the hypothesis $\eta = 0$ means the following specifications can be identified[4]:

a) asymmetric behavior in the hypothesized relationship (i.e. one change in the growth-government spending function, model LSTR(1));

b) a process with heterogeneous dynamic properties between both large and small values of and central values (model LSTR(2));

c) an Exponential Autoregressive model (EXPAR), an alternative of LSTR(2) when η is not close to zero (Granger & Teräsvirta, 1993).

Going back to the theoretical framework, the assumption of additive government expenditure components means that the share of government spending in GDP can be used as the predetermined transition variable. Methodologically, this implies distinguishing between two different cases depending on the inclusion or exclusion of the transition variable from z_t. When the nonlinear relationship uses total government spending as in equation (11), the transition variable is incorporated in z_t, giving the auxiliary regression:

$$y_t = \beta_0' z_t + \sum_{j=1}^{3} \beta_j' \tilde{z}_t s_t^j + u_t^* \qquad (16)$$

where the parameterization yields a vector $z_t = (1, \tilde{z}_t)$, in which $\tilde{z}_t$ is a $(mx1)$, and $u_t^* = u_t + R_3(\eta, c, s_t)\theta' z_t$ where the residual is $R_3(\eta, c, s_t)$. For other growth model specifications, the size of the total government spending in GDP transition variable is not an element of z_t and the empirical specification is given as:

$$y_t = \beta_0' z_t + \sum_{j=1}^{3} \beta_j' z_t s_t^j + u_t^* \qquad (17)$$

The null hypothesis of linearity $\beta_1 = \beta_2 = \beta_3 = 0$ is then tested against the alternative hypotheses shown in Table 1 using the strategy described above. The nonlinear model yields one choice among the available nonlinear specifications by the p-value. If the test gives the strongest rejection, the efficient

[4]A summary of the Granger-Teräsvirta test is presented in Table 1.

nonlinear models have to be LSTR(2) or EXPAR specifications, while if the p-value is greater than the usual 5% or 10%, the LSTR(1) model is not rejected.

4.2. Estimation issues of STAR models

From equation (15), with a transition variable and one regime change, the specification of the dynamic model can be estimated by defining z_t as a vector that includes the lagged values (p) of the endogenous and exogenous variables. The specification of the vector z_t depends on the type of public spending we have analyzed. When the estimation of the Barro's model is approached, we define $z_t = (1, \gamma_{t-h}, inv_t, G_{it-h})$ and the resulting STAR specification becomes:

$$\gamma_t = \phi_0 + \phi_1\gamma_{t-1} + ... + \phi_p\gamma_{t-p} + \phi_{p+1}inv_t + \theta_1 G_{t-1}(G_t) + ... + \theta_p G_{t-p}(G_t) + \mu_t, \tag{18}$$

with γ_{t-h} the lagged per-capita GDP growth rates, inv_t the fitted share of private investment in GDP and G_{t-h} the share of total government spending in GDP. Moreover, when we consider military (mil_t) and non-military (non_mil_t) burden, we can define $z_t = (1, \gamma_{t-h}, inv_t, mil_{t-h}, non\_mil_{t-h})$ and the STAR model as:

$$\begin{aligned}\gamma_t &= \phi_0 + \phi_1\gamma_{t-1} + ... + \phi_p\gamma_{t-p} + \phi_{p+1}inv_t + \theta_1 mil_{t-1}(G_t) \\ &\quad + ... + \theta_p mil_{t-p}(G_t) + \theta_{p+1} non\_mil_{t-1}(G_t) + ... + \theta_{2p} non\_mil_{t-p}(G_t) + \mu_t\end{aligned} \tag{19}$$

whereas, when we consider defense (def_t) and non-defense (non_def_t) burdens, we can define $z_t = (1, \gamma_{t-h}, inv_t, def_{t-h}, non\_def_{t-h})$ in order to have a specification given by:

$$\begin{aligned}\gamma_t &= \phi_0 + \phi_1\gamma_{t-1} + ... + \phi_p\gamma_{t-p} + \phi_{p+1}inv_t + \theta_1 def_{t-1}(G_t) \\ &\quad + ... + \theta_p def_{t-p}(G_t) + \theta_{p+1} non\_def_{t-1}(G_t) + ... + \theta_{2p} non\_def_{t-p}(G_t) + \mu_t\end{aligned} \tag{20}$$

