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THE IMPACT OF DEFENSE EXPENDITURE ON ECONOMIC GROWTH: PANEL DATA ANALYSIS BASED ON THE FEDER MODEL

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ABSTRACT

Defense economics has been studied since the 1960s. It involves researching defense problems from various economic fields. In general we treat defense as public goods in the national economy, but defense economics analyzes the interdependence between defense and the national economy through various routes. Defense economics research is carried out widely in the US and Europe, but it is not yet common in Japan.

After the Cold War, the reduction in defense expenditure was regarded as a “peace dividend”. But recently we have been faced with unconventional conflicts such as terrorism. To cope with these conflicts we should consider defense problems from a new point of view and change security measures. Defense economics will be the new tool to consider a country’s defense policy.

The purpose of this paper is to analyze the defense–growth relationship. We estimate the economic growth equation based on the Feder model for 109 countries including 30 OECD countries, using panel data over the period between 1995 and 2003. As Feder’s framework shows, we assume that the economy consists of two sectors, the civilian (private) sector and the defense sector. Usually, we think of defense expenditure as a burden on the economy. The main focus of this paper is on verifying how defense expenditure affects economic growth.

The empirical results of this paper suggest that defense expenditure has a positive impact on the rate of economic growth in all 109 countries. According to the results, as the defense sector increases, so does economic growth. The defense burden doesn’t have much negative effect on economies in this period.

Key words: Defense Economics, Defense Expenditure, Economic Growth

JEL Classification: H56, O47

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THE IMPACT OF DEFENSE EXPENDITURE ON ECONOMIC GROWTH: PANEL DATA ANALYSIS BASED ON THE FEDER MODEL

1. Introduction

The purpose of this paper is to analyze the defense–growth relationship. In general we treat defense as public goods in the national economy, but since the 1960s defense economics has been studied to analyze the interdependence between defense and the national economy through various routes. It derives from US defense strategy against the Soviet Union in the Cold War. After the Cold War, the reduction in defense expenditure was regarded as a "peace dividend". But recently we have been faced with unconventional conflicts such as terrorism. Therefore the importance of defense problems from a new point of view has been increasingly recognized. Defense economics research is carried out widely in the US and Europe, but it is not yet common in Japan.

As mentioned above, defense economics has been studied since the 1960s, a time when both the US and the Soviet Union held center positions in the world, namely, the Cold War. The US had to reconsider its defense strategy because the Soviet Union succeeded in launching a satellite first in 1957. The US's defense strategy called on it to deal with economic problems such as the efficient management of the defense budget, appropriate equipment and combat unit organization, and the efficient distribution of defense resources etc. Therefore the US started defense analysis using economic theory and tools.

Defense economics researches defense problems from various economic fields. Poast (2005) says we adapt to constrained optimization for defense problems that require the most suitable choice and action if we assume the case of national emergency from times of peace. We use microeconomics if we consider the defense industry, and we employ macroeconomics when we investigate how defense expenditure affects economic growth and development[1].

There is much previous research about the externality effects of defense on the economy. For example, Looney and Mehay (1990) consider the relation between US defense expenditure and the economy. They analyze empirically and estimate the demand function for US defense expenditure over the period 1965 to 1985. The estimated results of their analysis are that the preceding period of US expenditure, Soviet Union defense expenditure, the unpredictable Soviet Union defense expenditure, the trend deviation of federal revenue and NATO defense

[1] See Poast (2005).

expenditure, and the Vietnam War have a positive influence on US expenditure, whereas US inflation, financial deficit, and US-Soviet détente have a negative influence on it[2].

Gerace (2002) considers whether or not defense expenditure has a positive impact on economic growth and analyzes the relation between the growth rates of US defense expenditure, government expenditure not including defense expenditure, and the growth rate of GDP. He concludes that we have a countercyclical interaction between the growth rates of GDP and government expenditure not including defense expenditure. This interaction doesn't exist between the growth rates of GDP and defense expenditure. In other words, the growth rate of defense expenditure doesn't have a negative relation to that of GDP. The negative effect of defense expenditure on economic growth is different in each country and he says it may be more pronounced in developing economies.

