Military Spending and Economic Growth: A Longitudinal Analysis

by

Randolph T. Stevenson

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Texas A&M University

Honors Fellows Program

Approval:

Thesis Advisor Alex Mintz
Dr. Alex Mintz

Honors Program Director
Dr. Dale Knobel

The question of how defense spending affects economic growth has been important to both economist and political scientists for many years. The numerous works that have been written on the subject, however, have failed to produce any meaningful consensus as to whether defense spending encourages or discourages economic growth. Much of this failure can be attributed to the lack of a compelling theory of defense spending's economic effects. Without such a theory to guide researchers, the work that has been done has tended to vary widely in its theoretical justifications and thus, in its model specifications and research strategies. Some recent literature, however, has attempted to remedy many of these problems by introducing a model of the relationship between defense spending and the economy that is based on a compelling and well established model of economic growth (Mintz and Huang 1991a,b,c; Ram 1986, Ward 1991a).

This paper is an attempt to further the work of these authors in three ways. First, section one will explore the development of this new model, and demonstrate how it is based on a compelling model of growth that is both well accepted and theoretically driven. Section two will concentrate on explaining the theory behind the inclusion of defense variables in the model. And finally, the last section will test the model for 105 countries over time.

A New Approach

The relationship between military spending and economic growth is complex. Accordingly, the methods that have been employed to test for the existence and nature of this relationship have varied substantially among researchers.

The complexity of the relationship, however, is only part of the reason why so many different models have been used. Another, and probably more important, problem facing researchers of this question is that "the relationship between economic growth and military expenditures is not clearly defined in the economics literature." Indeed, there has not traditionally been a strong theory base available to guide researchers in this area, and this has caused model building to be somewhat arbitrary. Lebovic and Ishaq (1987) suggest that this has caused "the choice of variables used in existing studies [to be] dictated as much by data availability and a desire for simple model specification, as by underlying economic theory" (116).

This is indeed an important problem facing researchers interested in how the military affects the economy because the testing of the relationship between military spending and economic growth (or the testing of any hypothesis) is dependent on the analytical framework in which the relationship is tested. Thus, without a compelling theory of economic growth from which to begin, models trying to explain how the military contributes to (or detracts from) growth will necessarily be based on ad hoc formulations. It is perhaps then not surprising to find that, despite the many empirical studies which have proposed to answer this question (ranging from simple bi-variate correlations to complex systems of equations involving scores of variables), no dominant model of the proposed relationship has emerged as yet from either political science or traditional defense economics. Indeed, because there is no uniform source of theory, findings have been contradictory and confusing. Rasler and Thompson (1984) have concluded that a review of the literature in the area is "as likely to bewilder as it is to enlighten" (quoted in Chan 1984, 405).

Saadet Deger (1986) has recognized this problem but found no way to resolve it:

> In principle, economic theory should dictate what variables we should include in, for example, the growth equation. In practice, theory is rarely that precise... The determinants of growth, saving or trade balance are numerous... Therefore relatively ad hoc specifications are necessary, though these need to have intuitive plausibility. (260)

This sort of model building, however, seems inappropriate to test a relationship that is so thoroughly grounded in the economic theory of growth. What is needed then is to find a way to test these relationships in the context of a model of economic growth that is grounded soundly in economic theory and empirical validation. Furthermore, if such a model is to be useful, it must remain parsimonious enough to be relevant to a wide range of cases over time. In the search for such a model a few scholars have recently turned to the literature in economics and specifically theory of growth.

The development of growth theory and its use in defense studies

The subject of economic growth has been of interest to academics since classical times. Many economic theorists, such as Adam Smith, David Ricardo, and Thomas Malthus have addressed the topic. However, it was not until Keynes' General Theory appeared that there was much interest in the development of a model that could explain the long-term growth of the whole national economy. The macroaggregate analysis of the General Theory, however, prompted a revival of interest in macroeconomic growth theories. Two men, Roy Harrod (1939) (a close personal friend of Keynes) and Evsey Domar (1946), were the first to develop formal frameworks for the analysis of long-run economic growth. Taking somewhat different routes, both men arrived at the conclusion that sustained growth is only achieved when the national saving rate (the fraction of income saved) is equal to the product of the capital-output ratio and the rate of growth of the (effective) labor force. Only under these conditions could an economy maintain a balance between its capital stock and the supply of labor, so that steady growth could go on without the problems of labor shortage or unemployment. This model, known now as the Harrod-Domar model, was crucially dependent on the essential constancy of the various factors involved. The saving rate was considered a "fact about preferences;" the growth rate of labor supply was seen as a demographic-sociological fact, and the capital-output ratio was simply a technological fact. (Wan 1971; Hacche 1979; quote from Solow 1988). The implications of this model were that in an "unmanaged capitalist economy there would be no automatic tendency for a full-employment equilibrium growth path to exist." Indeed, "The possibility of steady growth would be a miraculous stroke of luck" (Solow 1988, 10) To Harrod and Domar this was consistent with the need for government intervention in the economy to assure growth (an essentially Keynesian view). It did not, however, correspond to the fact of steady growth that had been occurring in the United States since the Industrial Revolution. Thus, by the end of World War II, the Harrod-Domar model had come into question.

Harrod and Domar's unrealistically rigid assumption of a fixed relationship between capital, labor, and output (Hacche's so called "fixed-coefficients technology) led Solow and others (Tobin 1955, Swan 1956) to suggest that "in the real world production coefficients are variable, and this provides the economic system with a flexibility which, particularly in the analysis of the long run, can hardly be ignored" (Hacche 1979, 35). The remedy to this problem, according to Solow, was to formulate a model of economic growth in which both capital and output could increase in time faster than employment. In order to accomplish this, he injected technological progress into the model, and thus formed the basis for the neoclassical, or production function framework of the analysis of growth. Led by Solow then, "the neoclassical economists postulate a well-behaved aggregate production function with flexible inputs" - the now famous formulation: $Y=F(K,L)$.

The essential framework of Solow's production function has had remarkable staying power, and it remains the central focus of growth theory. Indeed, most of the subsequent work that has been done in the field of growth economics has concentrated on either further refinement and elaboration of Solow's original model, or on empirical estimation of the model. It has not, however, seriously challenged the conceptual basis of the model.

One of the most important and innovative aspects of Solow's formulation of the growth model was that it could be estimated and tested empirically. "Growth accounting," which was developed by Edward F. Denison (1962, 1985), is a direct result of the empirical nature of the production function, and may represent the most rigorous empirical use of the model. In his various works on the subject Denison showed that using Solow's basic formulation, it was possible to empirically estimate the contribution of various inputs to the overall output of the economy. In the simplest version of his 'sources-of-growth' model he attributes changes in levels of gross output to changes in inputs of capital, ($\Delta K = K - K_{-1} = I$), and changes in labor, (ΔL).

Feder (1982) and others (Chenery et al. 1970) have extended the work of Solow and Denison by developing a two sector production function which models both the effects of each sector on total output as well as the positive or negative effects these sectors have on each other's output. Furthermore, using Feder's formulation, the effects of non-optimal allocation between sectors with different productivities can be accounted for. Primarily concerned with the export sector, Feder suggested "that there are substantial differences between marginal factor productivities in export oriented and non-export oriented industries." (59) Furthermore, Feder hypothesized that the export sector exerted externality effects on other sectors that were not reflected in market prices (for example, better management techniques, the training of labor, etc.). Feder's specification and estimation of the two sector production function allowed for the estimation of the combined effects of these two variables (i.e - externalities and relative productivity differences between sectors.

Another scholar, Rati Ram (1986), adopted Feder's formulation in his analysis of the effect of government size on the economy. In Ram's model, the size of the government sector was substituted for size of the export sector in Feder's model. Ram, however, went one step further than Feder had, and estimated the separate effects of externalities generated by the government sector on the civilian sector. Furthermore, although he did not estimate the productivity effect directly, Ram was able to derive this effect from his estimates for the combined effect and the externality effect.[1]

Mintz and Huang (1991a,b,c) have incorporated the model into the realm of defense economics.[2] Following Feder and Ram, they have developed a framework which provides a formal rationalization for the incorporation of defense spending variables into the sources of growth equation. Like Ram, they assume that the economy is composed of both a government and a civilian sector. Unlike Ram, however, they disaggregate the

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1. Ram's article has generated some criticism by other economists (see Carr 1989, and Rao 1989). This criticism is concerned mainly with the assumptions that drive Ram's theoretical derivation of the model. However, as Ram points out in his response (1989), "the comments by Carr...have only minor implications," and "Rao's comment regarding the models and assumptions seems to matter little." (284)

2. In an earlier study, Biswas and Ram (1986) has also tested for the relationship between size of the defense sector and growth of the economy. However, this was done by simply replacing the government sector with the military sector. Mintz and Huang have shown, however, that the disaggregation of government into two components, the military and non-military, is a superior formulation.

government sector into it military and non-military components thus providing a means of isolating the effects of the military sector on the rest of the economy.

The original Mintz-Huang formulation (1991a) provided for the estimation of the overall effect of military spending on the economy. A second formulation, however, made it possible to both separately and directly estimate the effects of productivity differences between sectors, as well as the 'externality effects' that the military exerted on the civilian sector (1991).[3] The present form of the model (and the form used in this analysis) then suggests that output is a function of changes in capital, labor, military spending, and non-military government spending. Furthermore, the model takes into account both externality effects between sectors, as well as the effects of relative productivity differences between sectors.

As can be seen from the above discussion, there has been significant progress made in the formulation of a compelling model in which to test defense spending's effects on the economy. However, this literature is far from complete. Because this primary work has focused on justifying the formulation of the new model, relatively little has been done to clarify exactly what is meant by and included in the terms "externality effect", "productivity effect" or "direct effect". If these relationships do indeed exist, what exactly are the mechanisms through which they operate? How does the defense sector exert externalities on

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3. Several authors who have tried to estimate the separate effects of productivity differences and externalities using this model, have formed their theoretical models directly from the Mintz-Huang equation. These formulations have been criticized by Mintz and Huang who argue that the equation modeling the separate effects must be drawn directly from the original Ram formulation.

the civilian sector, and what are these externalities? How does the differences in productivities between sectors affect economic growth? To find the answers to these questions one must turn to the vast literature on defense and growth which has preceded the development of this new model.

Literature Review

The literature on the subject of defense spending and economic growth has benefited from several excellent and comprehensive reviews (Chan 1984, 1988; Lindgren 1984; Grobar and Porter 1989; Nueman 1978; Looney 1988). These reviews have tried to address all of the many theoretical and methodological questions that have been a part of the study of military spending and the economy. This review then, will not repeat what has already been done, but will instead examine the literature in light of the questions raised above (i.e.- What are the specific mechanisms through which the military affects the economy?).

The Military Sector and Capital Formation

One potentially negative effect of defense spending on the economy is decreased civilian investment (investment being seen as equal to the rate of change of capital).[4] The two most important ways in which this dampening can occur are through the

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4. Economic theory holds that investment is an essential part of economic growth. By adding to the physical capital of a nation, investment increases the absolute level of the country to produce goods and services. Also, if investment increases faster than labor, it improves the capital-labor ratio which in turn increases the productivity of labor and results in higher economic growth. This relationship between investment and growth has been widely upheld by empirical tests, and has indeed become a basic tenant of growth economics. One of the best known of these studies has been done by Edward Denison. Denison's work has shown that one fifth of the nearly three percent annual growth of the U.S. economy was due to investment (Denison 1985, p. 30).

'crowding out' of private investment and the creation of production bottlenecks that stifle civilian investment (Deger 1986; Degrasse 1983; and Cappelen, Gleditsch and Bjerkholf 1984; Smith 1980; Rasler and Thompson 1988).

CROWDING-OUT

Deger and Smith (1983) have suggested that crowding out is one of the most important ways in which defense spending dampen civilian investment. The logic of this argument is that because increases in spending for defense necessitate either higher taxes or higher borrowing by governments, they absorb funds that would otherwise have gone (at least partly) to civilian investment. Likewise, Mosely (1985) argues that when defense spending is financed by government borrowing, higher demand is placed on money markets. This demand drives up interest rates, which in turn increases the cost of investment funds for other borrowers (i.e. - civilian investors).

Dommen and Maizels (1988) point out that in order for this argument to be valid, one must assume that the resources which are used for the armed forces are unproductive relative to the civilian sector, "in the sense of contributing to capital formation" (378). Indeed, if military and civilian investment have similar productivities with respect to capital formation then crowding out of one by the other would make little difference in the aggregate economy. Despite Dommen and Maizels warning, however, the assumption seems a plausible one. Investment in weapons systems does not contribute to capital formation to the same extent that investment in such things as machines or highways does. Likewise, other military equipment that can contribute to capital formation (like trucks and transport planes), tends to be used in less productive capacities (to move troops or weapons instead of goods that will be used to add to the output of the nation).

PRODUCTION BOTTLENECKS

Another important way that defense expenditures can depress civilian investment is through the creation or exacerbation of production bottlenecks. In industries where defense procurement demand competes with civilian investment demand, defense spending can produce shortages in critical production materials as well as in other inputs such as technicians and scientists.

Mosely (1985) provides a particularly revealing example of the strains that military procurement can put on the industrial resources of a country. Recalling the U.S. military's aborted plan for the deployment of land-based mobile MX missiles, Mosely points out that, if the program had gone into effect, it would have required forty percent of the total U.S. cement production for three years (73). It is easy to see how this huge increase in demand for such a basic input of industrial production would have created severe short-term supply problems to civilian industries dependent on stable supplies of cement.