Hence, once the transition variable s_t and the transition function $G(\eta, c, s_t)$ have been selected, we can approach the estimation of the parameter vector $\Theta = (\phi', \theta', \ \eta, \ c)$ in the STAR model (15) through nonlinear least square [NLS]. Under the assumption that the errors u_t are normally distributed, the NLS is equivalent to the maximum likelihood. Issues deserving particular attention in the estimation include the sum of squares function, the choice of starting values for the parameters and the estimation of the smoothness parameter η in the transition function (van Dijk et al., 2002). In particular, it is difficult to obtain very accurate estimate of the smoothness of the transition between the two regimes characterized by η, when the parameter is large. This is due to the fact that for such large values of η, the STAR model is similar to a threshold model, and the transition function comes close to a step function. To obtain accurate estimates of η, one then need many observations in the immediate neighborhood of c, since in this case even large values of η have a small effect on the shape of the transition function. The choice of the parameters η and c is then made through a graphical analysis of the latter parameters in the minimization of the square function (van Dijk et al., 2002).

4.2.1. *Post-estimation tests for the STAR model*

The adequacy of the estimates through the STAR model is subjected to a number of misspecification tests. These evaluations are carried out through tests of no-residual autocorrelation, no remaining nonlinearity and parameter constancy. Eitrheim & Terasvirta (1996) develop LM-type tests for these three hypotheses in the basic two-regime STAR model. In this context, the tests of no remaining nonlinearity and parameter constancy can be interpreted as tests against the alternatives of a multiple regime STAR model.

In detail, the non-residual autocorrelation test measures the serial independence of the error term u_t by using the skeleton of Equation (15) (van Dijk et al., 2002). The resultant statistical test is asymptotically distributed as a χ^2 with q degrees of freedom corresponding to the lags of the error term which are considered. This test is a generalization of the linear LM test statistic of non-residual autocorrelation. The test for absence of non-linearity uses the same structure described in the last part of Section 4.1 and is based again on a third-order Taylor expansion of equation (15). The resultant test statistic has an asymptotic χ^2 distribution with $3m$ degrees of freedom. Finally, the parameter constancy in the two-regime STAR model, against the alternative of smoothly changing parameters is taken into account. The appropriate LM-type test statistic based on a third-order Taylor approximation has the same asymptotic distribution of the previous test statistic.

4.3. *The linear autoregressive model*

Following Chen (1993) and van Dijk et al. (2002), we can characterize the autoregressive model AR as a restricted version of the STAR model (as in Equation 15) under the assumption that the transition function $G()$ is constant over time. Since we are interested in analyzing the impact of military sector (i.e., military spending or defense spending) on growth also through its impact on the utility function (described by the first part of Equation 9), we specify an AR(p) of military burden, defense spending in GDP and a disaggregation of military spending, in particular the expenditures in peacekeeping and humanitarian missions (mil_peace_t). In according to the previous formulations, we define a partitioned vector $W_t = [mil_t;\ def_t;\ mil\_peace_t]$ so that the AR(p) model is specified as:

$$\gamma_t = a_0 + a_1\gamma_{t-1} + ... + a_s\gamma_{t-s} + a_t inv_t + b_1 W_t + ... + b_s W_{t-s} + \epsilon_t,\ with \epsilon_t \sim iid(0, \sigma^2) \tag{21}$$

It is important to stress that, since in the first part of Equation (9), which is related to the effect on household of a greater security, enters only military or defense spending, but not the civilian counterparts as in (20), we do not need to maintain in this context the additivity assumption. This means that we are able to account for the impact of expenditures in the defense function, excluding from the analysis the other ones. The accuracy of the model specification is still proved by an LM-type test for a non remaining auto-correlation and by a LM-type test for normality in the error term.

5. Results

According to the empirical framework, we present the main findings applied to the Italian economy. A preliminary analysis serves to extract the most appropriate model specification. Since the additivity condition is hold with respect to total government spending, the results of the preliminary analysis are valid for military or defense spending, and for its functional government components of expenditure.

Table 2: Results of the AR(1) model for GDP growth rate.