Thus this paper focuses on the interdependence between defense and economic growth in the field of defense economics. The main focus of this paper is on verifying how defense expenditure affects economic growth based on the Feder model. Feder (1982) divides the economies of developing countries into two sectors, the export sector and the other sector. Then he estimates the externality effect of the export sector over the period 1964 to 1973. Many researchers apply his model to defense economics. For example, Mueller and Atesoglu (1993) analyze the externality effect of US defense expenditure on economic growth from 1948–1990 by improving the Feder model. They consider two sectors, the civilian sector and the defense sector, including the element of technical change. Their result is that US defense expenditure has a small positive impact on economic growth, but it doesn't have a spillover on civilian product activities[3].

Thus, as earlier studies indicate, defense has some influence on the economy. Figure1 shows the effect of defense expenditure. As shown in Figure1, we can see the externality effect of defense on economy. The purpose of this paper is to analyze the defense–growth relationship. We estimate an economic growth equation based on the Feder model for 109 countries including 30 OECD countries and verify the externality effect over the period between 1995 and 2003. Previous research estimated the defense–growth relationship using time-series data, but we estimate it using panel data. Our research is very meaningful if we analyze it for modern periods including the period of terrorism such as September 11th after the Cold War.

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[2] Sandler and Hartley (1999) comment that Looney and Mehey (1990) don't research the simulation analysis, they don't consider their estimated result in relation to a definite theoretical model, and their model isn't a demand function because it doesn't include the items of national income and price.

[3] Ando (2004) analyzes the externality effect of US defense expenditure on economic growth using the Mueller and Atesoglu model. He concludes that the validity of their model is open to question because the performance of estimated results using their model doesn't work very well.

In the second section, we explain the structure of the model. In the third section, we estimate the model and examine its result. Finally we note our conclusions.

