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Defense Industry and Threats

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Abstract

This paper sets up a dynamic optimization model to analyze the impact of military threats on defense industry. We prove that a rise in the foreign military threats will result in the shift of economic resources from the civilian sector to the defense sector. As a result, civilian sector shrinks and defense sector expands, a phenomenon resemble to so-called ‘Dutch disease’ in the trade literature.

Keywords: Defense industry; Threats; Resources allocation; Dutch disease.

1. Introduction

The purpose of this paper is to explore the impact of military threats on defense industry. Clearly, military spending is an indicator of the amount of economic resources devoted to military activities. During the cold war period, the East-West struggle has evolved into the arms race, leading to an increase in the worldwide military spending. After the cold war, the military threats reduce and thus many countries accelerate the shift of resources from the defense sector to the civilian sector. Stockholm International Peace Research Institute (SIPRI) Yearbook (1999) states that world military spending has been on a declining trend during the period of 1987-1999. The reduction in world military spending is more than one-third; more specifically the strong cuts have been made in Europe by 55%, America 30%, and Africa 25%. In the meantime, the reduction in military spending has also caused a dramatic wave of defense industry mergers in America in which the defense industry is whittled down from a group of about fifteen companies to the five companies of Lockheed Martin, Boeing, Raytheon, General Dynamics, and Northrop Grumman.[1] As indicated by Markusen and Costigan (1999), the total defense-related employment in the world has fallen by 6.5 million workers during the period of 1987-1995. Obviously, these workers should migrate from the defense sector to the civilian sector.

It was not until the 911-event of terrorist attacks, the world military spending rebounded and began to rise on an upward trend.[2] Thereafter, the controversial defense programs of European and America are more likely to swim through on a rising tide of national insecurity. Meanwhile, the defense-related employment is expected to accelerate uptrend, corresponding to the phenomenon of return migration from the civilian sector to the defense sector.[3] In other words, the military threats will cause the reallocation of economic resources, leading to shrinkage or expansion of defense industry, see Bouthoul (1969). However, what we have observed from the above story is that an increase in the military threats will lead to the expansion of the defense industry and the shrinkage of other civilian sectors or conventional manufacturing sectors, a similar phenomenon of so-called 'Dutch disease' in the literature on trade theory.[4]

Our paper is formally to analyze the above-mentioned interesting phenomenon of the Dutch-disease induced by the military threats. More specifically, we will set up a dynamic optimization framework to analyze the impact of the military threats on the defense industry. The structure of the paper is as follows. Section 2 presents a simple dynamic optimization model. Section 3 presents the comparative static analysis. Section 4 concludes the paper.

2. Model

Consider a theoretical model consisting of the home country and the foreign country, and suppose that the home country is a small open economy which is confronted with foreign military threats. There are two sectors in home country: the civilian sector and the defense sector. The civilian sector produces consumption goods (*C*) and the defense sector produces weaponry (*R*). The home country derives utility from consumption, and the home weapon stock, and disutility from the foreign weapon stock (M^*): $U(C,R,M^*)$. Assume that $U(C,R,M^*)$ is concave and continuously differentiable in its arguments. Following Brtio (1972), Simaan and Cruz (1975), Deger and Sen (1983, 1984), van der Ploeg and de Zeeuw (1990), Zou (1995), and Chang et al. (1996, 2002), the instantaneous utility function *U* satisfies the following assumptions:

$$U_1 > 0,\ U_2 > 0,\ U_3 < 0,\ U_{11} < 0,\ U_{22} < 0,$$
$$U_{12} = U_{21} \geq 0,\ U_{13} = U_{31} \leq 0,\ U_{23} = U_{32} > 0.$$

Let U_i represent the derivative of the utility function with respect to the i^{th} argument. Similarly, U_{ij} represents the derivative of U_i with respect to j^{th} argument. The aforementioned assumptions imply that the marginal utility from consumption and home

[1] See *The Economist* (8280 July 2002, pp. 62-63).
[2] See SIPRI Yearbook (2006).
[3] See *The Economist* (8242 October 2001, pp. 57-58).
[4] *The Economist* (26 November 1977, pp. 82-83) first describes the phenomenon of 'Dutch disease'. The phenomenon originally refers to the adverse effects on Dutch manufacturing caused by the natural gas discoveries of the 1960s.

weapon stock is positive and diminishing. In addition, the marginal utility from foreign military threat is negative. The assumption $U_{13} = U_{31} < 0$ implies that more foreign weapon stocks reduces the marginal utility of consumption, whereas $U_{12} = U_{21} > 0$ states that a rise in the home weapon stock raises the marginal utility of consumption, similarly, $U_{23} = U_{32} > 0$ asserts that an increase in the foreign military threat will increase the marginal utility of home country's weapon stocks. Moreover, the assumption $U_{13} = U_{31} = U_{12} = U_{21} = 0$ implies that the utility function is separable between the consumption and the weapon stocks.