TECHNOLOGICAL SPIN-OFF

Whereas 'crowding-out' and production bottlenecks affect capital development quantitatively, technological spin-offs effect it qualitatively. The spin-off argument supposes that as governments either develop or import weapons systems, they gain use of technologies not previously available in the economy. To the extent that these technologies become available and are put to use in the civilian sector, the capital output ratio in these sectors will increase (i.e - positive spin-offs, or 'externalities' will occur).

Despite the generally accepted logic of the spin-off argument, however, some researchers have questioned its relevance for developing countries. Deger and Sen (1983) have found in a time series analysis of India, that "the beneficial spin-offs generally discussed in the literature are much less than what is claimed" (80). Their analysis is particularly convincing because it focuses only on the effects of spin-offs in industries that have strong direct 'technological linkages' with the defense sector (electronics for example). If these sectors show no positive benefits from influxes of military technology, then their is little reason to expect the wider economy to benefit from such spin-offs.

Others (Ball 1988; Maizels and Nissanke 1987) point out that many Third World countries import most, if not all of their weapons, and these economies often can not reproduce the technology of the weapons they import. Furthermore, these scholars suggest that, since most of the arms imported by the Third World are not very sophisticated, the technological spin-offs stemming from these weapons are probably minimal.

Traditionally, the case for technological spin-off has been much stronger for the developed world. In economies with large defense industries and huge R&D budgets, there is a much greater potential for the development of innovative technologies within the defense sector. Furthermore, the relative sophistication of civilian technology allows for the incorporation of new military technologies into the civilian sector.

Some have suggested, however, that the developed world may have surpassed the level of technological sophistication in which spin-offs are most relevant. Mosely (1985) makes the point that "the increasing divergence of military and civilian technologies and the industrial secrecy surrounding military research...inhibits its diffusion and application to civilian purposes" (81).

Mary Kaldor (1981) echoes this view when she suggests that the spin-off effects of military technology may be much greater at low levels of technological sophistication, and that high spending for technologies which produce only marginal improvements may have reached a point of diminishing returns in developed economies. Kaldor does, however, recognize that in the early stages of technological development, the defense markets and the R&D "climate" provided by military spending can be important to the development of important civilian industries (she gives the U.S. electronics industry as an example).

While most of the theoretical explanations of the relationship between military spending, investment and growth, posit a negative effect, some scholars have suggested that the investment dampening effects of defense spending may not be as important as the literature suggests. Bruce Russett (1969) has argued that increases in defense spending come mainly at the expense of private consumption - not private investment. Furthermore, Pryor (1968) makes the same argument for communist countries. If this is indeed true, then increases in defense spending, while they might exert a negative effect on consumption, would not hinder private investment.

The Military Sector and Human Capital Development

Although most scholars agree that the defense sector exerts an some effect on the civilian sector via human capital development (i.e. - development of labor), these scholars do not agree on whether the effect is positive or negative. Indeed, those who have addressed the question fall into two very distinct and opposite camps. One group sees defense spending as contributing to human capital formation in the civilian sector through its modernizing and educational roles. The other group suggests the opposite, that is that the use of resources by the military reduces the ability of governments to allocate resources to education, health and other such programs which are essential to human capital development in the civilian sector (i.e - guns-butter trade-offs).

Emile Benoit (1972, 1973, 1978) has been one of the leading proponents of the view that the military has a positive effect on human capital development. Benoit (focusing on underdeveloped countries) suggests that, in as far as the military educates its personnel, provides medical care, and teaches vocational and technical specialties, it plays a modernizing role. Indeed, his cross-national test of forty-four developing nations seemed to bear out the conclusion that defense spending in the Third World promotes economic growth.

Benoit's study, however, has been highly criticized, and much of the subsequent work discounts the educational and developmental role of the military in favor of other negative effects of the military on the economy (Lim 1983; Ball 1988). Benoit's argument, however, is far from dead. It continues to be put forward in the literature by such researchers as Stephanie Neuman (1978), who has suggested that the educational role of the military was very important in the modernization of pre-revolutionary Iran. She points out that the Shah's military (supported by the U.S.) were training thousands of technicians, and that "these students, schooled in electronics, engineering, mechanics, and management, provide needed skills to the military and the rest of society as well" (589). Similarly Weede (1983) has emphasized the role the military in teaching discipline and obedience to the labor force (qualities which, he suggests, are essential for development).

Robert Looney (1991), in a very recent work, also discusses the impact of military spending on human capital development. His conclusions, based on a study of seven Arab countries, suggest that even if the military sector does not add to human capital development, it at least does not hinder it.

GUNS-BUTTER TRADEOFFS

A second perspective on the military's role in human capital development is that, because governments can increase military spending only at the expense of welfare items such as education and health, increases in defense spending will hurt human capital development. The scholars who have put forward this argument suggest that, faced with limited resources, governments inevitably make trade-offs between Guns and Butter.[5] Thus, if the military commands an increasing share of national resources, other programs necessarily suffer. Furthermore, some authors have suggested that when government revenue is increasing (either through taxation or deficit spending) and allocations to both welfare and defense grow at the same time, trade-offs can still exist. In this case, however, the trade-off occurs between the relative growth of the two budgetary categories (Mok and Duval 1991).

The early empirical work that was done on the guns-butter question (mainly for the U.S.) confirmed the existence of a trade-off (Russett 1969). However, these early studies were highly criticized, and subsequent analysis denied that trade-offs occurred, at least for the developed countries (Russett, Mintz, others). The debate, however, continues, and some recent work has suggested that the relationship may be more complex than previous studies have recognized.

In one such study, Saadet Deger (1985) has suggested that developed countries pay the cost of defense mainly through decreased investment and not from trade-offs with education. In developing countries, however, education and the social wage may be more susceptible than investment to reduction because growth programs, which are often the first priority of Third World governments, emphasize investment growth. Furthermore, while Deger recognizes that "the military establishment [in the Third World] might take on some of the roles of civilian authority in

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5. Crecine's identity is the cornerstone of the guns-butter literature. This identity (Military spending + Non-military spending = Revenue + Deficit) was called by President Esienhower the 'great equation', which necessitates trade-offs of some kind.

human resource development and ease the task of the state education sector," she goes on to conclude that "in the absence of such factors, however, there may be considerable negative effects on human capital formation due to high defense spending... Given an upper limit on national budgets, an increase in military burden could be at the expense of education or health spending and thus may also have adverse consequences on the human capital of the nation" (ibid, 39). Indeed, Deger's evidence seems to bear out this conclusion. For a sample of fifty underdeveloped countries, Deger's empirical analysis showed that, "An increase in defense burden most certainly reduces education spending, taking all interdependent effects together" (ibid, 46).[6]

Another important study has recently focused attention on possible trade-offs in the developed countries. Using the same essential logic as Deger's analysis, Mintz and Huang (1991) have suggested that while it is true that the guns-investment trade-off is probably more important than the guns butter trade-off in developed countries, the negative effects of defense spending on investment will indirectly lead to lower education spending just the same. If investment promotes economic growth, and economic growth promotes welfare spending, then the negative, indirect effect of defense spending on welfare spending is clearly negative. Using a three equation model, Mintz and Huang tested this hypothesis on time-series data for the U.S., and indeed found support for all the links in their model.

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6. An important limitation of Deger's study, however, is that he used a static cross-national design to model trade-offs. This is clearly an inappropriate way to test for a relationship that, if it indeed exists, would necessarily be a dynamic one.

Relative Productivity Differences

One imortant effect the military sector can have on the economy comes as a result of intersectorial productivity differences between the military and civilian sectors. In a perfectly efficient economy all resources are allocated to their most productive uses. For capitalist economies this allocation is done through the working of the market. Government spending, however, represents a market distortion (whether good or bad) in which some resources are allocated apart from the market. This means that market mechanisms do not operate to equalize productivities between the market and non-market sectors. Thus, in the absence of optimal allocation by the government (the probability of which approaches zero), relative productivity differences between the sectors are likely to persist. Thus, if the military sector is more productive relative to the rest of the economy, resources allocated to the sector will produce more output than if these resources had gone elsewhere. Likewise, resources allocated to a relatively less productive military sector will not contribute to growth as much as they might have in the civilian sector.

Inflation, Unemployment, and Consumer Demand

Many of the authors who have suggested that military expenditure have a direct, positive effect on economic growth concentrate on the effects of defense spending on unemployment, inflation, and consumer demand. (Benoit 1972; Lim 1983; Kennedy 1974, 1983). These authors maintain that increased military spending stimulates employment, mild inflation and aggregate demand. When companies hire workers to build weapons or barracks, or the military expands its rosters, jobs are created. Likewise, (if savings remain constant) this short-term rise in employment must increase consumer demand because more people have money to spend. This increase in demand will cause mild inflation that will stimulate greater production and economic growth.

Despite the compelling logic of this scenario, however, many scholars have found fault with it. Faini, Arnez, and Taylor (1984) point out that this line of reasoning "will presumably apply more to industrialized countries than to the rest of the world. In poor countries, shortages of crucial production inputs such as capital stock, skilled labor, and foreign exchange to purchase required intermediate imports are more likely to limit output than aggregate demand." (488). In other words, aggregate demand in poor countries is probably sufficient to absorb current supply and may indeed (because of production bottlenecks) out pace supply. Thus, if increases in defense spending stimulate aggregate demand the existing production bottleneck problems will only be exacerbated.

Another point, made by Mosely (1985), is that, to the extent defense spending is financed by greater taxes, it will decrease the disposable income available to consumers. This drop in disposable income will cause a drop in consumer demand that will act to dampen any gains made through employment (66). Other scholars have also down played the effects of military spending on aggregate demand. Indeed, Chan (1984) has suggested that, even if the result of defense spending is higher aggregate demand and economic growth, this will only be a short-run phenomenon which will be quickly negated by the negative impact of military spending on investment and other areas of the economy (Deger and Smith 1983).

One important problem for the proponents of the positive effects of defense spending through increased employment and inflation has been that the existence of such a relationship has not yet been convincingly demonstrated empirically. Indeed, Chan (1985) concludes that a survey of the available evidence does not give support for either a short-term inflationary effect of defense spending, or a long-term positive effect on employment (419-420).

In summary, the literature suggests that investment, human capital, technology, productivity, and aggregate demand are all important mechanisms through which the effects of military spending on the economy are felt. In the past, however, these relationships have not been tested in the context of a compelling model of economic growth. The Mintz-Huang formulation, however, provides such a model by allowing for the conceptualization of these influences in terms of an overall effect, an externality effect and a direct effect. In the next section of the paper, then, the Mintz-Huang formulation is specified exactly, and an empirical model is estimated using time-series data for 105 countries.

Testing the Relationship

Thus far the use of this new model in testing the relationship between defense spending and economic growth has been limited to only a few case studies. (Mintz and Huang 1991a; Ward 1991a) Part of the reason for the use of case studies is that the time-series nature of the case study provides the most valid means of testing the dynamic relationships portrayed in the model. Static, cross-national studies, however, while providing the basis for comparative analysis, fail to properly capture these dynamic relationships. Thus far then, studies which have used this model have not provided evidence upon which a generalizeable relationship between defense spending and economic growth can be based. This section of the paper will attempt to remedy the problem of generalizing the model, while at the same time maintaining the methodological advantages of the time-series deign. This will be done by applying the model to time-series data for each of 105 countries.

Specification of the Model

The model which was described at the beginning of this paper has been derived by Mintz and Huang (1991d) following Feder's multi-sector production function framework. Mintz and Huang have divided the economy into three sectors, the civilian sector (C), the military sector (M), and the government non-military sector (N). Assuming that output in each sector depends on the inputs of labor (L) and capital (K), and that the output of the military and non-military sectors have separate effects on output in the non-government sector, production functions for the three sectors were formed as follows (pp. 1-4):

(1)

$$C=C(L_c,K_c,N,M)$$

(2)

$$N=N(L_n,K_n)$$

(3)

$$M=M(L_m,K_m)$$

where subscripts denote sectorial inputs. The total inputs are then:

(4a) $L_c+L_n+L_m=L$

(4b) $K_c+K_n+K_m=K$

The total output (Y) is just the sum of the outputs of the three sectors:

(4c) $Y=C+N+M$

Suppose that the marginal factor productivities in the three sectors differ by a factor of δ_i, i=n,m, that is,

(5a) $(N_L/C_L)=(N_K/C_K)=(1+\delta_N)$,

(5b) $(M_L/C_L)=(M_K/C_K)=(1+\delta_M)$,

where uppercase subscripts denote partial derivatives of the production functions with respect to the subscripted input. By manipulating the production functions, and using (4) and (5), the following equation of economic growth can be derived:

(6) $\dot{Y}/Y = (I/Y)+ (\dot{L}/Y)+(\delta'_n+C_n)(\dot{N}/Y)+(\delta'_m+C_m)(\dot{M}/Y)$

where a dot over the variable indicates its differentiation with respect to time; for example Y=dY/dt. The parameter is the marginal product of capital (K) in the (C) sector and I=dK/dt is investment; and is the elasticity of non-government output (C) with respect to (L). δ'_i equals $\delta_i / (1+\delta_i)$, i=n,m, and is the direct effect of sector i on economic growth. C_i, i=n,m, on the other hand, represents the marginal externality effect of sector i on the rest of the economy. The sum of δ_i and C_i (i=n,m) is interpreted as the overall effect of sector i on economic performance.