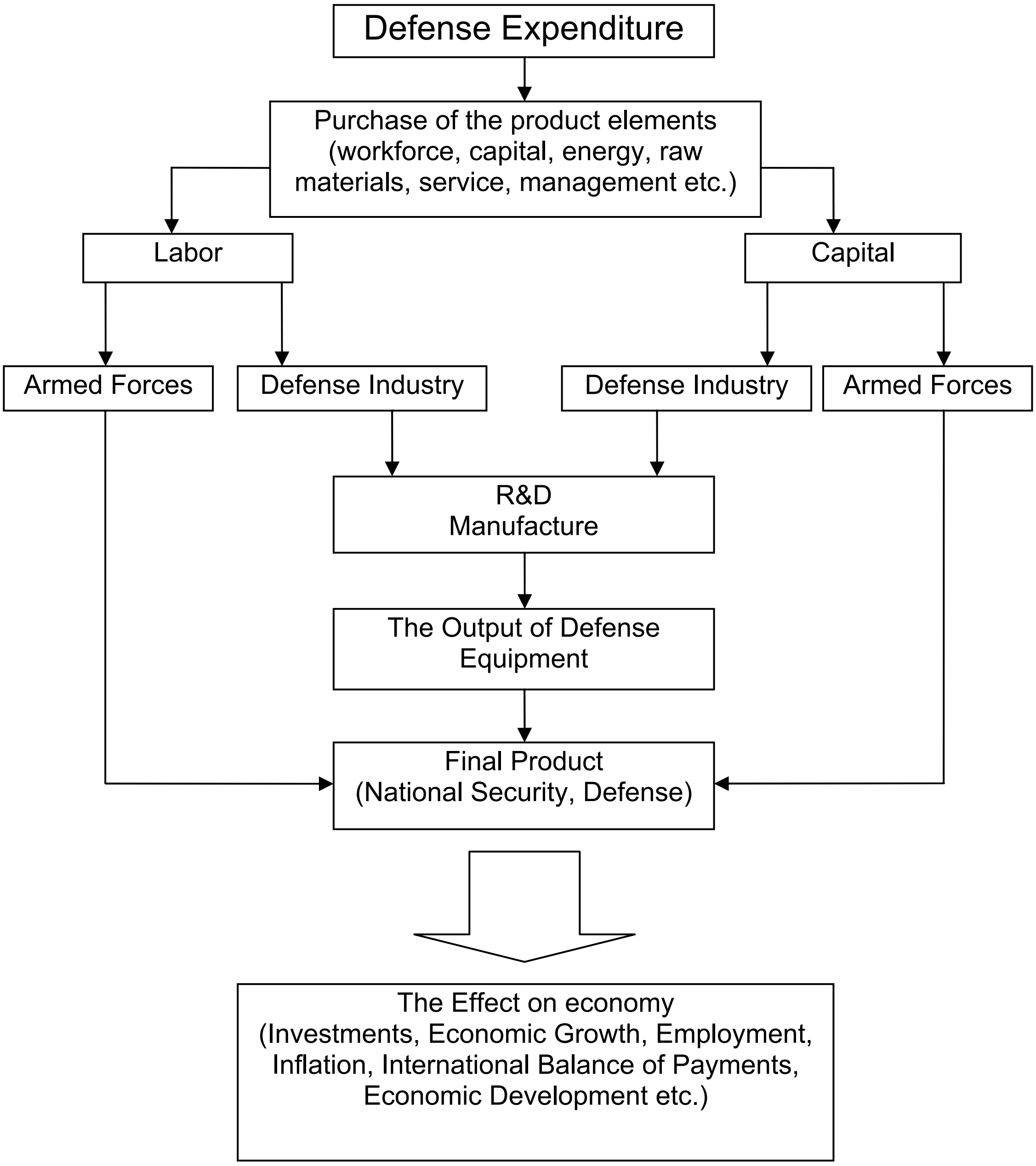

Figure 1: The Effect of Defense Expenditure
Source: Sandler, Todd and Hartley,Keith (1995), *The Economics of Defense*, Cambridge University Press

2. Specification of the Model
As Feder's framework shows, we assume that the economy consists of two sectors, the civilian (private) sector and the defense sector. The production functions for the two sectors are

$$B = B(K_b, L_b, M) \quad (1)$$

$$M = M(K_m, L_m) \quad (2)$$

in which B is the civilian (private) sector output and M is the defense sector output. The lower case subscripts denote sectoral inputs. Therefore K_b, K_m are capital inputs and L_b, L_m are labor inputs respectively and total inputs are given by

$$K = K_b + K_m \quad (3)$$

$$L = L_b + L_m \quad (4)$$

Thus the total output Y divides as follows

$$Y = B + M \quad (5)$$

We get sectoral marginal productivities of capital and labor from the partial differentials of equation (1) and (2)

$$\partial B / \partial K_b = B_K \qquad \partial M / \partial K_m = M_K$$
$$\partial B / \partial L_b = B_L \qquad \partial M / \partial L_m = M_L$$

and we assume the relations of each ratio are written as

$$M_K / B_K = M_L / B_L = 1 + \delta \quad (6)$$

where δ is the productivity index. As Ram (1986), Sandler and Hartley (1995) and Murdoch et al. (1997) say, it means if δ is positive (negative), the productivity of the defense sector is higher (lower) than that of the civilian sector.

Next the differentiations of equation (1), (2) and (5) yield

$$dB = B_K dK_b + B_L dL_b + B_M dM \quad (7)$$

$$dM = M_K dK_m + M_L dL_m \quad (8)$$

$$dY = dB + dM \tag{9}$$

where B_M is the marginal externality effect of the defense sector on the civilian sector and we define as follows

$$dK_b \equiv I_b \quad dK_m \equiv I_m$$

where I_b, I_m are investment in the two sectors. We can rewrite equations (7) and (8), and substitute them into equation (9), say

$$dY = B_K I_b + B_L dL_b + B_M dM + M_K I_m + M_L dL_m \tag{10}$$

Also, we can arrange equation (6)

$$M_K = (1+\delta)B_K \quad M_L = (1+\delta)B_L$$

Using the above in equation (10) yields

$$\begin{aligned} dY &= B_K I_b + B_L dL_b + B_M dM + (1+\delta)B_K I_m + (1+\delta)B_L dL_m \\ &= B_K(I_b + I_m) + B_L(dL_b + dL_m) + B_M dM + \delta(B_K I_m + B_L dL_m) \end{aligned} \tag{11}$$

Next we can transform equation (6) as follows

$$B_K = \frac{M_k}{1+\delta} \quad B_L = \frac{M_L}{1+\delta}$$

Then using the above, the fourth term in equation (11) yields

$$\begin{aligned} \delta(B_K I_m + B_L dL_m) &= \frac{\delta}{1+\delta}(M_K I_m + M_L dL_m) \\ &= \frac{\delta}{1+\delta} dM \end{aligned} \tag{12}$$