	I		II	
γ_{t-1}	-0.448	***	-0.362	***
	(0.129)		(0.106)	
d_inv_t	1.718	***	1.393	***
	(0.233)		(0.199)	
gov_{t-1}	-0.002		-0.026	
	(0.032)		(0.026)	
Constant	8.904	***	8.908	***
	(1.208)		(0.977)	
Trend	-0.178	***	-0.153	***
	(0.022)		(0.019)	
$d1970$			-4.583	***
			(1.093)	
$d2009$			-3.505	***
			(1.142)	
R^2	0.743		0.832	
adjusted R^2	0.719		0.808	
LM-test for residual autocorrelation (1 lag)	0.002 (0.959)		0.046 (0.828)	
Normality test	0.002 (0.959)		0.003 (0.962)	

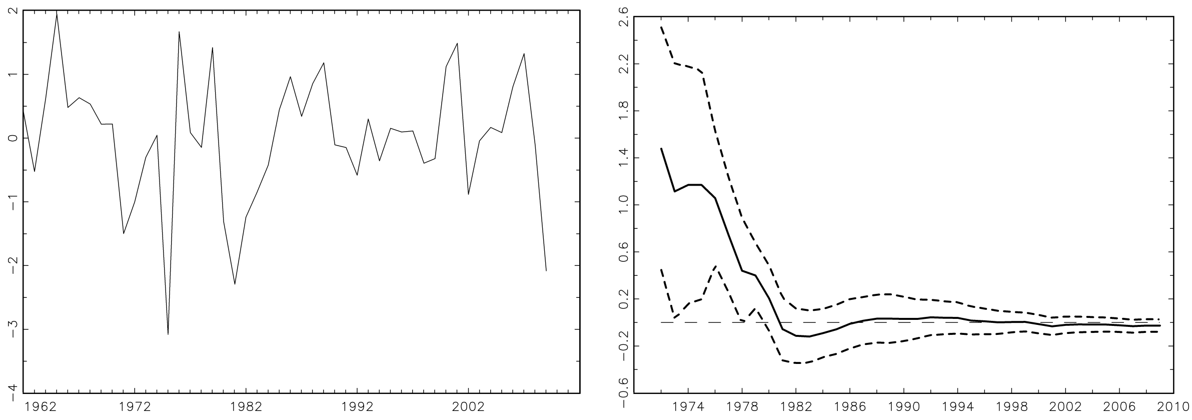
Notes: The table reports the estimation results from the conditional AR(1) model for growth rate in GDP. In parenthesis, we report the standard errors, while the asterisks stand for the p-value significance levels. We have that * $p < 0.1$,** $p < 0.05$,*** $p < 0.01$.

Table 2 reports the results from the AR(p) model with one lag in endogenous and exogenous variables[5]. The first column of Table 2 includes the benchmark model formulation, where we have excluded the deterministic components, whereas the second column introduces the dummy variables accounting for the recent economic crisis and for the intercept shift after the inclusion of welfare reform in 1975. The inclusion of these deterministic components stabilizes the standardized residuals as shown in the first panel of Figure 3.

Table 2 shows that all the variables except for total government spending are significant with the expected signs, whereas all the deterministic components contribute to variance reduction. The non-significance of total government spending may be in line with the expectations, since the linear model formulation does not take into account the presence of two opposite regimes, depending on the initial amount of resources allocated to public sector and the relative productivities of total government spending compared to the one of private investments (see section 2). This result is clarified by panel b of Figure 3, where we report recursive estimations for total government spending, along with bootstrapped standard

[5]Lag selection, not reported, is based on Akaike Information Criterion (AIC), Final Prediction Error (FPR), Hannan-Quinn Criterion (HQC), Schwarz Criterion (SC). All the proposed selection criteria suggest an optimal number of lags for the endogenous and exogenous variables equal to 1. Since private investment inv_t does not reject the assumption of unit-root (as described in Table 3), in the estimations we use this variable in first difference.

Figure 3: Patterns of standardized residuals and recursive estimations



(a) Standardized residuals

(b) Recursive estimation of *gov* parameter

Notes: Panel a) shows the standardized residuals from the estimation of the first column of Table 1, whereas panel b) shows recursive estimations for total government spending, based on the estimations of column II.

errors. As showed by the figure before the 80's, where the amount of resources allocated to public sector were lower, we have a positive impact of total government spending of economic growth of GDP, whereas, after that period, the parameter swings around the zero. This suggest that the instability of the estimated coefficients may explain the negative sign of gov_{t-1} in both columns of Table 2.