The civilian sector and the defense sector employ labor and capital as inputs. Labor and capital are intersect orally mobile. Hence, the production function of the consumption goods is expressed as:

$$Y = F(L, K), \qquad F_L > 0, F_K > 0, F_{LK} = F_{KL} > 0, F_{LL} < 0, F_{KK} < 0,$$

Where L denotes the labor employment and K represents the capital employment in civilian sector. Similarly, the production function of the weaponry is specified as: $G(L_R, K_R)$, $G_{L_R} > 0$, $G_{K_R} > 0$, $G_{L_R K_R} = G_{K_R L_R} > 0$, $G_{L_R L_R} < 0$, $G_{K_R K_R} < 0$, where L_R denotes the labor employment and K_R represents the capital employment in defense sector. The production functions are assumed to be linearly homogeneous, and the marginal products of labor and capital are positive and diminishing in both civilian and defense sectors. Let $\overline{L}$ and $\overline{K}$ represent the endowment of labor and capital respectively. The full-employment conditions for labor and capital can be derived as:

$$L + L_R = \overline{L}, \tag{1a}$$
$$K + K_R = \overline{K}. \tag{1b}$$

Following McMillan (1978), the weapon accumulation in the home country is:

$$\dot{R} = G(L_R, K_R) - \delta R, \ \delta \geq 0, \tag{2a}$$

Where δ represents the depreciation rate of the weapon stock. Substituting equations (1a) and (1b) into equation (2a), we have:

$$\dot{R} = G(\overline{L} - L, \overline{K} - K) - \delta R. \tag{2b}$$

The household budget constraint can be described as:

$$PF(L, K) + G(\overline{L} - L, \overline{K} - K) = PC + T, \tag{3}$$

Where P represents the relative price of the consumption goods, and T is a lump-sum tax.

The objective is to maximize the discounted sum of utility over an infinite horizon with a constant rate of time preference (ρ), and $0 < \rho < 1$:

$$\max \int_0^\infty U(C, R, M^*) e^{-\rho t} dt,$$

Subject to equations (2b) and (3). The initial home weapon stock is given as R_0.

To solve the optimization problem, we specify the corresponding Hamiltonian as following:

$$Ham = U(C, R, M^*) + \lambda[G(\overline{L} - L, \overline{K} - K) - \delta R]$$

$$+ \gamma[PF(L, K) + G(\overline{L} - L, \overline{K} - K) - PC - T]. \quad (4)$$

Where λ is the costate variable which can be interpreted as the marginal contribution of weaponry to utility. The variable γ represents the shadow price of the consumption goods. Normalize prices so that γ =1. Hence, the first-order necessary conditions for the optimization are:

$$U_1(C, R, M^*) = P, \quad (5a)$$

$$PF_L(L, K) = (\lambda + 1)G_{L_R}(\overline{L} - L, \overline{K} - K), \quad (5b)$$

$$PF_K(L, K) = (\lambda + 1)G_{K_R}(\overline{L} - L, \overline{K} - K), \quad (5c)$$

$$\dot{\lambda} = (\rho + \delta)\lambda - U_2(C, R, M^*), \quad (5d)$$

$$\lim_{t \to \infty} R\lambda e^{-\rho t} = 0, \quad (5e)$$

and equations (2b) and (3). Equation (5a) says that the marginal utility of consumption is equal to its price. Equation (5b) implies the equality of the marginal productivity of labor between the civilian sector and the defense sector. Equation (5c) implies the equality of the marginal productivity of capital between the civilian sector and the defense sector. The familiar Euler condition is giver by equation (5d), which governs the optimal choice between consumption and weapon accumulation. The transversality condition is given by equation (5e).