While in equation (6) the coefficient (δ'_n+C_n) gives an indication of the overall effect of the military on the economy, it does not allow for the separate estimation of the externality effects apart from the direct effects. However, in a later paper Mintz and Huang (1991c) have attempted a further specification which can accomplish this. Assuming that N and M affect the production of C with constant elasticities of $_n$ and $_m$, respectively:

(7a)

$$C=C(L_c, K_c, N, M,)=N^{\theta n} \phi_n(L_c, K_c, M),$$

(7b)

$$C=C(L_c, K_c, N, M,)=M^{\theta m} \phi_m(L_c, K_c, M).$$

It can then be shown that,

(8a) $\partial C/\partial N \equiv C_N=\theta_n \cdot (C/N)$,

(8a) $\partial C/\partial M \equiv C_M=\theta_m \cdot (C/M)$,

Equation (6) can now be rewritten as:

(9) $\dot{Y}/Y = \alpha(I/Y)+\beta(\dot{L}/Y)+[\delta'_n+\theta_n \quad (C/N)](\dot{N}/Y)+(\delta'_m+\theta_m \cdot (C/M)](\dot{M}/Y).$

By rearranging the terms, this equation becomes

(9) $\dot{Y}/Y = \alpha(I/Y)+\beta(\dot{L}/Y)+\delta'_n(\dot{N}/Y)+\theta_n \ [(\dot{N}/N)(C/Y)]+ \delta'_m(\dot{M}/Y)+\theta_m \cdot [(\dot{M}/M)(C/Y)].$

Where

θ_i (i=n,m) is the elasticity measure of the externality effect, and can be interpreted as the "effect of the interaction between the growth rate of sector i and the share of the non-government sector (C) in total output (Y) on economic growth" (ibid, 3). Likewise δ'_i is seen as the direct effect and can be interpreted, at least in part, as a measure of the effect of intersectorial productivity differences.

By converting the instantaneous change rate of variables in equations (6) and (9) to their discrete equivalents (for example $\dot{Y}/Y$ becomes $\Delta Y/Y_{-1}$), and further assuming that a linear relationship exists between the real marginal productivity of labor in a given sector and the average output per labor in the economy, two empirically estimatable equations can be formed:

(10) $\Delta Y/Y_{-1} = \alpha(I/Y_{-1}) + \beta(\Delta L/L_{-1}) + (\delta'_n + C_n)(\Delta N/Y_{-1}) + (\delta'_m + C_m)(\Delta M/Y_{-1})$,

(11) $\Delta Y/Y_{-1} = \alpha(I/Y_{-1}) + \beta(\Delta L/L_{-1}) + \delta'_n(\Delta N/Y_{-1}) + \theta_n[(\Delta N/N_{-1})(C/Y_{-1})] + \delta'_m(\Delta M/Y_{-1}) + \theta_m[(\Delta M/M_{-1})(C/Y_{-1})]$.

Where Y is GNP, I is investment, L is employment of labor (proxied by population), military spending is M, and nonmilitary government spending is N.

Data

Data on GDP, population, government consumption of goods and services, and gross domestic investment were taken from the data set that has been made available from the International

Comparison Project headed by Robert Summers and Alan Heston. The data are valued at 1980 international prices, and the exact methods of data collection and tabulation can be found in Summers and Heston (1984, 1988). Data on military spending were taken from SIPRI's yearbook, World Armaments and Disarmament (1974, 1979, 1980, 1989; see appendix 1B for definitions, sources and methods). The data on military expenditure was collected in constant dollars and standardized to 1980 dollars using the U.S. consumer price deflator, which was taken from the Statistical abstract of the United States.

All data refer to the time periods given in Table 1. For each country the time periods represent the first and last year for which comparable data was available.

The Summers-Heston data set includes 130 countries of which military expenditure data where not available for 16. Furthermore, the Summers-Heston data did not include gross domestic investment, or government consumption of goods and services for 9 centrally planned economies (namely China, Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, Romania, USSR, Yugoslavia). Finally, the total number of countries for which data for reasonably long time-series were available was 105.[7]

Issues about the Data

1. comparability

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7. Judgments concerning the inclusion shorter time-series were made liberally because the design of the study allows the reader to judge each series on its own merits and to discount any series found objectionable.

The use of the SIPRI data along with the ICP data seems at first a dubious proposition. The SIPRI data are valued using exchange rates, while the ICP project has explicitly rejected exchange rates and valued their estimates using 'international prices'. The ICP researchers have indeed argued that, because exchange rates are based only on the prices of internationally traded goods, they consistently undervalue the output of developing countries. Indeed, Summers and Heston's estimates of output for developing countries tend to be much higher than estimates valued using exchange rates. Likewise, in developed countries, where almost all goods are traded internationally, the ICP estimates are very close to those valued using exchange rates.

This study has used military expenditure data which was converted from domestic currencies by means of exchange rates. The use of this data with the ICP estimates is justifiable only because the vast majority of military expenditures go to purchase weapons or labor, and both these items are internationally traded. Consequently, military expenditure values converted using exchange rates should be very similar to those that would have been derived, had the data had been collected using the ICP method.

2. Labor

Following Ram (1986) and others (Ward 1991a; Lebovic and Ishaq 1987), this study uses the rate of population growth (P) in place of the rate of increase in labor (L). As Ram points out, although this is not a good proxy in some cases, it has the advantage that data on population tend to be reliable, whereas time-series data on labor force are rare and of questionable quality, particularly for the less developed countries. Also Lebovic and Ishaq (1987) have suggested that, "Because labor participation rates show little volatility in the short run, the population growth rate may be used instead of L/L."(118)

3. Military Expenditure Data

Many scholars have criticized the quality of the military expenditure data which is available cross-nationally (see Ball 1984; West 1987; Brzoska 1981). These criticisms tend to focus on the incomparability of the data cross-nationally, as well as on the uncontrollably of the data collection and reporting procedures of the major sources.

Of the three major sources of military expenditure data (SIPRI, ACDA, and IISS), all use a combination of international and national definitions of military expenditure. Thus, the comparability of countries using different definitions is highly questionable.[8] This analysis, however, does not require direct comparison of data across countries, but only comparison of results derived from individual time-series. The comparability problem then, is not severe in this analysis.

Several other important problems with the major data sources for military expenditures are generated by the procedures followed by the collecting agencies. These procedures, regarding deflation rates, exchange rates, and methods of data can effect the validity of time-series designs. Brzoska (1981) has compared the major sources and discussed these procedural issues. His

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8. SIPRI, the source used in this study, uses national definitions of military expenditure except for NATO, WTO, and China (see SIPRI 1979, p.27 for these definitions).

conclusion is that, while he can not praise SIPRI, this source clearly presents fewer problems than the other major sources (ACDA and IISS). In his conclusion, Brzoska can "raise no specific criticism about SIPRI." However, he warns that the sources should not be used uncritically.

Methodology

This part of the paper estimates equations (10) and (11) using the ordinary least squares regression procedure (OLS). OLS, however, was not appropriate for all of the countries for both equations. In many cases (and in all cases for equation (11)) the data did not conform to the basic assumptions of the multiple regression procedure. In these cases, appropriate statistical procedures were employed to overcome the problems. These procedures, as well as some other pertinent methodological questions, are discussed below.

1. Multi-collinearity

Mintz and Huang (1991a) have suggested that multicollinearity is often a problem in the study of the guns-growth trade-off. Thus, it was necessary for this study to test specifically for the existence of collinearity among the independent variables in the model. Accordingly, a variance inflation factor statistic (VIF) was generated for each of the 105 time-series in equation (10). The VIF statistic is a measure of collinearity, and it is more sensitive than simple correlations because it can detect collinearity between a given variable and all of the independent variables combined - instead of just between pairs of variables.[9] There is some difference of opinion regarding the interpretation of the VIF, so in this study, a conservative interpretation was employed. That is, if the VIF statistic was greater than 5, collinearity among the independent variables was assumed. In all but three of the time-series for equation (10), the VIF statistic proved to be less than 5.[10] This result then, provides confidence that collinearity among the independent variables in equation (10) is not a problem.

Collinearity was a much greater problem in the estimation of equation (11). Tests of correlation among the independent variables in this equation show that the externality and productivity variables are consistently collinear at approximately the .9 level.

Traditionally, the methods employed to deal with collinearity have not been very satisfying. These have included dropping one or more of the independent variables, creating a composite index of the collinear variables, or adding data points to break the pattern of collinearity. None of these methods, however, are appropriate for this study. Dropping variables from an already parsimonious and theoretically driven model is unacceptable; creating an index of the collinear variables defeats the purpose of separate estimation; and data to extend the sample is not available.

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9. Simple correlation matrices using all the independent variables did not show strong collinearity between any pairs of variables in equation (10).

10. The three cases in which the VIF was greater than five were Egypt, Somalia, and Iraq. For these countries ridge regression was employed in the manner discussed below.

Mintz and Huang (1991), however, have suggested another approach for dealing with collinearity in the analysis of defense spending and economic growth. They suggest using the ridge regression estimator as an alternative to the above methods. Their explanation of ridge regression is as follows:

> The idea behind ridge regression is the introduction of a small and <u>known</u> amount of bias in the estimation of the regression equation in exchange for substantially reducing the inflated variances associated with multicollinearity and thus stabilizing the regression coefficient estimates. (ibid, 4)

Mintz and Huang further point out that, since its introduction in 1970, many researchers from different fields have demonstrated the superiority of ridge regression over OLS when faced with collinearity among explanatory variables (see Mintz and Huang 1991, p. 4 for these cites).

A detailed explanation of how ridge regression handles the multicollinearity problem is provided by Mintz and Huang (1991a) and appears in the appendix of this paper. For those less schooled in statistics, however, the most important point to understand about the use of ridge regression is that, while it does introduce some bias into the estimates produced by the regression equation, this bias is small in comparison to the reduction of variance inflation that is achieved.[11]

2. Autocorrelation

The Durbin-Watson statistic of the OLS residuals was used to determine the existence of first-order autocorrelation in each of the time-series for equations (10) and (11). For those cases in which the Durbin-Watson statistic indicated the existence of

11. A Time Series Processor (TSP) program, which is provided in Mintz and Huang (1991a), was used to apply ridge regression to the data.

first-order autocorrelation, the generalized least squares (GLS) estimation method was used instead.[12] In cases in which both multicollinearity and autocorrelation where present, the GLS procedure was included in the ridge regression program in the manner suggested by Ward (1991b)[13]

3. Simultaneity

Problems of simultaneity bias are problematic in studies of military spending and the economy. If it is true that economic growth has a strong influence on military spending, then coefficients obtained by OLS will be biased and inconsistent. Indeed, several scholars, assuming that just such an influence exists, have specifically adjusted their research designs to combat this problem (Faini, Arnez, and Taylor 1984; Deger 1986; and Deger and Smith 1983, use three stage least squares estimation to do this). Some other work, however, has suggested that the supposed influence that economic growth has on military spending is not easily demonstrated. Deger and Sen (1983) argue that, when security factors are taken into account, economic performance has little to do with military spending. These two authors have shown using a formal optimizing model, that defense burden in LDC's is principly determined by strategic factors (such as security threat), and is relatively autonomous of economic factors. A very recent study also confirms the absence of simultaneity. Abdur Chowdhury (1991), using Granger analysis to test for simultaneity between economic growth and defense

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12. The Yule-Walker estimation of GLS was the method employed for all cases except those in which multicollinearity was also a problem. In these cases the Cochran-Orcutt method was used in order to provide uniformity to the data subsequently analyzed by the ridge procedure.

13. One difference with Ward was the use of the Cochran-Orcutt method of GLS as specified in the previous note.

spending, found that for fifty-five LDC's, time-series data did not support a reciprocal relationship.

Results

The results in Table 1 are for equation (10). The coefficient of most interest for this paper is $({}_m+C_M)$, which is an estimate of the total effect of military spending on growth. An examination of Table 1 shows quite clearly that, while military spending does have significant effects in a few economies, there exist no statistically significant relationship between rate of change of military spending and economic growth on the whole. Indeed, the results of are robust in their insignificance. In only 19 countries (18 percent) did rate of change of military expenditure reach significance at even the .1 level [only 8 (7.5 percent) reaching significance at the .05 level!][14] In general, this evidence seems to strongly refute both the contention that there is a significant, immediate trade-off between military spending and growth, and also the opposite argument that military spending promotes growth. A closer look at the specific cases which were significant, however, raises some interesting points.

The group of countries in which military spending was significant is somewhat diverse, and it would be dangerous to draw any strong conclusions about them. However, there seems to be one trend worth noting. Countries which face a high security

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14. The countries reaching significance at .05 were Ireland (+), Spain(+), Argentina (-), Australia (-), Sierra Leone (+), Uganda (+), Israel (+), and Taiwan (+); at .1 were Iran (+), Jordan (+), South Korea (+), Oman (+), Canada (+), Dominican Republic (-), El Salvador (+), Nicaragua (+), Panama (+), and Ecuador (+).

threat, seem to be overly represented among those countries with significantly positive coefficients (11 out of 20). Israel, Taiwan, Iran, Iraq, Jordan, and South Korea, and Somalia all face continuing security problems. Furthermore, Nicaragua, El Salvador, and Uganda all faced extended periods of security threat from internal actors. While this group does not include all the countries in the study which are in volatile security situations, it represents a substantial majority of those cases.