Given the deterministic structure of the model and the optimal lag structure, Table 3 lists the unit root[6] and the non-linear tests for each series, along with Granger-Teräsvirta test for each growth equations (19), (20) and (21). The specifications proposed for Granger-Teräsvirta test uses time trend and dummy variables accounting for 1975 structural break and 2008 economic crisis in the linear part of the model. The upper part of Table 3 (columns 2 and 3), shows that the null hypothesis of a unit root is accepted when we analyze private investments, whereas military and defense expenditures are stationary when we include a trend into the estimations. Moreover, from columns 4 and 5, we show that the Harvey & Leybourne (2007) test rejects the linearity hypothesis only when total government spending gov_t ($p-value$ of 0.092), non-military spending non_mil_t ($p-value$ of 0.073), and non-defense spending non_def_t ($p-value$ of 0.063) are considered. All the remaining variables, including military and defense spending accept the null hypothesis of linearity. On the contrary, the Granger-Teräsvirta test (lower part of Table 3) suggests a non-linear specification of the proposed models[7] considering both total government spending and military/non-military and defense/non-defense aggregations. These results appear to be not in line with our theoretical framework when military and defence spending are considered, since the Harvey & Leybourne (2007) test does not reject the non-linearity hypothesis for military and defense spending. Here, we suggest an explanation for these results. That is, even if military and defense spending are, at least in Italy, classified unproductive, it does not exlude an effect of these variables through the utility function, a mechanism that may be responsible for a significant impact on

[6]It is important to stress that the hypothesis of stationary is a necessary condition for testing a linear endogenous growth model against a non-linear model specification

[7]Taking into account a linear model as benchmark specifications, there is a strong evidence for the presence of non-linearities. The results show that the null hypothesis of linearity (H_{01} hypothesis) can be rejected in favor of the alternative hypothesis for every specification. Within the group of non-linear specifications, the LSTR(1) specification is always selected, as linearity is rejected most strongly for this form of non-linear model (H_{02} hypothesis).

Table 3: Preliminary tests non-linear model formulation

a	Non-linearity tests for single variables (Harvey-Leybourne test statistic)		Unit root test		Non-linearity test	
			$coefficient$	$p-value$	$coefficient$	$p-value$
	Growth rate of GDP	γ_t	25.474	0.000	18.932	0.000
	Share of private investment in GDP	inv_t	-1.287	0.635	3.566	0.058
	First difference of the share of private investment in GDP	Δinv_t	-4.402	0.000		
	Total government spending in GDP	gov_t	2.489	0.098	2.460	0.092
	Military spending in GDP	mil_t	1.764	0.190	2.8576	0.581
	Military spending in GDP*	mil_t	8.283	0.006		
	Non-military spending in GDP	non_mil_t	2.415	0.096	3.196	0.073
	Defense spending in GDP *	def_t	1.980	0.166	2.452	0.345
	Defense spending in GDP	def_t	8.793	0.004		
	Non-defense spending in GDP	non_def_t	2.346	0.940	3.430	0.063

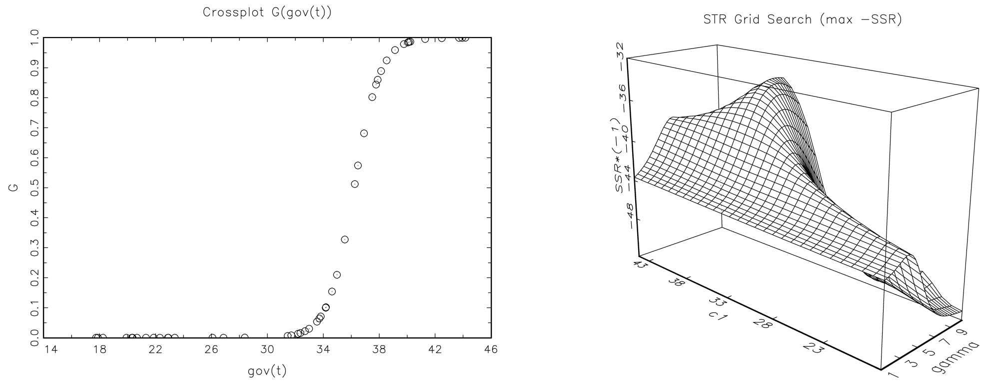
b.	Non-linearity F-tests for model specification, Granger-Teräsvirta test ($p-value$)	H_{01}	H_{04}	H_{03}	H_{02}	
I	Total government spending	0.027	0.080	0.214	0.046	LSTR1
II	Military and non military spending	0.014	0.028	0.588	0.022	LSTR1
III	Defense and non-defense spending	0.042	0.135	0.158	0.076	LSTR1