Let τ denote the tax rate. The lump-sum tax revenue can be described as:

$$T = \tau[PF(L, K) + G(\overline{L} - L, \overline{K} - K)]. \quad (6)$$

The government is assumed to collect its lump-sum tax revenue to purchase the armament and then freely offers internal and external security. Hence, the government budget constraint is:

$$\tau[PF(L, K) + G(\overline{L} - L, \overline{K} - K)] = G(\overline{L} - L, \overline{K} - K),$$

or

$$G(\overline{L} - L, \overline{K} - K) = \frac{\tau}{1 - \tau} PF(L, K). \quad (7)$$

Combining (5b) with (5c), we have:

$$F_L(L, K)G_{K_R}(\overline{L} - L, \overline{K} - K) = F_K(L, K)G_{L_R}(\overline{L} - L, \overline{K} - K). \quad (8a)$$

Solving equation (8a), we have:

$$K = K(L, \overline{L}, \overline{K}), \quad (8b)$$

And

$$\Lambda = \frac{\partial K}{\partial L} = \frac{G_{K_R} F_{LL} + F_K G_{L_R L_R} - F_L G_{K_R L_R} - G_{L_R} F_{KL}}{G_{L_R} F_{KK} + F_L G_{K_R K_R} - F_K G_{L_R K_R} - G_{K_R} F_{LK}} > 0 . \tag{8c}$$

Substituting equations (6) and (7) into equation (3), we have:

$$C = F(L, K). \tag{9}$$

Substituting equations (5a), (8b) and (9) into equation (5b), we have:

$$U_1(F(L, K(L, \overline{L}, \overline{K})), R, M^*) F_L(L, K(L, \overline{L}, \overline{K}))$$

$$= (\lambda + 1) G_{L_R}(\overline{L} - L, \overline{K} - K(L, \overline{L}, \overline{K})) . \tag{10a}$$

Substituting equations (8b) and (9) into equations (2b) and (5d), we have:

$$\dot{R} = G(\overline{L} - L,\ \overline{K} - K(L, \overline{L}, \overline{K})) - \delta R , \tag{10b}$$

$$\dot{\lambda} = (\rho + \delta)\lambda - U_2(F(L, K(L, \overline{L}, \overline{K})), R, M^*) . \tag{10c}$$

Differentiating equation (10a) with respect to time, we get:

$$\dot{L} = \frac{1}{\Delta U_1}\left[\frac{G_{L_R}}{F_L}\dot{\lambda} - U_{12}\dot{R}\right], \tag{11a}$$

Where

$$\Delta = \frac{U_{11}(F_L + F_K \Lambda)}{U_1} + \frac{(F_{LL} + F_{LK}\Lambda)}{F_L} + \frac{(G_{L_R L_R} + G_{L_R K_R}\Lambda)}{G_{L_R}} = \frac{\psi}{U_1 F_L} < 0 ,$$

$$\psi = U_{11} F_L F_L + U_1 F_{LL} + (\lambda + 1) G_{L_R L_R} + \Lambda[U_{11} F_L F_K + U_1 F_{LK} + (\lambda + 1) G_{L_R K_R}] < 0 .$$ [5]

Substituting equations (10a), (10b) and (10c) into equation (11a), we have:

$$\dot{L} = \frac{1}{\Delta}\left[(\rho + \delta)\left(1 - \frac{G_{L_R}}{U_1 F_L}\right) - \frac{U_2 G_{L_R}}{U_1 F_L} - \frac{U_{12}}{U_1}(G - \delta R)\right]. \tag{11b}$$

Equation (11b) states how the labor will mobilize intersectorally over time. Therefore, equations (11b) and (10b) describe the transitional dynamics of the economy. In characterizing the steady-state equilibrium of the model, we get that there exists a unique stationary state (i.e., $\tilde{R}$, and $\tilde{L}$), which satisfies $\dot{L} = \dot{R} = 0$. Appendix states the stability analysis of the dynamic system. The phase diagram is illustrated in Figure 1. The point *E* is a saddle point. The path *SS* is the unique saddle path.

In the next section, we will explore the impact of the foreign weapon stock on the labor employment of civilian sector and the home weapon stock at the steady-state equilibrium.

[5] Using the assumption of the linearly homogeneous production function and the relationship of the first-order conditions, we can prove that ψ <0 is hold.