Another interpretation of these results is also possible. All the countries mentioned as facing a security threat also receive, or have received substantial amounts of military aid. Military aid (and aid in general) is often mentioned as a way that Third World countries can avoid the economic costs of defense. This evidence would seem to support that view.

Turning now to the other variables in equation (10), it was not surprising to find that investment plays an important part in economic growth. Indeed, the variable was significant and positive in 49 of the countries in the sample (47 percent), In only one case, Saudi Arabia, was it significant and negative. This result provides some confirmation that the model is indeed a good one for studying issues of economic growth.

The results for Labor growth (proxied by population growth) are some what disconcerting. Although it has been clearly shown in the economics literature that labor growth is an important element in the total growth of the economy, only 23 of the countries in the sample had significant coefficients for the labor variable. Furthermore, 10 of these were negative. It could be that population is not a good proxy for labor force. In countries in which their is a surplus of labor, increased population is likely to exacerbate existing production bottlenecks without increasing the effective labor force. Also, in many Third World countries, the age composition of the population makes population growth a problem. In these countries forty percent of the population is typically in the "non-productive" age brackets (compared with 30 percent in developed countries; Hogendorn 1987). Hogendorn (1987) argues that, "These dependents, contributing relatively little in labor power, but making heavy demands on food, shelter, clothing, and education, are an extra burden on an LDC's resources" (196).

The results for non-military government spending are consistent with Ram's analysis of the effects of government size on economic performance. Indeed, in terms of the direction and number of significant coefficients in the sample, the results are strikingly similar (Ram 1986).[15] These two results taken together, leave little room to doubt that the overall effect of non-military government spending on the economy is positive generally, and negative rarely.[16]

Turning now to the results of the estimation of equation (11); table 2 presents the coefficients and t ratios for each country for equation (11). Table 3 summarizes those results. The results for the military spending coefficients are consistent with the previous equation. Estimating the effects of externalities generated by the military sector separate from the other direct effects does little to improve the significance of

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15. Ram reports 56 out of 115 positive and significant coefficients, and this analysis produced XX.

16. No countries in Ram's analysis showed significantly negative (alpha=.05) effects of the government sector, and in only one country in this study (Australia) did non-military government spending prove significant at .05.

the military sector on the economy. At the .05 level of significance (t-ratio > 1.96) only 10 countries have significant externality effects on output, although these tend to be in the positive direction (7 are positive).[17] Regarding the direct effects, only 12 countries have significant coefficients, with seven positive and five negative coefficients.[18] The lack of significance for the military sector coefficients suggests that there is no consistent, immediate relationship between military spending and the economy, even when looking at the externality and direct effects separately.[19] Furthermore, this result makes it impossible to speculate as to the conditions in which the externality and direct effects of military spending might, or might not be important in an economy. Indeed, these results suggest that such seemingly important structural factors as arms production capability, or resource availability do not condition the relationship between military spending and growth, as has been suggested in by some researchers using static designs (Looney 1988).

As can be seen from Table 3, the other variables in equation (11) look much the same as they did in equation (10). Investment remains significant in 46 cases, and labor in only 22.

Non-military government spending remains much more important than military spending, and it exerts significant externality effects in 33 cases (28 in the positive direction). Likewise, the direct effects are also significant in 30 cases (22 in the

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17. The countries with positive coefficients are Kenya, Iran, Pakistan, Singapore, Austria, W. Germany, Guatemala, and Paraguay. Those with negative coefficients are Nicaragua and New Zealand.
18. Those which are positive are Morocco, Nicaragua, Indonesia, New Guinea, Uganda, Israel, and Oman. Those which are negative are: Paraguay, West Germany, Guatemala, Honduras, Pakistan, Bahrain, and Mozambique.
19. This conclusion does not rule out the possibility of indirect effects such as those suggested by Mintz 1990.

positive direction). No pattern in the cases which have significant effects is apparent (i.e - countries with similar results can be found regardless of level of development, resource constraints, or any of the other structural variables that might have served to condition the effects of the variables in the equation).

conclusions

In the introduction, my goals in undertaking this analysis were stated. First, I wanted to explore the development of the Mintz-Huang model as it has emerged from growth economics, and to show how it is based on a compelling theory of economic growth. Second, I hoped to explain how the concepts that the model claimed to test (i.e.- the overall, externality, and direct effects) related to the previous literature on the subject of the military and the economy, as well as to specify the mechanisms through which these effects might be felt. Finally, I wanted to employ this model in a way that would allow me to make confident generalizations about the effects of defense expenditure on the economy. The extent to which I have accomplished these goals, and what that might mean for the study of the military and the economy, is, of course, up to the reader to evaluate.

I might, however, be allowed to speculate on the broader implications of this analysis. My results, when considered in light of previous work, suggest that the continued search for an immediate effect of military spending on economic performance may have reached the point of diminishing returns. At this stage, it may be more beneficial to look for indirect links, such as those specified in some recent work on the guns-butter question (see Mintz and Huang 1991). Furthermore, such analysis would benefit from the use of lags in order to capture any delayed effects that might be important.[1]

The scope of the empirical testing that was undertaken in this study also has implications as to the appropriateness of individual case studies in the study of this question. It was seen in the results of equation (10) that countries which are receiving (or had received) large amounts of aid, or in which security threats are severe (Israel, Taiwan, and South Korea being important examples), tend to have significant, positive coefficients for the military spending variable, while most other countries do not. These countries, however, are the very ones upon which most case studies are done. Thus, there is a danger that studies of these countries may provide a misleading picture of the general relationship between military spending and the economy in the absence of foriegn aid and security threat.

The review of the model developed by Mintz and Huang should also be considered as a guide to future study, in that it is both parsimonious and theoretically driven. If a theory of defense and the economy is to be developed it can not be done through *ad hoc* specifications. Future work must begin from compelling theoretical arguments, and must place defense variables in the context of the growth of the whole economy.

Finally, the main conclusion of the analysis is worth re-iteration. That is, the study of the effects of defense spending on the economy must move away from *ad hoc* models of the immediate, direct effects of military spending on economic

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1. In 'growth accounting' type formulations, such as the Mintz-Huang model, the use of lags is inappropriate.

growth, and must instead seek to determine if other (perhaps indirect, or delayed) effects exist.

Table 1 - Estimated Coefficients of the Variables in Equation (10)

COUNTRY	YEARS	METHOD	Const.	α	(δ'_n+C_n)	(δ'_m+C_m)	β	Adj R2
ALGERIA	1962-1985	OLS	0.228**	0.336*	0.841	-4.942	-8.672**	0.21
			(0.078)	(0.172)	(0.841)	(4.365)	(3.129)	
BENIN	1961-1985	OLS	-0.154	0.559	0.774	2.284	4.074	0.01
			(0.168)	(0.401)	(0.707)	(7.483)	(5.346)	
BRUNEI	1961-1985	OLS	-0.074**	0.774*	1.660**	-0.746	1.950	0.40
			(0.029)	(0.383)	(0.441)	(5.547)	(1.273)	
CAMEROON	1960-1985	OLS	-0.015	0.239	1.167*	2.020	1.117	0.09
			(0.046)	(0.502)	(0.655)	(5.272)	(3.111)	
CAR	1961-1983	YW	-0.098	0.790*	0.073	2.985	1.182	0.44
			(0.053)	(0.408)	(0.298)	(3.350)	(1.826)	
CHAD	1961-1979	YW	0.010	0.771	0.409	5.405	-3.517**	0.60
			(0.055)	(0.444)	(0.701)	(3.251)	(1.432)	
CONGO	1961-1985	YW	0.009	0.731*	0.105	0.283	-5.412	0.38
			(0.138)	(0.257)	(0.842)	(2.927)	(5.268)	
EGYPT[1]	1950-1985	ORR	-0.048	0.527**	0.133	0.060	0.550	0.175
				(3.295)	(1.176)	(0.120)	(0.388)	

1. These cases suffered from multicollinearity and the ridge regression procedure was used to correct for this. The numbers in parentheses for these cases are T-ratios.
2. Numbers in parentheses are standard errors.
3. YW is the Yule-Waller method of GLS.

Table 1 - Estimated Coefficients of the Variables in Equation (10)

COUNTRY	YEARS	METHOD	Const.	α	(δ'_n+C_n)	(δ'_m+C_m)	β	Adj R2
ETHEOPIA	1959-1985	YW	0.019	0.073	0.019	3.004**	0.072	0.42
			(0.027)	(0.459)	(0.208)	(1.409)	(0.127)	
GABON	1961-1985	OLS	0.025	0.189	1.095	1.033	-0.265	0.04
			(0.046)	(0.173)	(0.871)	(11.752)	(1.067)	
GHANA	1957-1985	OLS	-0.085	1.049**	1.095	0.008	-0.103	0.13
			(0.060)	(0.500)	(0.772)	(1.638)	(1.632)	
KENYA	1956-1985	YW	-0.030	0.174	1.198**	3.353	0.955	0.29
			(0.054)	(0.163)	(0.555)	(2.252)	(0.831)	
LIBERIA	1963-1985	YW	0.295**	0.117	0.751	-0.981	-9.359**	0.53
			(0.098)	(0.182)	(0.666)	(1.970)	(2.736)	
MADAG.	1960-1985	OLS	-0.009	0.613*	1.717**	-0.526	-0.914	0.46
			(0.047)	(0.350)	(0.448)	(2.760)	(1.293)	
MALAWI	1964-1985	OLS	0.155	0.504	1.048**	4.150	-6.454**	0.51
			(0.101)	(0.244)	(0.464)	(4.350)	(2.732)	
MALI	1961-1985	OLS	0.111	0.013	1.588**	3.799	-3.960	0.42
			(0.081)	(0.519)	(0.413)	(2.250)	(3.541)	

1. These cases suffered from multicollinearity and the ridge regression procedure was used to correct for this. The numbers in parentheses for these cases are T-ratios.
2. Numbers in parentheses are standard errors.
3. YW is the Yule-Waller method of GLS.

Table 1 - Estimated Coefficients of the Variables in Equation (10)

COUNTRY	YEARS	METHOD	Const.	α	(δ'_n+C_n)	(δ'_m+C_m)	β	Adj R2
MAURITANIA	1961-1985	OLS	-0.228	-0.210	0.782	0.374	13.92	-.03
			(0.369)	(0.193)	(0.521)	(1.921)	(17.433)	
MAURITIUS	1957-1985	OLS	0.164	-0.014	1.149	-5.504	-6.142**	0.20
			(0.093)	(0.316)	(1.094)	(9.180)	(2.534)	
MOROCCO	1958-1985	OLS	-0.271	-0.172	0.458	2.714	13.175*	0.02
			(0.199)	(0.411)	(0.676)	(2.767)	(7.572)	
NIGER	1961-1985	OLS	0.178	0.154	4.586**	3.999	-6.049	0.40
			(0.199)	(0.315)	(1.100)	(5.848)	(7.983)	
NIGERIA	1958-1985	OLS	-0.004	0.025	2.082*	-0.183	0.844*	0.12
			(0.049)	(0.317)	(1.086)	(4.037)	(0.453)	
RWANDA	1963-1985	OLS	0.273	0.621	3.216**	9.081	-9.738	0.38
			(0.374)	(0.793)	(0.935)	(6.016)	(11.858)	
SENEGAL	1961-1985	YW	0.134	-0.030	2.121**	-0.598	-4.694	0.39
			(0.121)	(0.419)	(0.928)	(3.199)	(3.947)	
SIERRA L.	1960-1985	YW	-0.108	0.727	0.674	23.176**	3.525	0.50
			(0.034)	(0.497)	(0.406)	(8.663)	(3.107)	

1. These cases suffered from multicollinearity and the ridge regression procedure was used to correct for this. The numbers in parentheses for these cases are T-ratios.
2. Numbers in parentheses are standard errors.
3. YW is the Yule-Waller method of GLS.

Table 1 - Estimated Coefficients of the Variables in Equation (10)

COUNTRY	YEARS	METHOD	Const.	α	$(\delta'_n + C_n)$	$(\delta'_m + C_m)$	β	Adj R2
SOMALIA[1]	1961-1985	ORR	-0.299	0.727**	0.764**	0.633**	6.481	0.13
				(1.975)	(2.862)	(2.360)	(1.658)	
S. AFRICA	1950-1985	YW	-0.098**	0.545**	0.747	0.329	0.547	0.33
			(0.037)	(0.166)	(0.941)	(1.513)	(0.474)	
SUDAN	1955-1985	OLS	-0.038	1.040**	0.204	9.863*	-3.000	0.14
			(0.065)	(0.451)	(0.595)	(5.741)	(2.390)	
TANZANIA	1962-1985	OLS	0.272	-0.096	0.508	-0.614	-6.254	-.09
			(0.209)	(0.436)	(0.481)	(0.995)	(6.969)	
TOGO	1961-1985	OLS	-0.113	0.101	1.618*	3.424	4.420	0.03
			(0.185)	(0.233)	(0.849)	(3.637)	(5.726)	
TUNISIA	1960-1985	OLS	0.052	0.620	0.331	0.612	-4.209	-.09
			(0.062)	(0.508)	(1.205)	(2.071)	(3.241)	
UGANDA	1958-1985	YW	-0.049**	1.708**	1.858**	2.539**	-0.258	0.82
			(0.018)	(0.454)	(0.353)	(0.657)	(0.559)	
ZAIRE	1963-1985	YW	0.192*	0.461	-0.238	-1.521	-8.180	0.27
			(0.110)	(0.522)	(0.436)	(1.206)	(4.783)	
ZAMBIA	1963-1985	YW	-0.248	0.116	1.241**	0.881	7.105	0.48
			(0.201)	(0.100)	(0.493)	(0.653)	(5.883)	

1. These cases suffered from multicollinearity and the ridge regression procedure was used to correct for this. The numbers in parentheses for these cases are T-ratios.
2. Numbers in parentheses are standard errors.
3. YW is the Yule-Walker method of GLS.