Note: In this Table we report the linearity test for the government expenditures and its functional components by Harvey & Leybourne (2007) test. Granger & Teräsvirta (1993) test shows the strategy for selecting the model. F-statistic values are reported for each of the four hypotheses. The asterisks (∗) show that the linearity hypothesis for the Granger & Teräsvirta (1993) test are not rejected at the 5% level. ∗∗ Coherently with the non-linear models of the Table1, we report the values of the specification where the government component is the share of non-military spending in GDP. Because we use as transition variable the share of total government, the additivity condition with the share of military spending in GDP determines the same F-test results of the model II.

growth. Indeed, since in the analysis of the non-linear part of equation (9) the additivity assumption should be hold, we are not able to test (through the Granger-Teräsvirta test) each series separately. As a consequence, since non-military and non-defense spending are predominant burdens, the acceptance of non-linearity assumption in Granger-Teräsvirta test may be driven by these variables which account for more than 95% of total government spending on average. Furthermore, the Granger-Teräsvirta test suggests a LSTR(1) model specification when total government spending is used as a transition variable, for each proposed specifications.

Before presenting the main results from estimations through LSTR(1) models, Figure 4 introduces the negative of the sum of squares function $Q_T(\eta, c)$ and the transition function versus the transition variable g_t (in our case total government spending), which are used to set the initial values of parameters c, η in the LSTR(1) estimations (van Dijk et al. (2000)). We recall that, parameter c determines the transition point where the shape of the function changes, whereas η describes the transition speed. The panel b of the figure shows that for fixed values of c the sum of squares of the Q_T function is not flat in the direction of η. As a consequence, also for large values of η, the value of the logistic transition function changes from 0 to 1 almost instantaneously at c, and the large changes in η have only little

Figure 4: Logistic Smooth Transition model preliminaries



(a) Transition function versus g_t (b) Negative of the sum of squares function $Q_T(\eta, c)$

effect on the shape of the function (see section 4). This outcome suggests that our estimation results remain robust also for large values of η.

Smooth transition regression (LSTR(1)) estimates are presented in Table 4. The first column of the table reports the estimation for total government spending whereas, in the last two columns, are reported the estimates for military/non-military and defense/non-defense, respectively. At the bottom of the table, we present the diagnostic of estimation. As a first outcome, from all the columns of the table, we find that the parameters of the linear part of the model (upper part of the table) are similar to the ones estimated in Table 1, and the deterministic components are still significant.

In particular, the estimations presented in Table 4 highlight three main results. First of all the optimal amount of total government spending, described by parameter c, is around 36% of GDP. This result seems reasonable for Italy where total government spending includes both social security and welfare spending and where the total government burden has reached values higher than 45% of GDP. This result does not change for each of the proposed models, showing that the additivity assumption is satisfied. Secondly, since in recent years total government spending in GDP has been lower the 36%, we have that gov_{t-1} has a positive impact on growth even if not so large (0.372). A similar outcome is found when non-military spending (0.343) and non-defense spending (0.361) are taken into account. This suggests that civilian spending has a behavior that follows the one of total government spending in Italy. Thirdly, as showed by column 2 and 3, military and defense spending have positive but not significant coefficients, confirming the Harvey & Leybourne (2007) test statistic. As a consequence, the estimations suggest that while total government spending and civilian spending have complementary effects on private investment, military and defense spending have to be considered as unproductive and variations in the latter variables are not able to impact on the growth rate of per-capita GDP in Italy. Hence, in line with a peace dividend hypothesis a shift of resources from military sector to civilian spending may be able to stimulate growth.