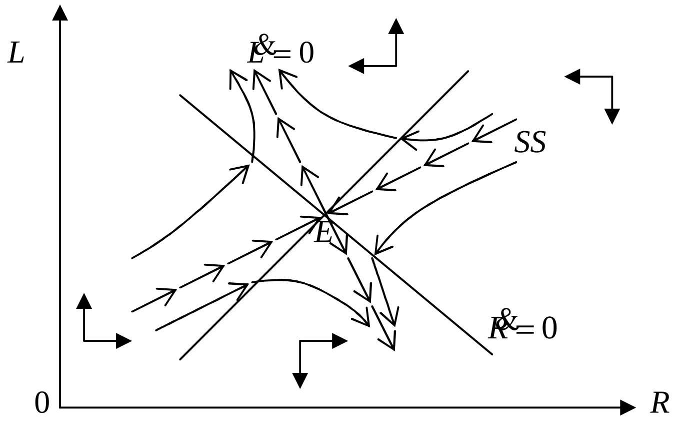

Figure 1: Stably dynamic system

3. Comparative Static Analysis

At the steady-state equilibrium, the economy is characterized by $\dot{R} = \dot{\lambda} = 0$ and *L*, *R*, and λ are at their stationary level, in other words, $\tilde{L}$, $\tilde{R}$, and $\tilde{\lambda}$. From equations (10a), (10b) and (10c), we can derive the steady-state relationships as follows:

$$\frac{\partial \tilde{L}}{\partial M^*} = -\frac{\delta}{(G_{L_R} + G_{K_R}\Lambda)}\frac{\partial \tilde{R}}{\partial M^*} < 0 , \tag{12a}$$

$$\frac{\partial \tilde{R}}{\partial M^*} = \frac{(G_{L_R} + G_{K_R}\Lambda)}{\Omega}[(\rho + \delta)F_L U_{13} - G_{L_R} U_{23}] > 0 , \tag{12b}$$

$$\frac{\partial \tilde{\lambda}}{\partial M^*} = \frac{A}{\Omega} \gtrless 0 , \tag{12c}$$

Where

$$\Omega = -(\rho + 2\delta)U_{12} F_L G_{L_R}(1 + \frac{F_K}{F_L}\Lambda) + \delta(\rho + \delta)\psi + U_{22} G_{L_R}(G_{L_R} + G_{K_R}\Lambda) < 0 ,$$

$$A = -(G_{L_R} + G_{K_R}\Lambda)F_L(U_{12}U_{23} - U_{13}U_{22}) + \delta U_{23}\psi - \delta U_{13}U_{21}F_L(F_L + F_K\Lambda) .$$

Equation (12a) indicates that a rise in the foreign threats has a negative impact on the labor employment of civilian sector. From equation (8c), we also can prove that a rise in the foreign threats has a negative impact on the capital employment of civilian sector. In other words, an increase in the foreign military threats will result in the shift of economic resources from the civilian sector to the defense sector. Equation (12b) states that an increase in the foreign threats leads to more home weapon stocks. Equation (12c) describes that the relationship between the foreign threats and the shadow price of home weapon stocks is ambiguous. However, if the utility function is separable between the consumption and the weapon stocks (i.e., $U_{13} = U_{31} = U_{12} = U_{21} = 0$), equation (12c) definitely indicates that a rise in the foreign threats will increase the shadow price of home weapon stocks (see Chang et al. (1996) and Lee (2007)). Therefore, we get the following proposition:

Proposition 1: An increase in the foreign threats will lead to the shift of economic resources from the civilian sector to the defense sector, and vice versa.

Proposition 2: A rise in the foreign threats will lead to the booming defense industry, and vice versa, a similar phenomenon of so-called 'Dutch disease' in the trade literature.

4. Conclusions

This paper sets up a dynamic optimization model to analyze the impact of the military threats on the defense industry. We prove that an increase in the foreign military threats will lead to the shift of labor and capital from the civilian sector to the defense sector, and vice versa. Namely, an increase in the foreign military threats will result in the shift of economic resources from the civilian sector to the defense sector. As a result, civilian sector shrinks and defense sector expands, a phenomenon resemble to so-called 'Dutch disease' in the trade literature.