Table 4 - Estimated Coefficients of the Variables in Equation (10)

COUNTRY	YEARS	METHOD	Const.	α	(δ'_n+C_n)	(δ'_m+C_m)	β	Adj R2
BANGLADESH	1972-1985	OLS	0.034	-0.138	1.697	1.007	1.115	-.035
			(0.207)	(1.561)	(2.083)	(20.115)	(5.902)	
BURMA	1950-1985	OLS	-0.065	0.655**	1.775**	0.638	0.730	0.31
			(0.057)	(0.267)	(0.612)	(1.932)	(2.014)	
HONG KONG	1962-1985	OLS	-0.035	0.528*	1.326	12.244	0.117	0.28
			(0.053)	(0.299)	(1.227)	(13.032)	(0.646)	
INDIA	1950-1985	YW	0.028	0.239	0.770**	2.508	-1.764	0.57
			(0.023)	(0.180)	(0.142)	(2.323)	(1.702)	
IRAN	1955-1983	YW	-0.176*	1.277**	2.142*	2.107	-0.529	0.58
			(0.097)	(0.458)	(0.954)	(1.035)	(1.131)	
IRAQ[1]	1983-1985	ORR	0.216	0.491	3.850	3.285	-9.757	0.22
				(1.413)	(-1.074)	(3.611)	(2.948)	
ISRAEL	1950-1985	OLS	-0.123**	0.719**	0.336**	0.585**	-1.485**	0.67
			(0.027)	(0.123)	(0.140)	(0.190)	(0.638)	
JAPAN	1951-1985	YW	0.034	0.132	1.496*	0.355	-1.358	0.36
			(0.045)	(0.110)	(0.849)	(3.569)	(1.452)	

1. These cases suffered from multicollinearity and the ridge regression procedure was used to correct for this. The numbers in parentheses for these cases are T-ratios.
2. Numbers in parentheses are standard errors.
3. YW is the Yule-Walker method of GLS.

Table 1 - Estimated Coefficients of the Variables in Equation (10)

COUNTRY	YEARS	METHOD	Const.	α	(δ'_n+C_n)	(δ'_m+C_m)	β	Adj R2
JORDAN	1954-1985	OLS	0.006	0.097	0.848	2.968*	0.697	0.08
			(0.119)	(0.189)	(0.634)	(1.54)	(3.700)	
S. KOREA	1953-1985	OLS	0.016	0.148	2.789**	3.695*	0.173	0.32
			(0.043)	(0.093)	(0.980)	(2.000)	(1.346)	
KUWAIT	1961-1985	OLS	-0.016	0.033	-0.925	-3.807	0.641	-0.08
			(0.106)	(0.372)	(3.002)	(3.424)	(1.044)	
MALDIVES	1955-1985	OLS	0.012	0.082	3.783**	-1.164	0.109	0.32
			(0.140)	(0.158)	(1.041)	(2.351)	(4.203)	
NEPAL	1960-1985	OLS	-0.006	-0.101	0.542	-20.452	1.701	0.04
			(0.041)	(0.272)	(0.361)	(15.336)	(2.211)	
OMAN	1970-1985	OLS	-0.000	0.730**	0.653**	1.113*	-2.774	0.78
			(0.110)	(0.236)	(0.202)	(0.536)	(2.895)	
PAKISTAN	1950-1985	OLS	-0.039*	0.426**	1.294**	1.261	1.170**	0.56
			(0.020)	(0.138)	(0.242)	(1.605)	(0.386)	
PHILIPPINES	1950-1983	OLS	0.023	-0.135	1.341**	2.450	1.518**	0.22
			(0.032)	(0.146)	(0.517)	(2.194)	(0.738)	
SAUDI A.	1961-1985	YW	-0.14	-0.656**	0.060	-0.573	4.054	0.69
			(0.117)	(0.147)	(0.614)	(1.349)	(2.984)	

1. These cases suffered from multicollinearity and the ridge regression procedure was used to correct for this. The numbers in parentheses for these cases are T-ratios.
2. Numbers in parentheses are standard errors.
3. YW is the Yule-Walker method of GLS.

Table 1 - Estimated Coefficients of the Variables in Equation (10)

COUNTRY	YEARS	METHOD	Const.	α	(δ'_n+C_n)	(δ'_m+C_m)	β	Adj R2
SINGAPORE	1967-1985	OLS	0.023	0.290	1.240	3.059	-4.120	-0.10
			(0.134)	(0.273)	(2.463)	(2.524)	(5.962)	
SRI LANKA	1958-1985	YW	0.028	0.238	1.946**	-9.274	-1.324	0.72
			(0.052)	(0.189)	(0.260)	(12.996)	(1.708)	
SYRIA	1960-1985	OLS	0.346	1.156**	3.564**	1.733	-15.243*	0.39
			(0.282)	(0.408)	(1.263)	(1.221)	(8.423)	
TAIWAN	1953-1985	OLS	-.13332	0.503**	4.480**	5.783**	1.115	0.68
			(0.087)	(0.234)	(0.660)	(1.918)	(1.812)	
THAILAND	1950-1985	OLS	-0.041	0.425**	0.663	5.407	0.698	0.20
			(0.053)	(0.178)	(1.139)	(4.308)	(1.866)	
U. A. E.	1972-1985	OLS	-0.380	1.037	0.476	1.974	0.911*	0.26
			(0.239)	(0.710)	(3.107)	(3.071)	(0.409)	
AUSTRIA	1950-1985	YW	0.022	0.050	0.550	0.825	2.145	0.17
			(0.028)	(0.124)	(0.925)	(2.262)	(1.848)	
BELGIUM	1950-1985	OLS	-0.074**	0.446**	0.259	-0.575	0.786	0.39
			(0.024)	(0.108)	(0.753)	(1.022)	(1.291)	
CYPRUS	1964-1985	YW	-0.535**	1.809**	3.948**	0.301	-3.234	0.77
			(0.094)	(0.262)	(1.389)	(4.127)	(2.766)	

1. These cases suffered from multicollinearity and the ridge regression procedure was used to correct for this. The numbers in parentheses for these cases are T-ratios.
2. Numbers in parentheses are standard errors.
3. YW is the Yule-Walker method of GLS.

Table 2 - Estimated Coefficients of the Variables in Equation (10)

COUNTRY	YEARS	METHOD	Const.	α	(δ'_n+C_n)	(δ'_m+C_m)	β	Adj.R2
DENMARK	1950-1985	YW	-0.050*	0.315**	0.880	1.399	-1.191	0.31
			(0.026)	(0.107)	(0.934)	(1.855)	(1.857)	
FINLAND	1950-1985	OLS	-0.055	0.327**	-4.795**	-2.161	0.1045	0.24
			(0.047)	(0.113)	(1.787)	(2.492)	(1.453)	
FRANCE	1950-1985	YW	-0.54**	0.281**	0.156	0.309	2.823**	0.57
			(0.026)	(0.097)	(0.408)	(0.324)	(1.003)	
W. GERMANY	1950-1985	YW	-0.248**	1.022**	0.919	0.496	-2.663**	0.73
			(0.047)	(0.171)	(0.723)	(0.700)	(1.273)	
GREECE	1950-1985	OLS	-0.019	0.292**	-2.831	-1.033	0.787	0.13
			(0.038)	(0.107)	(1.753)	(1.744)	(2.184)	
IRELAND	1950-1985	OLS	-0.014	0.153	2.118**	2.309**	-0.933	0.32
			(0.024)	(0.115)	(0.871)	(0.879)	(0.881)	
ITALY	1950-1985	YW	-0.136**	0.713**	2.190**	-0.359	-2.489	0.59
			(0.031)	(0.132)	(0.795)	(1.998)	(2.729)	
LUXEMBOURG	1950-1985	OLS	-0.036	0.197	-0.951	-2.650	1.620	0.08
			(0.043)	(0.160)	(1.726)	(1.959)	(1.643)	
NETHERL.	1950-1985	OLS	-0.085**	0.462**	2.390**	1.912	-0.824	0.63
			(0.0177)	(0.084)	(0.627)	(1.208)	(1.310)	

1. These cases suffered from multicollinearity and the ridge regression procedure was used to correct for this. The numbers in parentheses for these cases are T-ratios.
2. Numbers in parentheses are standard errors.
3. YW is the Yule-Walker method of GLS.

Table 1 - Estimated Coefficients of the Variables in Equation (10)

COUNTRY	YEARS	METHOD	Const.	α	(δ'_n+C_n)	(δ'_m+C_m)	β	Adj.R2
NORWAY	1950-1985	OLS	0.021	0.006	2.548**	0.631	0.182	0.04
			(0.042)	(0.142)	(1.195)	(1.306)	(1.707)	
PORTUGAL	1950-1985	OLS	-0.122	0.287	0.1453	0.4979	-1.141	0.21
			(0.037)	(0.171)	(1.209)	(1.1070	(1.031)	
SPAIN	1950-1985	YW	-0.028	0.626**	7.107**	10.074**	-7.594*	0.50
			(0.042)	(0.229)	(1.600)	(3.632)	(4.050)	
SWEDEN	1950-1985	YW	-0.014	0.159	0.968	0.375	-0.540	0.17
			(0.032)	(0.147)	(0.766)	(1.024)	(2.024)	
SWITZ.	1950-1985	OLS	-0.028	0.143	0.425	-2.715	2.121	0.34
			(0.035)	(0.127)	(2.434)	(1.972)	(0.610)	
TURKEY	1950-1985	OLS	-0.221	0.321	1.506	3.663	7.943**	0.11
			(0.146)	(0.291)	(1.395)	(2.844)	(4.068)	
U.K.	1950-1985	OLS	-0.033	0.327**	0.111	0.104	-0.369	0.13
			(0.020)	(0.115)	(0.470)	(0.489)	(1.235)	
CANADA	1950-1985	YW	-0.196*	1.080**	0.874	1.082	-2.061**	0.58
			(0.043)	(0.183)	(0.849)	(0.615)	(0.763)	
COSTA RICA	1950-1985	OLS	-0.111**	0.601**	0.983	1.573	2.037**	0.28
			(0.047)	(0.233)	(0.760)	(1.204)	(0.963)	

1. These cases suffered from multicollinearity and the ridge regression procedure was used to correct for this. The numbers in parentheses for these cases are T-ratios.
2. Numbers in parentheses are standard errors.
3. YW is the Yule-Walker method of GLS.

Table 1 - Estimated Coefficients of the Variables in Equation (10)

COUNTRY	YEARS	METHOD	Const.	α	(δ'_n+C_n)	(δ'_m+C_m)	β	Adj.R2
DOM. REP.	1958-1985	YW	-0.348**	0.508**	1.369**	-7.500*	11.286**	0.48
			0.108	0.164	0.483	4.099	3.315	
EL SALVADOR	1950-1984	YW	-0.036	0.817**	1.106**	0.982*	-0.004	0.57
			(0.035)	(0.361)	(0.426)	(0.495)	(0.564)	
GUATEMALA	1950-1985	YW	-0.159*	0.501**	1.528**	-3.251	4.962*	0.70
			(0.081)	(0.167)	(0.572)	(2.199)	(2.807)	
HAITI	1960-1985	OLS	-0.032	0.210	1.291*	-6.313	1.801	0.09
			(0.093)	(0.293)	(0.694)	(8.939)	(6.346)	
HONDURAS	1950-1985	YW	-0.166*	0.640**	0.446	-2.213	3.457	0.39
			(0.085)	(0.216)	(0.403)	(1.805)	(2.307)	
JAMAICA	1962-1985	OLS	-0.090*	0.661**	-1.226	-9.179	-0.869	0.45
			(0.046)	(0.145)	(0.999)	(6.305)	(2.521)	
MEXICO	1950-1985	YW	-0.063	0.501**	3.333**	0.340	0.147	0.55
			(0.041)	(0.200)	(1.322)	(11.066)	(0.477)	
NICARAGUA	1961-1984	OLS	-0.170*	1.479**	0.974	1.376**	-0.998	0.61
			(0.090)	(0.256)	(0.715)	(0.655)	(2.230)	
PANAMA	1962-1985	OLS	-0.137**	0.171	0.842	8.998*	5.109**	0.39
			(0.061)	(0.121)	(0.511)	(4.433)	(1.979)	

1. These cases suffered from multicollinearity and the ridge regression procedure was used to correct for this. The numbers in parentheses for these cases are T-ratios.
2. Numbers in parentheses are standard errors.
3. YW is the Yule-Walker method of GLS.