Table 5 shows the post estimation tests. The results do not highlight shortcomings concerning the proposed estimations. In particular, non-linearity tests suggest the absence of residual non-linearity after

Table 4: Estimation results of the Smooth Transition Regression model for government spending, military spending and defense spending

	I		II		III	
Linear part						
$Constant$	8.796	***	8.722	***	8.751	***
	(0.709)		(0.722)		(0.725)	
$Trend$	-0.157	***	-0.152	***	-0.153	***
	(0.020)		(0.023)		(0.023)	
$d1970$	-4.737	***	-4.789	***	-4.769	***
	(1.018)		(1.034)		(1.036)	
$d2009$	-3.004	***	-2.922	**	-2.985	**
	(1.134)		(1.133)		(1.128)	
γ_{t-1}	-0.386	***	-0.381	***	-0.384	***
	(0.100)		(0.100)		(0.100)	
$d.inv_t$	1.383	***	1.364	***	1.370	***
	(0.189)		(0.196)		(0.197)	
Non-linear part						
$Constant$	-15.785	***	-16.848	**	-16.537	**
	(5.364)		(6.801)		(6.585)	
η	8.595		6.813		7.330	
	(7.617)		(5.777)		(6.577)	
c	36.206	***	36.155	***	36.225	***
	(0.976)		(1.237)		(1.148)	
gov_{t-1}	0.372	**				
	(0.129)					
mil_{t-1}			1.341			
			(2.361)			
non_mil_{t-1}			0.343	**		
			(0.152)			
def_{t-1}					0.941	
					(1.997)	
non_def_{t-1}					0.361	**
					(0.142)	
Estimation diagnostic						
R^2	0.888		0.889		0.888	
adjusted R^2	0.890		0.891		0.891	
SD of transition variable	7.972		7.972		7.972	
SD of of residuals	0.949		0.959		0.960	

Note: The dependent variable is the per-capita growth rate in GDP. In parenthesis we report standard errors. The variables (η) and (c) are the estimated initial values for the maximum-likelihood estimation. At the bottom of the table are also listed several measures of estimation accuracy (Granger & Teräsvirta, 1993).

that total government spending is used to describe the transition in the LSTR(1) model.

Finally, Table 6 reports the main findings from the estimations of equation (9) as specified in equation (21). As previously, diagnostic estimation accuracy measures are reported at the bottom of the table. The first two columns of Table 6 account for military spending in the whole sample and in the sub-sample 1986-2009, the next two consider the same distinction for defense spending, whereas the last column proposes the estimates for peacekeeping and humanitarian missions (mil_peace_t), in the available period 1986-2009. The estimates use the same specification of Table 4.

As showed by the first two columns of the table, we find a strong positive effect of military spending on the growth rate. The magnitude of the coefficient of mil_{t-1} is about 2.5 percentage points and decreases when the estimation is carried out in the sub-sample 1986-2009 (about 1.8). On the contrary, when defense spending is taken into account, our estimations (column III and IV) do not give significant outcomes either for full or sub-sample estimates. These outcomes suggest that there is a positive impact within military spending of that part of expenditure devoted to peacekeeping and humanitarian missions which reduce the effects of external threats. This result is emphasized in column V, where the share of military spending in peacekeeping and humanitarian missions is analyzed. The column shows that

Table 5: Estimation checks for the Smooth Transition Regression model

Total government spending								
	Tests for $q-th$ order serial correlation							
q	1	2	3	4	5	6	7	8
$p-value$	0.259	0.135	0.279	0.236	0.283	0.389	0.107	0.040
	Tests for parameter constancy				Tests for remaning non-linearities			
$p-value$	0.212	0.309	0.422		0.512	0.060	0.925	0.236
Military and non-military spending								
	Tests for $q-th$ order serial correlation							
q	1	2	3	4	5	6	7	8
$p-value$	0.2038	0.1475	0.2999	0.2516	0.3074	0.4202	0.1591	0.0826
	Tests for parameter constancy				Tests for remaning non-linearities			
$p-value$	0.281	0.459	0.663		0.222	0.056	0.623	0.025
Defense and non-defense spending								
	Tests for $q-th$ order serial correlation							
q	1	2	3	4	5	6	7	8
$p-value$	0.2412	0.1511	0.3055	0.2142	0.2451	0.3612	0.1393	0.0626
	Tests for parameter constancy				Tests for remaning non-linearities			
$p-value$	0.151	0.277	0.575		0.409	0.023	0.061	0.265

Note: the Table reports the post-estimation test statistics from the STR model presented in Table 4. These tests statistics consider the autocorrelation in the residual, the constancy of the estimated parameters, and the absence of non-linearity after estimation, as described in section 4.2.1.

military spending in peacekeeping missions has a significant and large in magnitude coefficient close to the 3 percentage points.