Now we define as follows

$$I \equiv I_b + I_m, \; dL \equiv dL_b + dL_m$$

We substitute the above and equation (12) into equation (11)

$$dY = B_K I + B_L dL + (B_M + \frac{\delta}{1+\delta})dM \tag{13}$$

As Feder (1982) says, we assume there is a linear relationship between the real marginal productivity of labor and the real output per laborer. Therefore we arrange as

$$B_L = \beta \frac{Y}{L}$$

And then we define $B_K \equiv \alpha$. Dividing equation (13) through by *Y*, equation (13) can be rewritten as

$$\frac{dY}{Y} = \alpha \frac{I}{Y} + \beta \frac{dL}{L} + (B_M + \frac{\delta}{1+\delta})\frac{dM}{M}\frac{M}{Y} \tag{14}$$

where the coefficient of the third term in equation (14) is the effect of added productivity and externality. Even if we estimate equation (14), it is difficult to distinguish which of the two effects worked because the estimated coefficient of the third term of equation (14) includes the effects of both productivity and externality. If we consider the externality effect only, we need more restrictions. Therefore to separate the effect of externality from that of productivity we assume the production function of the civilian sector as follows

$$B = B(K_b, L_b, M) = M^{\theta} f(K_b, L_b) \tag{15}$$

where θ is the parameter.

If $\theta > 0$, defense expenditure has a positive externality effect on economic growth and if $\theta < 0$, it has a negative effect. Also, as Ando (1998) follows, we take the logarithm of both sides in equation (15)

$$\ln B = \theta \ln M + \ln f(K_b, L_b)$$

and moreover partially differentiate the above with respect to $\ln M$

$$\frac{\partial \ln B}{\partial \ln M} = \frac{\partial B / B}{\partial M / M} = \frac{\partial B}{\partial M} \cdot \frac{M}{B} = B_M \frac{M}{B} = \theta$$

Thus we define

$$\partial B / \partial M \equiv B_M = \theta \frac{B}{M}$$

and we represent as follows

$$\theta \frac{B}{M} = \theta \frac{B/Y}{M/Y} = \theta \frac{(1 - M/Y)}{M/Y} = \frac{\theta}{M/Y} - \theta \qquad (16)$$

We substitute equation (16) into equation (14) as

$$\frac{dY}{Y} = \alpha \frac{I}{Y} + \beta \frac{dL}{L} + \left(\frac{\delta}{1+\delta} + \frac{\theta}{M/Y} - \theta\right) \frac{dM}{M} \frac{M}{Y} \qquad (17)$$

Then we assume as follows

$$\frac{\delta}{1+\delta} = \theta$$

Thus equation (17) can be represented as

$$\frac{dY}{Y} = \alpha \frac{I}{Y} + \beta \frac{dL}{L} + \frac{\theta}{M/Y} \frac{dM}{M} \frac{M}{Y}$$

$$= \alpha \frac{I}{Y} + \beta \frac{dL}{L} + \theta \frac{dM}{M} \qquad \alpha > 0 \qquad \beta > 0 \qquad (18)$$

We estimate the externality effect of the defense sector using equation (18).

3. Estimated Method and Results

3.1. Estimated Method

We estimate equation (18) for 109 countries including 30 OECD countries using panel data over the period 1995 to 2003. Equation (18) is estimated using the ordinary least squares (OLS) procedure. To analyze equation (18) we transform it into the following:

$$\frac{\Delta Y}{Y_{-1}} = \alpha \frac{I}{Y_{-1}} + \beta \frac{\Delta L}{L_{-1}} + \theta \frac{\Delta M}{M_{-1}} \qquad (19)$$

The data of equation (19) is obtained from the Center for International Comparisons at University of Pennsylvania "Penn World Table",[4] SIPRI and ACDA data at constant 2000 prices.[5] We estimate equation (19) and also estimate an equation with dummy variables added to it. The dummy variables we used are countries at war (dummy1), and countries under military alliances with other countries (dummy2) over the period 1995 to 2003. Table 1 shows the armed conflicts related to the 109 countries we estimated in 1995–2003. Dummy2 alliances NATO and ECOMOG.