Table 4 - Estimated Coefficients of the Variables in Equation (10)

COUNTRY	YEARS	METHOD	Const.	α	$(\delta'_n + C_n)$	$(\delta'_m + C_m)$	β	Adj R2
TRIN.&TAB.	1963-1985	OLS	0.039	-0.123	2.058**	5.371	-1.016	0.22
			(0.046)	(0.202)	(0.796)	(6.194)	(1.600)	
U.S.A.	1950-1985	OLS	-0.256**	1.197**	0.397	0.175	2.151**	0.70
			(0.037)	(0.147)	(0.244)	(0.194)	(0.864)	
ARGENTINA	1959-1985	YW	-0.045	0.933**	-0.519	-6.027**	-10.554	0.53
			(0.198)	(0.230)	(0.309)	(2.627)	(13.352)	
BOLIVIA	1956-1985	YW	0.002	0.651**	0.777**	0.593	-2.709	0.75
			(0.075)	(0.138)	(0.304)	(2.532)	(2.756)	
BRAZIL	1955-1984	OLS	-0.055	0.755**	1.326	-0.774	-2.942	0.22
			(0.107)	(0.299)	(1.524)	(5.162)	(3.610)	
CHILE	1957-1985	YW	-0.139*	0.881**	2.055**	0.591	-5.848	0.77
			(0.077)	(0.165)	(0.757)	(1.282)	(4.065)	
COLOMBIA	1950-1985	OLS	-0.023	0.408**	1.428**	2.306	-0.635	0.25
			(0.036)	(0.189)	(0.564)	(1.479)	(0.427)	
ECUADOR	1955-1984	YW	-0.117	0.418	1.430**	1.849*	1.907	0.45
			(0.171)	(0.297)	(0.527)	(0.964)	(4.483)	

1. These cases suffered from multicollinearity and the ridge regression procedure was used to correct for this. The numbers in parentheses for these cases are T-ratios.
2. Numbers in parentheses are standard errors.
3. YW is the Yule-Walker method of GLS.

Table 2 - Estimated Coefficients of the Variables in Equation (10)

COUNTRY	YEARS	METHOD	Const.	α	(δ'_n+C_n)	(δ'_m+C_m)	β	Adj R2
GUYANA	1966-1985	YW	-0.151**	0.664**	0.210**	-0.120	-4.144*	0.83
			(0.036)	(0.140)	(0.093)	(1.272)	(2.174)	
PARAGUAY	1961-1983	YW	-0.058	0.325	0.597	-1.267	2.606	0.41
			(0.125)	(0.239)	(0.777)	(3.449)	(4.317)	
PERU	1950-1981	YW	0.016	0.273	0.860	0.181	-0.483	0.34
			(0.029)	(0.178)	(0.516)	(1.466)	(0.467)	
URUGUAY	1961-1985	YW	-0.012	0.224	0.749	4.476	-1.258	0.33
			(0.036)	(0.230)	(0.608)	(3.450)	(3.119)	
VENEZUELA	1950-1985	YW	-0.177**	-0.042	-0.666	-4.171	6.129**	0.48
			(0.084)	(0.234)	(0.957)	(4.061)	(2.032)	
AUSTRALIA	1950-1985	OLS	-0.085**	0.469**	-3.381**	-2.613**	-0.525	0.50
			(0.037)	(0.112)	(0.949)	(1.264)	(0.821)	
FIJI	1968-1985	OLS	-0.281**	0.906**	2.316**	22.747	4.901	0.47
			(0.090)	(0.324)	(0.934)	(44.823)	(3.021)	
INDONESIA	1962-1985	YW	-0.159	0.235	0.639	3.833	8.211	0.50
			(0.129)	(0.160)	(0.448)	(3.761)	(6.304)	
NEW ZEAL.	1950-1985	OLS	-0.079	0.388	0.122	0.015	1.387*	0.11
			(0.053)	(0.237)	(0.765)	(0.877)	(0.796)	

1. These cases suffered from multicollinearity and the ridge regression procedure was used to correct for this. The numbers in parentheses for these cases are T-ratios.
2. Numbers in parentheses are standard errors.
3. YW is the Yule-Walker method of GLS

Table 2 - Estimated Coeffcients of the Variables in Equation (11)

COUNTRY	YEARS	METHOD	α	β	δ'_n	δ'_m	θn	θm	CON.	adj. R2
ALGERIA	1962-1985	OLS	0.463 (-1.943)	-0.469 (-1.989)	-1.542 (-1.432)	0.934 (1.254)	1.830 (1.664)	-1.252 (-1.672)		0.32
		ORR	0.300 (1.946)	-7.253 (-2.531)	-2.201 (-1.045)	7.698 (0.864)	0.583 (1.621)	-0.218 (-1.516)	0.189	0.17
BENIN	1961-1985	OLS	0.340 (1.457)	0.194 (0.634)	-0.172 (-0.125)	-0.321 (-0.385)	0.420 (0.295)	0.370 (0.445)		-0.02
		ORR	0.357 (1.333)	2.212 (0.646)	0.319 (0.993)	0.833 (0.226)	0.926 (1.279)	0.012 (0.415)	-0.080	-0.16
BRUNEI	1961-1985	OLS	0.262 (1.205)	0.382 (1.796)	0.546 (1.110)	0.328 (0.809)	0.123 (0.243)	-0.419 (-0.964)		0.40
		ORR	0.611 (1.987)	1.756 (1.764)	0.903 (2.650)	2.830 (0.630)	0.077 (1.600)	-0.054 (-1.032)	-0.058	0.22
CAMEROON	1960-1985	OLS	-0.112 (-0.277)	0.192 (0.532)	-1.380 (-1.180)	-0.019 (-0.026)	1.856 (1.532)	0.163 (0.219)		0.33
		ORR	0.114 (0.285)	1.238 (0.503)	-0.530 (-0.586)	2.894 (0.318)	0.394 (1.982)	-0.006 (-0.052)	-0.005	0.03
CAR	1961-1983	COR	0.440 (2.026)	0.105 (0.418)	0.346 (0.092)	0.158 (0.388)	-0.301 (-0.080)	0.001 (0.001)		0.08
		ORR	0.575 (2.374)	0.634 (0.665)	0.129 (0.987)	1.586 (0.853)	0.040 (0.872)	0.003 (0.151)	-0.063	-0.12

1. Values in parentheses are T-ratios ($T > 1.96$ = significance at the .05 level).
2. COR is the Cochran - Orcutt Generalized Least Squares regression procedure.
3. OLS is the Ordinary Least Squares regression procedure.
4. ORR is the Ordinary Ridge Regression procedure.
5. Where COR is used for the first equation, ORR for the second equation has also been adjusted to control for autocorrelation.

Table 2 - Estimated Coeffcients of the Variables in Equation (11)

COUNTRY	YEARS	METHOD	α	β	δ'_n	δ'_m	θn	θm	CON.	adj R2
CHAD	1961-1979	COR	0.874 (3.057)	-0.736 (-2.273)	-1.048 (-0.943)	0.143 (0.500)	1.208 (1.057)	0.027 (0.071)		0.28
		ORR	1.293 (2.222)	-20.711 (-1.624)	-0.528 (-0.862)	1.597 (0.558)	0.274 (0.976)	0.004 (1.129)	0.293	-0.15
CONGO	1861-1985	OLS	0.538 (2.774)	0.019 (0.010)	2.662 (2.331)	-0.433 (-1.451)	-2.645 (-2.300)	0.584 (1.837)		0.41
		ORR	0.584 (2.629)	-0.225 (-0.052)	5.825 (2.263)	-7.141 (-1.523)	-1.304 (-2.195)	0.233 (1.754)	-0.010	0.26
EGYPT	1950-1985	COR	0.692 (4.176)	-0.027 (-0.161)	0.626 (1.373)	1.665 (2.237)	-0.172 (-0.834)	-1.209 (-2.045)		0.35
		ORR	0.682 (3.580)	0.462 (0.274)	0.200 (0.788)	0.506 (1.659)	0.001 (0.029)	-0.057 (-1.363)	-0.070	0.19
ETHIOPIA	1959-1985	COR	-0.062 (-0.175)	-0.051 (-0.188)	-0.638 (-0.647)	0.677 (1.099)	0.683 (0.683)	-0.253 (-0.424)		0.09
		ORR	0.242 (0.955)	0.094 (0.815)	-0.357 (-1.790)	1.355 (1.243)	0.077 (1.869)	0.016 (0.878)	0.010	-0.13
GABON	1961-1985	OLS	0.166 (0.667)	0.018 (0.084)	0.176 (0.291)	-0.264 (-0.882)	0.111 (0.174)	0.427 (1.365)		0.09
		ORR	0.091 (1.115)	-0.765 (-0.129)	0.462 (1.375)	-1.477 (-0.265)	0.075 (1.400)	0.071 (1.489)	0.035	-0.10

1. Values in parentheses are T-ratios ($T > 1.96$ = significance at the .05 level).
2. COR is the Cochran - Orcutt Generalized Least Squares regression procedure.
3. OLS is the Ordinary Least Squares regression procedure.
4. ORR is the Ordinary Ridge Regression procedure.
5. Where COR is used for the first equation, ORR for the second equation has also been adjusted to control for autocorrelation.

Table 2 - Estimated Coeffcients of the Variables in Equation (11)

COUNTRY	YEARS	METHOD	α	β	δ'_n	δ'_m	θn	θm	CON.	adj. R2
GHANA	1957-1985	COR	0.464 (1.984)	0.001 (0.002)	0.203 (0.413)	-0.502 (-1.184)	-0.003 (-0.006)	0.529 (1.286)		0.17
		ORR	0.778 (2.043)	-0.136 (-0.105)	0.534 (1.012)	-0.697 (-0.606)	0.072 (0.918)	0.019 (1.020)	-0.061	-0.001
KENYA	1956-1985	COR	0.121 (0.803)	-0.262 (-0.901)	2.247 (2.853)	-0.150 (-0.799)	-2.083 (-2.458)	0.635 (3.220)		0.57
		ORR	0.149 (0.954)	-0.806 (-0.866)	2.933 (2.196)	1.603 (0.761)	-0.558 (-1.630)	0.029 (2.022)	0.033	0.11
LIBERIA	1963-1985	COR	0.100 (0.543)	-0.490 (-2.640)	-0.328 (-0.385)	-0.168 (-0.439)	0.521 (0.664)	0.105 (0.247)		0.47
		ORR	0.151 (0.891)	-6.396 (-2.201)	0.105 (0.334)	-1.926 (-1.105)	0.164 (1.421)	0.026 (0.616)	0.196	-0.05
MADAG.	1960-1985	OLS	0.226 (1.345)	-0.093 (-0.556)	-1.300 (-0.488)	0.978 (0.392)	1.938 (0.721)	-0.179 (-0.710)		0.46
		ORR	0.523 (1.425)	-0.920 (-0.711)	0.606 (1.214)	1.428 (0.354)	0.239 (2.252)	-0.007 (-0.640)	-0.002	0.41
MALAWI	1964-1985	COR	0.334 (2.307)	-0.429 (-3.127)	2852.5 (0.953)	2823.3 (0.953)	1630.8 (1.240)	-1631.3 (-1.240)		0.74
		ORR	44.755 (1.950)	-7.463 (-2.877)	20.543 (1.872)	20.540 (1.872)	-105.042 (-1.711)	105.147 (1.711)	0.202	0.36

1. Values in parentheses are T-ratios ($T > 1.96$ = significance at the .05 level).
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4. ORR is the Ordinary Ridge Regression procedure.
5. Where COR is used for the first equation, ORR for the second equation has also been adjusted to control for autocorrelation.

Table 2 - Estimated Coeffcients of the Variables in Equation (11)

COUNTRY	YEARS	METHOD	α	β	δ'n	δ'm	θn	θm	CON.	adj. R2
MALI	1961-1985	OLS	-0.024 (-0.118)	-0.265 (-1.139)	1.396 (0.950)	0.287 (0.430)	-0.790 (-0.512)	-0.030 (-0.049)		0.40
		ORR	0.046 (0.095)	-3.604 (-1.0654)	1.054 (2.589)	3.296 (1.054)	0.183 (1.203)	0.009 (0.116)	0.100	0.36
MURITANIA	1961-1985	OLS	-0.376 (-1.073)	0.217 (0.860)	0.173 (0.258)	-0.095 (-0.202)	0.187 (0.296)	0.209 (0.4450)		-0.06
		ORR	-0.050 (-0.901)	4.879 (0.623)	0.205 (1.226)	-0.095 (-0.174)	0.074 (1.348)	0.005 (0.265)	-0.067	0.25
MAURITIUS	1957-1985	OLS	-0.026 (-0.101)	-0.589 (-2.182)	-0.112 (-0.071)	-0.086 (-0.245)	0.338 (0.212)	-0.078 (-0.224)		0.14
		ORR	0.067 (0.379)	-3.394 (-2.352)	0.446 (0.978)	-0.639 (-0.132)	0.061 (0.882)	-0.003 (-0.613)	0.091	-0.16
MOROCCO	1958-1985	OLS	0.094 (0.408)	0.327 (1.877)	-0.325 (-0.558)	-1.447 (-2.280)	0.278 (0.533)	1.729 (2.692)		1.76
		ORR	-0.016 (-0.033)	12.312 (1.853)	-0.112 (-0.112)	-9.465 (-1.996)	0.041 (0.258)	0.355 (2.765)	-0.266	0.08
NIGER	1961-1985	COR	-0.198 (-0.750)	0.132 (0.552)	-3.873 (-2.070)	-0.038 (-0.071)	4.560 (2.325)	0.402 (0.906)		0.55
		ORR	0.037 (0.122)	-3.305 (-0.439)	-2.009 (-0.384)	3.464 (0.241)	1.239 (1.244)	0.031 (0.241)	0.108	0.34

1. Values in parentheses are T-ratios (T > 1.96 = significance at the .05 level).
2. COR is the Cochran - Orcutt Generalized Least Squares regression procedure.
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4. ORR is the Ordinary Ridge Regression procedure.
5. Where COR is used for the first equation, ORR for the second equation has also been adjusted to control for autocorrelation.