Appendix

In order to examine the stability of the dynamic system, we rewrite equations (11b) and (10b) which describe the dynamics of the economy as follows:

$$\dot{L} = H(L, R, M^*), \tag{A.1}$$

$$\dot{R} = J(L, R, M^*). \tag{A.2}$$

Expanding equations (A.1) and (A.2) around the stationary values of $\tilde{L}$ and $\tilde{R}$, we get:

$$\begin{bmatrix} \dot{L} \\ \dot{R} \end{bmatrix} = \begin{bmatrix} H_L & H_R \\ J_L & J_R \end{bmatrix} \begin{bmatrix} L - \tilde{L} \\ R - \tilde{R} \end{bmatrix}, \tag{A.3}$$

Where

$$H_L = \frac{G_{L_R}[(\rho+\delta)+U_2]}{U_1 F_L} > 0,$$

$$H_R = \frac{1}{\Delta U_1}[(H_L+\delta)U_{12} - \frac{G_{L_R}U_{22}}{F_L}] < 0,$$

$$J_L = -(G_{L_R} + G_{K_R}\Lambda) < 0,$$

$$J_R = -\delta < 0.$$

Let H_i and J_i represent the derivatives of the functions H and J with respect to the variable i respectively, where i= L, R. The slopes of loci $\dot{L} = 0$ and $\dot{R} = 0$ from equations (A.1) and (A.2) are:

$$\left.\frac{\partial L}{\partial R}\right|_{\dot{L}=0} = -\frac{H_R}{H_L} > 0,$$

$$\left.\frac{\partial L}{\partial R}\right|_{\dot{R}=0} = -\frac{J_R}{J_L} < 0.$$

Assume that μ_1 and μ_2 are the two characteristic roots that satisfy the dynamic system described by equations (A.1) and (A.2), we have:

$$\mu_1\mu_2 = H_L J_R - H_R J_L < 0.$$

Obviously, the two characteristic roots of the dynamic system are opposite signs, $\mu_1 < 0 < \mu_2$. Therefore, we indicate that the system displays the saddle-point stability and prove that there exists a unique saddle path *SS* in the dynamic system. However, the slope of saddle path *SS* is positive as following:

$$\begin{bmatrix} H_L - \mu_1 & H_R \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = 0 \Rightarrow \frac{v_1}{v_2} = -\frac{H_R}{H_L - \mu_1} > 0,$$

Where $[v_1 \;\; v_2]$ represents the characteristic vector. Meanwhile, the slope of saddle path *SS* is smaller than the slope of loci $\dot{L} = 0$.

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References

[1] G. Bouthoul, *La Guerre*, *PUF (Que Sais-Je ?)*, (1969), France University Press.

[2] D. Brito, A dynamic model of an armaments race, *International Economic Review*, 13(1972), 359-375.

[3] W.Y. Chang, H.F. Tsai and C.C. Lai, Effects of anticipated foreign military threat on arms accumulation, *Southern Economic Journal*, 63(1996), 507-514.

[4] W.Y. Chang, H.F. Tsai and C.C. Lai, Anticipated foreign military threat, arms accumulation and the current account in a small open economy, *Journal of International Money and Finance*, 21(2002), 1035-1052.

[5] S. Deger and S. Sen, Military expenditure, spin-off and economic development, *Journal of Development Economics*, 13(1983), 67-83.

[6] S. Deger and S. Sen, Optimal control and differential game models of military expenditures in less developed countries, *Journal of Economic Dynamics and Control*, 7(1984), 153-169.

[7] C.T. Lee, A new explanation of arms races in the third world: A differential game model, *Journal of Economics and Management*, 3(2007), 161-176.

[8] A.R. Markusen and S.S. Costigan, *Arming the Future*: *A Defense Industry for the 21st Century*, (1999), New York: Council on Foreign Relations Press.

[9] J. McMillan, A dynamic analysis of public intermediate goods supply in open economy, *International Economic Review*, 19(1978), 665-678.

[10] M. Simaan and J. Cruz Jr., Formulation of Richardson's model of arms race from a differential game viewpoint, *Review of Economic Studies*, 42(1975), 67-77.

[11] F. Van der Ploeg and A. de Zeeuw, Perfect equilibrium in a model of competitive arms accumulation, *International Economic Review*, 31(1990), 131-146.

[12] H.F. Zou, A dynamic model of capital and arms accumulation, *Journal of Economic Dynamics and Control*, 19(1995), 371-393.