6. Some concluding remarks and policy implications

This paper has investigated the effect of military sector on economic growth in Italy. The proposed analysis may serve to foster the debate on the role of military sector in the current society and contributes to the policy intervention aimed to increase the efficiency of government spending. By extending previous works on the optimal size of government expenditure, the proposed analytical framework explores how external threat affects the preferences of the representative household and, in turn, stimulates economic growth. The comprehensive model is then able to capture two different effects of military sector on economic growth, one depending on the complementarities with private investments and the share of government expenditure and one through a greater perceived security of consumers.

Post World War II Italian data are used to estimate nested non-linear growth models using time-series semi-parametric methods. The estimates show that total government and civilian burdens are productive, whereas military burden has significant effects on economic growth, promoting "productively" peacekeeping and humanitarian missions which reduces the insecurity from the external threat. Robust to the proposed specifications, these results show that a reduction of military burden in favoring government

Table 6: Estimation results of the linear model formulation for several spending categories

	I Military spending	II Military spending	III Defense spending	IV Defense spending	V military spending in peacekeeping
γ_{t-1}	-0 .450 ***	-0 .099	-0 .459 ***	-0 .085	-0 .102
	(0 .120)	(0 .147)	(0 .126)	(0 .151)	(0 .143)
$d.inv_t$	0 .383 ***	0 .335 ***	0 .372 ***	0 .339 ***	0 .356 ***
	(0 .056)	(0 .056)	(0 .058)	(0 .057)	(0 .055)
mil_{t-1}	2 .491 ***	1 .796 *			
	(1 .237)	(1 .262)			
def_{t-1}			0 .843	1 .849	
			(1 .403)	(1 .894)	
mil_peace_{t-1}					2 .892 **
					(1 .403)
Constant	2 .050	2 .420	6 .594 *	2 .004	7 .182 ***
	(3 .525)	(3 .544)	(4 .013)	(5 .435)	(1 .196)
Trend	-0 .117 ***	-0 .106 ***	-0 .128 ***	-0 .082 ***	-0 .163 ***
	(0 .028)	(0 .035)	(0 .037)	(0 .063)	(0 .034)
D1975	-0 .142		-0 .677		
	(0 .780)		(0 .874)		
D2008	-2 .594 **	-2 .413 ***	-3 .146 ***	-2 .798 ***	-1 .765 **
	(1 .389)	(0 .907)	(1 .428)	(1 .028)	(0 .970)
R^2	0 .803	0 .904	0 .786	0 .898	0 .912
Adjusted R^2	0 .774	0 .870	0 .754	0 .863	0 .878
Log likelihood	-73 .500	-20 .989	-75 .555	-21 .685	-19 .358
LM-test for residual autocorrelation (1 lag)	0.002	0.000	0.749	0.045	0.193
	(0.959)	(0.991)	(0.386)	(0.831)	(0.660)
Normality test	1.652	0.026	1.852	0.002	0.250
	(0.198)	(0.870)	(0.168)	(0.959)	(0.616)

Note: The dependent variable is the per-capita growth rate in GDP. In parenthesis, we report standard errors. At the bottom of the table are also reported several measures of estimation accuracy.

resources to the civilian sector enhances economic growth by the complementarities that this spending has on the private inputs.

As a first suggestion for the political economy, the evidence is concordant to recognize for military spending a role in enhancing economic growth, although this role is not the one based on the spillover effects on economy or positive externalities by human capital discussed above. This role is linked to the reduction of the level of external threat that peacekeeping and humanitarian missions determined. In fact, military spending is, at least for Italy, a deterrent for external attacks and serves to maintain far sources of instability that may affect the perception of consumers and the propensity to consume.

However, this evaluation depends on the dimension of peacekeeping mission participations and from the allocation of public resources. The global recession and financial crisis started in 2008 has focused attention on the efficiency of the public sector in order to reduce public debt and to foster economic growth. The recent spending review promoted by the Italian government is in accordance with the inefficiencies of the military sectors (or less efficiency with respect to civilian expenditure), with the idea of a massive cut on personnel expenditures and investments. The reduction of the commitment in buying the F-40 airplanes represents an example of the revision of the optimal allocation of government spending without that the perception of security of the Italian citizens were affected.