Table 1: Armed conflicts related to the 109 countries we estimate in 1995–2003

Asia & the Middle East

Period	Name of conflict
1992–97	The Tajik Civil War
1997–98	Cambodian Conflict
1999	Jammu and Kashmir Conflict
From Nov 2001	The Military Operation in Afghanistan
From Mar 2003	The Military Operation in Iraq

Europe

Period	Name of conflict
1969–98	Northern Ireland Conflict
1991–95	Croatian War of Independence
1992–95	Bosnian War
1994–96 From 1999	The War in Chechnya
1998–99	Kosovo Conflict

Africa

Period	Name of conflict
1989–03	Liberian Civil War
1997–98	Conflict in Sierra Leone
1998–00	Ethiopia-Eritrea border conflict
1998–99	Congo Civil War
1998–99	Sierra Leone Civil War
1998–02	Angolan Civil War
Sept 2002 – July 2003	Civil War in Ivory Coast

Source: Defense of Japan 2006

[4] Center for International Comparisons at University of Pennsylvania "Penn World Table" http://pwt.econ.upenn.edu/php_site/pwt_index.php

[5] Data for GDP, investment, labor input are calculated by the data, i.e. population, real GDP per capita, investment share of RGDP, real GDP chain per worker, from Penn World Table. Defense data are military expenditure by country from SIPRI.

3.2 Estimated Results

Table 2a shows the empirical results for 109 countries. Regressor1 in Table 2a is an estimated OLS regressor not included in the panel option, the cross-section effect and the time effect. Regressor1 is statistically significant for the coefficients *α, β,* and *θ*. Regressor2 in Table 2a is the estimated coefficient in the fixed effect model considering both the cross-section and time. It shows that the statistical significance of all coefficients other than *θ* is the same result as Regressor1. The coefficients of constant terms and *β* are negative unlike Regressor1. Dummy1 and dummy2 for both Regressors are statistically insignificant. The coefficient *θ,* the growth rate of defense expenditure and our focus, is statistically significant at the 1% level. This result shows that the defense sector has a positive impact on the civilian sector and if the defense sector goes up positively, so does economic growth, although the value of elasticity is small.

We also estimate for OECD countries to verify the externality effect of the defense sector in advanced economies. The estimated result is shown in Table 2b. In Table 2b, we obtain the same result as Table 2a. For the coefficient *θ* of the defense sector, Regressor1 and Regressor2 in Table 2b are significant at 5% and 10% levels respectively. The sign conditions are met although the value is smaller than that of Table 2a. Thus the defense sector in OECD countries also affects the civilian sector positively.

Table 2a: Estimated Coefficients in equation (19) for 109 countries: 1995–2003

Dependent Variable: dY/Y_1
Method: Panel Least Squares
Sample: 1995–2003
Cross-Sections included: 109
Total panel (balanced) observations: 981

Regressor	**1**	**2**
constant	0.015***	−0.031***
	(3.384)	(−3.322)
α	0.087***	0.438***
	(4.715)	(8.827)
β	0.279**	−0.314*
	(2.553)	(−1.778)
θ	0.082***	0.065***
	(9.155)	(7.180)
dummy1	0.003	−0.007
	(0.545)	(−0.963)
dummy2	−0.002	0.001
	(−0.445)	(0.091)
Cross-section	None	Fixed
Time	None	Fixed
$\bar{R}^2$	0.101	0.303

Note: Numbers in parentheses are t-statistics. ***, ** and * indicate significant at 1%, 5% and 10% levels respectively.

Estimation Method: In Regressor 2, the null hypothesis is rejected because the test statistics of Hausman-test are 75.24(P-value=0.00). Therefore we choose fixed effects model in both cross-section and time.

Table 2b: Estimated Coefficients in equation (19) for OECD countries: 1995–2003

Dependent Variable: dY/Y_1
Method: Panel Least Squares
Sample: 1995–2003
Cross-Sections included: 30 (OECD countries)
Total panel (balanced) observations: 270

Regressor	1	2
constant	−0.021**	−0.057***
	(−2.118)	(0.000)
α	0.177***	0.327***
	(5.314)	(7.922)
β	1.128***	0.797***
	(5.800)	(2.745)
θ	0.039**	0.028*
	(2.268)	(1.881)
dummy1	0.002	0.000
	(0.394)	(0.042)
dummy2	0.002	0.007
	(0.865)	(1.569)
Cross-section	None	Random
Time	None	Random
$\overline{R}^2$	0.209	0.223

Note: Numbers in parentheses are t-statistics. ***, ** and * indicate significant at 1%, 5% and 10% levels respectively.
Estimation Method: In Regressor 2, the null hypothesis isn't rejected. Therefore we choose random effects model in both cross-section and time.