Table 2 - Estimated Coeffcients of the Variables in Equation (11)

COUNTRY	YEARS	METHOD	α	β	δ'_n	δ'_m	θn	θm	CON.	adj. R2
NIGERIA	1958-1985	COR	0.009 (0.039)	0.363 (2.051)	-0.128 (-0.354)	0.196 (0.592)	0.459 (1.165)	-0.354 (-1.217)		0.20
		ORR	-0.036 (-0.168)	0.597 (1.894)	0.493 (0.774)	1.522 (0.632)	0.098 (2.212)	-0.045 (-1.503)	0.017	0.04
RWANDA	1963-1985	OLS	0.128 (0.798)	-0.023 (-0.126)	-0.657 (-0.962)	-0.398 (-0.269)	1.309 (1.977)	0.652 (0.442)		0.51
		ORR	0.551 (0.808)	-4.785 (-0.468)	-0.442 (-0.344)	0.619 (0.112)	0.482 (2.972)	0.088 (1.500)	0.115	0.39
SENEGAL	1961-1985	COR	-0.143 (-0.896)	-0.184 (-1.041)	-1.332 (-1.400)	-0.586 (-1.666)	1.929 (1.946)	0.615 (1.581)		0.29
		ORR	0.121 (0.257)	-4.177 (-1.024)	0.175 (0.127)	-5.245 (-1.029)	0.716 (1.570)	0.041 (0.665)	0.105	0.04
SIERRA L.	1960-1985	COR	0.234 (1.230)	0.576 (2.564)	0.054 (0.066)	-0.225 (-0.337)	0.127 (0.152)	0.893 (1.262)		0.596
		ORR	0.428 (1.144)	0.283 (0.122)	0.561 (1.933)	8.155 (1.270)	0.054 (0.960)	0.082 (1.584)	-0.024	0.13
SOMALIA	1961-1985	OLS	0.823 (2.373)	0.668 (1.900)	2.018 (2.798)	-1.928 (-0.767)	-2.482 (-1.258)	2.023 (1.227)		0.27
		ORR	0.911 (2.103)	7.834 (1.658)	1.145 (3.015)	0.170 (0.347)	-0.084 (-1.601)	0.046 (1.464)	-0.371	0.14

1. Values in parentheses are T-ratios ($T > 1.96$ = significance at the .05 level).
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4. ORR is the Ordinary Ridge Regression procedure.
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Table 2 - Estimated Coeffcients of the Variables in Equation (11)

COUNTRY	YEARS	METHOD	α	β	δ'_n	δ'_m	θn	θm	CON.	adj. R2
S. AFRICA	1950-1985	OLS	0.518 (3.269)	0.205 (1.361)	-1.493 (-1.731)	-0.294 (-1.254)	1.630 (1.941)	0.327 (1.473)		0.26
		ORR	0.435 (3.046)	0.614 (1.264)	-2.868 (-1.470)	-1.913 (-0.950)	0.493 (2.000)	0.041 (1.436)	-0.078	0.17
SUDAN	1955-1985	OLS	0.482 (2.267)	-0.023 (-0.092)	-0.611 (-1.280)	0.141 (0.462)	0.763 (1.543)	0.332 (0.937)		0.20
		ORR	0.908 (2.438)	-1.263 (-0.651)	-0.586 (-0.991)	5.336 (0.960)	0.208 (1.669)	0.103 (1.061)	-0.075	0.06
TANZANIA	1962-1985	OLS	-0.051 (-0.198)	-0.056 (-0.181)	-0.578 (-0.452)	-0.773 (-0.894)	0.882 (0.689)	0.659 (0.759)		-0.10
		ORR	-0.090 (-0.241)	-4.900 (-0.816)	0.133 (0.388)	-0.772 (-0.887)	0.136 (1.016)	0.186 (0.353)	0.226	-0.24
TOGO	1961-1985	OLS	0.146 (0.587)	0.158 (0.605)	-0.184 (-0.164)	0.022 (0.074)	0.577 (0.524)	0.165 (0.530)		0.02
		ORR	0.054 (0.438)	1.415 (0.489)	0.485 (1.483)	0.898 (0.414)	0.103 (1.857)	0.020 (1.009)	-0.022	-0.13
TUNISIA	1960-195	OLS	0.194 (0.638)	-0.086 (-0.248)	-4.006 (-1.520)	-0.963 (-0.852)	3.852 (1.523)	0.716 (0.726)		-0.01
		ORR	0.493 (0.958)	-3.077 (-0.963)	-5.090 (-1.430)	-2.989 (-0.505)	0.841 (1.445)	0.054 (0.533)	0.048	-0.17

1. Values in parentheses are T-ratios ($T > 1.96$ = significanceat the .05 level).
2. COR is the Cochran - Orcutt Generalized Least Squares regression procedure.
3. OLS is the Ordinary Least Squares regression procedure.
4. ORR is the Ordinary Ridge Regression procedure.
5. Where COR is used for the first equation, ORR for the second equation has also been adjusted to control for autocorrelation.

Table 2 - Estimated Coeffcients of the Variables in Equation (11)

COUNTRY	YEARS	METHOD	α	β	δ'_n	δ'_m	θn	θm	CON.	adj. R2
UGANDA	1958-1985	OLS	0.245 (2.178)	0.076 (0.760)	2.203 (4.961)	0.394 (3.334)	-1.542 (-3.621)	0.078 (0.657)		0.85
		ORR	1.248 (2.813)	0.217 (0.391)	5.207 (5.044)	1.980 (3.022)	-0.690 (-3.323)	0.013 (0.915)	-0.043	0.81
ZAIRE	1963-1985	COR	0.218 (0.740)	-0.585 (-1.560)	-1.633 (-2.139)	0.261 (0.755)	1.438 (1.878)	-0.604 (-1.755)		0.22
		ORR	0.257 (0.667)	-7.420 (-2.179)	-1.508 (-2.203)	1.516 (0.935)	0.201 (1.512)	-0.071 (-1.694)	0.192	0.001
ZAMBIA	1958-1985	COR	0.465 (2.521)	0.468 (2.684)	-0.570 (-1.304)	0.292 (1.080)	1.123 (2.556)	0.140 (-0.492)		0.48
		ORR	0.200 (2.058)	12.528 (2.060)	-0.308 (-0.561)	0.091 (0.120)	0.623 (3.146)	0.023 (0.648)	-0.453	0.29
BANGLADESH	1972-1985	COR	-0.291 (-0.456)	-0.685 (-2.150)	2.476 (1.348)	1.737 (1.750)	-2.436 (-1.212)	-2.073 (-1.941)		0.38
		ORR	-0.598 (-0.421)	0.104 (0.021)	-0.744 (-0.232)	44.116 (1.331)	0.199 (0.804)	-0.209 (-1.403)	0.096	-0.71
BURMA	1950-1985	OLS	0.426 (2.859)	0.096 (0.670)	1.085 (2.133)	-0.600 (-1.420)	-0.668 (-1.280)	0.762 (1.800)		0.37
		ORR	0.665 (2.690)	0.865 (0.461)	2.332 (2.340)	-3.383 (-1.079)	-0.097 (-0.638)	0.150 (1.556)	-0.070	0.28

1. Values in parentheses are T-ratios ($T > 1.96$ = significance at the .05 level).
2. COR is the Cochran - Orcutt Generalized Least Squares regression procedure.
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4. ORR is the Ordinary Ridge Regression procedure.
5. Where COR is used for the first equation, ORR for the second equation has also been adjusted to control for autocorrelation.

Table 2 - Estimated Coeffcients of the Variables in Equation (11)

COUNTRY	YEARS	METHOD	α	β	δ'_n	δ'_m	θn	θm	CON.	adj. R2
HONG KONG	1962-1985	OLS	0.224 (0.861)	0.070 (0.375)	1.201 (1.071)	-0.632 (-0.955)	-0.877 (-0.825)	1.002 (1.435)		0.34
		ORR	0.420 (1.569)	0.205 (0.340)	1.887 (1.368)	-11.236 (-0.646)	-0.003 (-0.310)	0.073 (1.550)	-0.018	0.22
INDIA	1950-1985	COR	0.151 (1.298)	-0.109 (-0.884)	0.139 (0.313)	0.388 (1.347)	0.557 (1.184)	-0.229 (-0.784)		0.60
		ORR	0.298 (1.900)	-2.109 (-1.494)	0.379 (3.284)	0.575 (0.246)	0.074 (2.786)	0.015 (0.572)	0.026	0.34
IRAN	1955-1983	COR	0.663 (2.618)	-0.061 (-0.441)	0.087 (0.148)	0.025 (0.081)	0.306 (0.764)	0.328 (1.340)		0.47
		ORR	1.262 (4.166)	-0.874 (-0.895)	1.130 (2.187)	0.627 (0.843)	0.045 (1.137)	0.109 (2.085)	-0.175	0.33
IRAQ	1953-1985	OLS	0.106 (0.476)	-0.031 (-0.160)	0.980 (2.674)	0.786 (1.743)	0.471 (2.872)	0.084 (0.453)		0.45
		ORR	0.228 (0.789)	-3.517 (-0.459)	2.313 (3.047)	1.320 (1.587)	0.175 (3.593)	0.070 (1.132)	0.092	0.35
ISREAL	1950-1985	OLS	0.947 (6.072)	-0.383 (-2.508)	0.338 (2.492)	0.457 (2.062)	0.242 (2.254)	0.110 (0.645)		0.72
		ORR	0.622 (6.154)	-1.075 (-2.086)	0.274 (2.302)	0.479 (2.068)	0.033 (2.064)	0.048 (1.304)	-0.108	0.66

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Table 2 - Estimated Coeffcients of the Variables in Equation (11)

COUNTRY	YEARS	METHOD	α	β	δ'_n	δ'_m	θ_n	θ_m	CON.	adj. R2
JAPAN	1951-1985	COR	1.904 (4.885)	-0.076 (-0.684)	-0.419 (-0.755)	-1.041 (-0.714)	0.455 (0.847)	1.118 (0.770)		0.49
		ORR	-0.022 (-0.364)	-0.942 (-0.775)	-1.850 (-1.007)	-11.560 (-1.568)	0.730 (2.224)	0.117 (1.850)	0.071	0.01
JORDAN	1954-1985	OLS	0.186 (1.108)	-0.090 (-0.523)	-1.748 (-1.890)	1.771 (1.855)	1.971 (2.146)	-1.405 (-1.490)		0.22
		ORR	0.144 (0.813)	-0.542 (-0.155)	-2.699 (-1.523)	7.501 (1.716)	1.083 (2.018)	-0.474 (-1.044)	0.028	0.09
S. KOREA	1953-1985	OLS	0.278 (1.272)	0.140 (0.651)	-0.708 (-0.854)	-0.528 (-0.708)	1.007 (1.384)	0.579 (0.915)		0.35
		ORR	0.129 (1.525)	0.297 (0.260)	0.124 (0.114)	-0.019 (-0.008)	0.424 (2.037)	0.075 (1.802)	0.018	0.28
KUAIT	1961-1985	OLS	-0.013 (-0.047)	0.223 (0.776)	-0.450 (-0.797)	-0.108 (-0.254)	0.453 (0.697)	-0.185 (-0.511)		-0.09
		ORR	-0.033 (-0.183)	0.373 (0.738)	-0.255 (-0.235)	-1.162 (-0.867)	0.0221 (0.739)	-0.027 (-0.747)	0.007	-0.24
MALAYSIA	1955-1985	OLS	0.306 (1.389)	0.186 (0.822)	-2.265 (-2.142)	0.340 (0.646)	2.826 (2.726)	-0.324 (-0.635)		0.46
		ORR	0.146 (1.036)	1.959 (0.500)	-6.036 (-1.786)	2.961 (0.465)	1.290 (2.927)	-0.075 (-0.550)	-0.050	0.36