Of course, the instability of the Mediterranean region, where the Italy is positioned, does not ensure a permanent security in the region, which in the future may further require interventions of the Italian military forces. For example, the onset of the African immigration on the Italian seaboard from 2009 has determined massive landings in Sicily that currently has not been solved in the international offices. People from different African country are potentially recognized as refugees or similarly from Italian law and generally enter with temporary permits. This may prefigure in the future an use of government funds for "humanitarian missions" in the home country to select who is eligible for the residence permit and who not, although it could conduct toward a distortion of money with respect to more productive expenditures, an issue that the right political part in Italy has already brought to the attention of voters. On the other hand, following the results of the paper, the absence of this "military spending" for motivations that are linked with the security could bring to a fall of the future growth rate.

References

Aizenman, J., & Glick, R. (2006). Military expenditure, threats, and growth. *Journal of International Trade & Economic Development*, *15*, 129–155.

Barro, R. J. (1990). Government spending in a simple model of endogenous growth. *Journal of Political Economy*, *98*, S103–26.

Chen, R. (1993). Functional coefficient autoregressive models: estimation and tests of hypotheses. *Journal of the American Statistical Association*, *88*, 298–308.

d'Agostino, G., Dunne, J., & Pieroni, L. (2011). Optimal military spending in the us: A time series analysis. *Economic Modelling*, *28*, 1068–1077.

d'Agostino, G., Dunne, J., & Pieroni, L. (2012). Corruption, military spending and growth. *Defence and Peace Economics*, *Forthcoming*.

Deger, S., & Sen, S. (1995). *Military Expenditures and Third World Countries* volume Handbook of Defence Economics. BV Amsterdam: Elseiver Science.

Devarajan, S., Swaroop, V., & Heng-fu, Z. (1996). The composition of public expenditure and economic growth. *Journal of Monetary Economics*, *37*, 313–344.

van Dijk, D., Terasvirta, T., & Franses, P. H. (2002). Smooth transition autoregressive models - a survey of recent developments. *Econometric Reviews*, *21*, 1–47.

van Dijk, D., Tersvirta, T., & Franses, P. H. (2000). *Smooth Transition Autoregressive Models - A Survey of Recent Developments*. Working Paper Series in Economics and Finance 380 Stockholm School of Economics.

Eitrheim, O., & Terasvirta, T. (1996). Testing the adequacy of smooth transition autoregressive models. *Journal of Econometrics*, *74*, 59–75.

Granger, C., & Teräsvirta, T. (1993). *Modelling Nonlinear Economic Relationships*. Oxford University Press.

Harvey, I., D., & Leybourne, J. (2007). Testing for time series linearity. *Econometrics Journal*, *10*, 149–165.

Kapetanios, G., Shin, Y., & Snell, A. (2003). Testing for a unit root in the nonlinear star framework. *Journal of Econometrics*, *112*, 359–379.

Knight, M., Loayza, N., & Villanueva, D. (1996). The peace dividend: Military spending cuts and economic growth. *IMF Staff Papers*, *43*, 1–37.

Lipow, J. & Antinori, C. M. (1995). External security threats, defense expenditures, and the economic growth of less-developed countries. *Journal of Policy Modeling*, *17*, 579–595.

Looney, R. E. (1997). Excessive defense expenditures and economic stabilization: The case of Pakistan. *Journal of Policy Modeling*, *19*, 381–406.

Lutkepohl, H. M. K. (2004). *Applied Time Series Econometrics*. Cambridge: Cambridge University Press.

Mittnik, S., & Neumann, T. (2003). Time-series evidence on the nonlinearity hypothesis for public spending. *Economic Inquiry*, *41*, 565–573.

Nascia, L., & Pianta, M. (2009). Gli italiani in guerra. chapter La spesa militare in Italia, 1948-2008. Utet.

Neack, L., (1995). UN Peace-Keeping: In the Interest of Community or Self? *Journal of Peace Research*, *32*, 181–196.

Pieroni, L. (2008). *Military Spending and Economic Growth*. Technical Report 0708 University of the West of England, School of Economics.

Polachek, S. W., & Seiglie, C. (2007). Trade, peace and democracy: An analysis of dyadic dispute. chapter 31. (pp. 1017–1073). Elsevier volume 2 of *Handbook of Defense Economics*.

Shieh, J.-y., Lai, C.-c., & Chang, W.-y. (2002). The impact of military burden on long-run growth and welfare. *Journal of Development Economics*, *68*, 443–454.

Vogelsang, T. J. (1998). Trend function hypothesis testing in the presence of serial correlation. *Econometrica*, *66*, 123–148.