Next we analyze equation (19) by sorting the countries into two groups, developed and developing countries. In general, many countries import conventional weapons, especially from developed countries. Therefore part of defense expenditure flows out to exporting countries. We must distinguish the analyses between developed and developing countries. Also, defense expenditure usually includes the cost of arms purchases. We subtract the sum of arms imports from defense expenditure and use them as the defense sector output.[6] These results are shown in Tables 3a and 3b. Table 3a shows the estimated coefficients for 79 developing countries and Table 3b shows those for 30 OECD countries. We find that the coefficient θ in Table 3a is also statistically significant and positive with defense sector data excluding arms imports, whereas the one in Table 3b is statistically insignificant. We can see the positive externality effect of the defense sector in developing countries. As mentioned above, developing countries import arms from developed countries. Therefore defense expenditure for developing countries usually has a negative effect on their economies. However, our result of coefficient θ is positive. This paper indicates that domestic defense industries in countries which import arms tend to promote a positive economic effect. Although developing countries have no choice but to import arms, we suggest that defense expenditure for their countries has a positive effect on their economies if we consider the internal effect only by excluding arms imports.

[6] We use ACDA data for defense expenditure and the sum of arms imports. The estimated periods are 1995–1999 due to the lack of data for arms imports from 2000 onwards.

Table 3a: Estimated Coefficients in equation (19) for 79 developing countries and emerging nations: 1995–1999 using ACDA data

Dependent Variable: dY/Y_1
Method: Panel Least Squares
Sample: 1995–1999
Cross-Sections included: 79 (developing countries and emerging nations)
Total panel (balanced) observations: 395

Regressor	1	2
constant	0.008	0.008
	(1.099)	(1.119)
α	0.180***	0.182***
	(4.986)	(5.026)
β	0.120	0.103
	(0.687)	(0.585)
θ	0.001**	0.002**
	(2.151)	(2.198)
dummy1	−0.003	−0.005
	(−0.205)	(−0.423)
dummy2	0.023*	0.025**
	(1.946)	(2.066)
Cross-section	None	None
Time	None	Fixed
$\overline{R}^2$	0.078	0.085

Note: Numbers in parentheses are t-statistics. ***, ** and * indicate significant at 1%, 5% and 10% levels respectively.
Estimation Method: In Regressor 2, the null hypothesis is rejected because the test statistic of Hausman-test is 39.94 (P-value = 0.00). Therefore we choose time fixed effects model.

Table 3b: Estimated Coefficients in equation (19) for 30 OECD countries: 1995–1999 using ACDA data

Dependent Variable: dY/Y_1
Method: Panel Least Squares
Sample: 1995–1999
Cross-Sections included: 30 (OECD countries)
Total panel (balanced) observations: 150

Regressor	1	2
constant	−0.014	−0.094***
	(−1.261)	(−4.638)
α	0.158***	0.614***
	(3.744)	(8.971)
β	0.799***	−1.521
	(2.836)	(−1.280)
θ	−3.05E−05	−2.70E−05
	(−0.717)	(−0.728)
dummy1	0.058***	−0.005
	(4.663)	(−0.262)
dummy2	0.007*	−0.003
	(1.692)	(−0.197)
Cross-section	None	Fixed
Time	None	None
$\overline{R}^2$	0.269	0.647

Note: Numbers in parentheses are t-statistics. *** and * indicate significant at 1% and 10% levels respectively.
Estimation Method: In Regressor 2, the null hypothesis is rejected because the test statistic of Hausman-test is 61.34 (P-value = 0.00). Therefore we choose fixed effects model in cross-section.

4. Conclusion

In this paper, we considered defense economics and analyzed the defense–growth relationship. We estimated the economic growth equation based on the Feder model for 109 countries including 30 OECD countries using panel data over the period 1995 to 2003 to verify how defense expenditure affects economic growth. The empirical results of this paper suggest that defense expenditure has a positive impact on the rate of economic growth in all 109 countries. We also estimated for OECD countries and obtained the same results. Next we subtracted the sum of arms imports from defense expenditure and estimated equation (19) by using them as the defense sector output between 1995 and 1999. In developing countries, we can see the positive externality effect of the defense sector even with defense sector data excluding arms imports.

According to the results, as the defense sector increases, so does economic growth. Usually, we think of defense expenditure as a burden on the economy but this paper has found that a defense burden doesn’t have a greatly negative effect on economies in our estimated periods.

For further research, this paper’s model based on the Feder model is very simple and Dunne et al. (2005) point out that there are a number of econometric problems in estimating the Feder model. It may therefore be beneficial to extend the focus into various models for defense.

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