1. Values in parentheses are T-ratios (T>1.96 = significance at the .05 level).
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COUNTRY	YEARS	METHOD	α	β	δ'_n	δ'_m	θn	θm	CON.	adj R2
NEPAL	1960-1985	OLS	-0.148 (-0.531)	0.222 (0.807)	0.585 (0.919)	0.439 (0.673)	-0.390 (-0.454)	-0.737 (-1.130)		0.052
		ORR	-0.049 (-0.266)	1.182 (0.793)	0.356 (1.252)	2.756 (-0.227)	0.008 (0.392)	-0.051 (-1.487)	0.004	-0.08
OMAN	1970-1985	OLS	0.3307 (1.945)	-0.357 (-2.013)	0.826 (4.685)	0.790 (3.359)	-0.256 (-1.299)	-0.569 (-2.117)		0.87
		ORR	0.504 (2.739)	-4.201 (-1.963)	0.869 (4.627)	2.086 (3.456)	-0.063 (-1.173)	-0.133 (-1.826)	0.1122	0.76
PAKISTAN	1950-1985	COR	0.378 (2.881)	0.290 (2.299)	-0.644 (-0.748)	-0.852 (-2.441)	1.150 (1.296)	0.958 (2.531)		0.68
		ORR	0.379 (3.168)	0.842 (2.448)	-0.005 (-0.011)	-6.442 (-1.990)	0.189 (2.076)	0.176 (2.489)	-0.028	0.59
PHILIPPINES	1950-1983	OLS	0.078 (0.399)	0.253 (1.629)	-1.080 (-1.283)	-0.033 (-0.076)	1.512 (1.798)	0.260 (0.5844)		0.28
		ORR	-0.051 (-0.357)	1.340 (1.923)	-0.562 (-0.668)	1.257 (0.331)	0.324 (2.301)	0.014 (0.368)	0.015	0.194
SAUDI ARAB.	1961-1985	OLS	-0.987 (-6.3329)	0.284 (1.775)	0.043 (0.192)	0.109 (0.585)	-0.175 (-0.761)	-0.303 (-1.566)		0.63
		ORR	-0.669 (-6.257)	3.187 (1.481)	0.115 (0.142)	0.688 (0.525)	-0.015 (-0.614)	-0.072 (-1.262)	0.033	0.49

1. Values in parentheses are T-ratios (T>1.96 = significance at the .05 level).
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COUNTRY	YEARS	METHOD	α	β	δ'_n	δ'_m	θn	θm	CON.	adj. R2
SINGAPORE	1967-1985	OLS	0.486	-0.198	0.776	-0.867	-0.828	1.309		0.11
			(1.776)	(-0.748)	(0.549)	(-1.149)	(-0.561)	(2.022)		
		ORR	0.387	-3.273	0.705	-1.139	-0.009	0.138	-0.028	-0.14
			(1.565)	(-0.663)	(0.440)	(-0.538)	(-0.125)	(2.123)		
SRI LANKA	1958-1985	COR	0.163	-0.120	0.625	-0.456	0.223	0.349		0.73
			(1.071)	(-0.712)	(2.133)	(-0.598)	(0.721)	(0.474)		
		ORR	0.208	-0.649	0.970	-4.753	0.246	0.006	0.016	0.59
			(1.388)	(-0.475)	(2.973)	(-0.495)	(2.700)	(0.162)		
SYRIA	1960-1985	OLS	0.496	-0.332	0.5334	-0.023	0.115	0.3441		0.38
			(2.864)	(-1.842)	(1.607)	(-0.045)	(0.393)	(0.753)		
		ORR	0.975	-10.183	1.706	0.382	0.064	0.055	0.214	0.20
			(2.927)	(-1.525)	(2.044)	(0.525)	(1.256)	(1.210)		
TAIWAN	1953-1985	OLS	0.215	0.128	0.446	0.069	0.386	0.253		0.68
			(1.123)	(0.750)	(1.028)	(0.156)	(0.971)	(0.593)		
		ORR	0.239	1.151	1.971	1.888	0.609	0.175	-0.072	0.60
			(1.470)	(0.947)	(3.949)	(1.184)	(4.225)	(1.937)		
THAILAND	1950-1985	COR	0.599	0.074	-2.843	0.874	2.698	-0.825		0.59
			(4.628)	(0.712)	(-4.981)	(1.664)	(5.198)	(-1.542)		
		ORR	0.528	1.354	-8.951	10.218	0.902	-0.054	-0.068	0.29
			(3.342)	(0.870)	(-2.856)	(0.836)	(3.215)	(-0.443)		

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COUNTRY	YEARS	METHOD	α	β	δ'_n	δ'_m	θn	θm	CON.	adj. R2
U.A.E.	1972-1985	OLS	0.626 (1.638)	0.796 (3.162)	-0.238 (-0.561)	0.911 (1.203)	0.089 (0.223)	-1.084 (-1.952)		0.49
		ORR	1.134 (1.996)	0.933 (2.806)	-1.521 (-0.658)	3.270 (1.484)	0.003 (0.533)	-0.056 (-1.616)	-0.385	0.06
AUSTRIA	1950-1985	OLS	0.272 (1.187)	0.397 (2.542)	1.587 (2.175)	-0.298 (-1.641)	-1.146 (-1.526)	0.818 (3.406)		0.29
		ORR	0.048 (0.484)	3.060 (2.278)	4.248 (2.406)	-3.541 (-1.624)	-0.409 (-1.064)	0.021 (3.252)	0.012	0.19
BELGIUM	1950-1985	OLS	0.802 (5.181)	-0.030 (-0.201)	-2.228 (-1.854)	-1.140 (-2.031)	2.289 (1.910)	1.130 (2.008)		0.49
		ORR	0.516 (5.026)	0.265 (0.2119)	-4.295 (-1.717)	-5.466 (-1.931)	0.469 (1.856)	0.149 (1.859)	-0.088	0.42
CYPRUS	1964-1985	OLS	1.094 (9.245)	-0.304 (-2.458)	2.775 (4.151)	0.753 (1.952)	-2.386 (-3.658)	-0.802 (-2.083)		0.82
		ORR	1.868 (8.966)	-4.109 (-1.962)	20.984 (4.052)	26.426 (1.852)	-2.944 (-3.413)	-0.391 (-1.954)	-0.5332	0.74
DENMARK	1950-1985	COR	1.513 (7.339)	-1.378 (-4.661)	-0.400 (-1.015)	-0.350 (-0.858)	0.789 (1.931)	0.686 (1.519)		0.81
		ORR	0.208 (3.194)	-2.953 (-2.477)	-5.029 (-3.644)	1.620 (0.508)	1.194 (4.153)	0.022 (0.295)	-0.018	0.23

1. Values in parentheses are T-ratios ($T > 1.96$ = significance at the .05 level).
2. COR is the Cochran - Orcutt Generalized Least Squares regression procedure.
3. OLS is the Ordinary Least Squares regression procedure.
4. ORR is the Ordinary Ridge Regression procedure.
5. Where COR is used for the first equation, ORR for the second equation has also been adjusted to control for autocorrelation.

Table 2 - Estimated Coeffcients of the Variables in Equation (11)

COUNTRY	YEARS	METHOD	α	β	δ'_n	δ'_m	θn	θm	CON.	adj R2
FINDLAND	1950-1985	OLS	0.379 (2.199)	-0.087 (-0.528)	-1.347 (-1.413)	-0.708 (-0.692)	0.831 (0.856)	0.526 (0.521)		0.26
		ORR	0.305 (2.786)	-0.082 (-0.058)	-5.658 (-2.398)	-4.213 (-1.299)	0.167 (0.566)	0.040 (0.809)	-0.048	0.17
FRANCE	1950-1985	COR	1.563 (8.641)	0.086 (0.713)	-1.106 (-3.292)	0.911 (2.797)	1.065 (2.917)	0.889 (-2.493)		0.75
		ORR	0.143 (3.099)	3.562 (7.748)	-3.604 (-3.427)	0.842 (1.012)	0.497 (3.699)	-0.017 (-0.345)	-0.029	0.43
W. GERMANY	1950-1985	COR	1.333 (10.519)	-0.701 (4.109)	0.626 (1.346)	-0.501 (-2.075)	-0.718 (-1.443)	0.335 (1.788)		0.85
		ORR	0.560 (5.223)	-0.020 (-0.028)	4.029 (4.376)	-2.450 (-3.491)	-0.432 (-3.824)	0.115 (5.752)	-0.128	0.50
GREECE	1950-1985	COR	2.027 (6.872)	0.131 (0.723)	0.301 (0.459)	-1.405 (-2.149)	-0.608 (-0.859)	1.327 (2.077)		0.70
		ORR	0.279 (2.905)	0.593 (0.325)	-2.716 (-0.883)	-4.129 (-1.256)	-0.007 (-0.021)	0.145 (1.018)	-0.015	0.07
IRELAND	1950-1985	OLS	0.327 (0.989)	-0.190 (-0.540)	-1.334 (-0.659)	-0.115 (-0.095)	1.877 (0.985)	0.632 (0.506)		0.32
		ORR	0.128 (1.280)	-0.690 (-0.906)	0.291 (0.327)	0.867 (0.733)	0.323 (2.044)	0.022 (1.104)	-0.009	0.27

1. Values in parentheses are T-ratios (T > 1.96 = significance at the .05 level).
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Table 2 - Estimated Coeffcients of the Variables in Equation (11)

COUNTRY	YEARS	METHOD	α	β	δ'_n	δ'_m	θn	θm	CON.	adj. R2
ITALY	1950-1985	COR	1.100 (7.074)	-0.362 (-1.776)	1.646 (1.281)	-0.173 (-0.110)	-1.348 (-1.174)	0.037 (0.034)		0.60
		ORR	0.652 (5.945)	-2.451 (-1.219)	10.040 (4.179)	-2.731 (-0.534)	-1.282 (-3.209)	0.038 (0.279)	-0.118	0.49
LUXEMB	1950-1985	OLS	0.305 (1.381)	0.220 (1.103)	0.542 (0.473)	-0.190 (-0.777)	-0.645 (-0.561)	-0.116 (-0.508)		0.07
		ORR	0.182 (1.477)	1.572 (1.227)	-0.213 (-0.221)	-1.524 (-0.883)	-0.044 (-0.584)	-0.002 (-0.671)	-0.032	-0.003
NETHERLAND	1950-1985	OLS	0.873 (5.638)	-0.206 (-1.326)	1.306 (3.245)	-0.482 (-0.534)	-0.811 (-2.043)	0.717 (0.771)		0.66
		ORR	0.475 (5.972)	-1.042 (-0.847)	4.205 (3.330)	0.065 (0.030)	-0.303 (-1.610)	0.062 (0.721)	-0.083	0.61
NORWAY	1950-1985	OLS	0.059 (0.296)	-0.139 (-0.456)	-0.446 (-0.368)	0.183 (0.258)	0.826 (0.702)	-0.100 (-0.138)		0.23
		ORR	0.021 (0.179)	-0.196 (-0.138)	0.906 (1.373)	0.509 (0.547)	0.216 (2.042)	-0.001 (-0.019)	0.021	-0.04
PORTUGAL	1950-1985	OLS	0.305 (1.525)	-0.126 (-0.557)	-0.680 (-1.626)	0.348 (0.769)	0.675 (1.879)	-0.316 (-0.696)		0.28
		ORR	0.228 (1.783)	-0.991 (-1.344)	-1.329 (-1.404)	0.957 (0.996)	0.211 (1.897)	-0.020 (-0.541)	-0.002	0.18

1. Values in parentheses are T-ratios ($T > 1.96$ = significance at the .05 level).
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4. ORR is the Ordinary Ridge Regression procedure.
5. Where COR is used for the first equation, ORR for the second equation has also been adjusted to control for autocorrelation.

Table 2 – Estimated Coeffcients of the Variables in Equation (11)

COUNTRY	YEARS	METHOD	α	β	δ'_n	δ'_m	θn	θm	CON.	adj. R2
SPAIN	1950-1985	OLS	0.424 (2.268)	-0.199 (-1.302)	1.247 (0.821)	0.132 (0.047)	-0.433 (-0.288)	0.513 (1.704)		0.45
		ORR	0.462 (2.435)	-5.083 (-1.445)	4.200 (3.027)	2.037 (0.429)	0.317 (2.472)	0.053 (1.871)	-0.024	0.39
SWEDEN	1950-1985	OLS	0.125 (0.455)	-0.099 (-0.310)	-1.088 (-1.071)	0.831 (0.518)	1.335 (1.323)	-0.833 (-0.526)		0.06
		ORR	0.111 (0.960)	-0.299 (-0.179)	-0.934 (-0.923)	1.055 (1.023)	0.425 (1.799)	-0.039 (-0.648)	-0.001	-0.03
SWITZER.	1950-1985	OLS	0.266 (1.457)	0.496 (3.110)	-0.056 (-0.051)	-1.055 (-1.134)	0.637 (0.060)	0.836 (0.944)		0.35
		ORR	0.151 (1.273)	1.978 (3.409)	0.945 (0.417)	-3.356 (-1.567)	-0.015 (-0.145)	0.021 (0.475)	-0.028	0.28
TURKEY	1950-1985	OLS	0.281 (1.357)	0.346 (1.637)	0.984 (-1.045)	0.388 (0.525)	1.168 (1.271)	-0.220 (-0.296)		0.13
		ORR	0.294 (1.119)	6.895 (1.908)	-1.111 (-0.656)	3.102 (0.855)	0.365 (1.540)	0.009 (0.100)	-0.188	0.05
U.K.	1950-1985	OLS	0.464 (2.012)	-0.059 (-0.317)	-0.449 (-0.170)	0.333 (0.203)	0.553 (0.193)	-0.236 (-0.165)		0.10
		ORR	0.268 (2.783)	-0.145 (-0.140)	0.042 (0.203)	0.070 (0.294)	0.011 (0.266)	-0.001 (0.057)	-0.02	0.02

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Table 2 – Estimated Coeffcients of the Variables in Equation (11)

COUNTRY	YEARS	METHOD	α	β	δ'_n	δ'_m	θn	θm	CON.	adj. R2
CANADA	1950-1985	COR	0.841 (6.327)	-0.512 (-2.384)	0.135 (0.159)	0.836 (2.683)	-0.039 (-0.047)	-0.790 (-1.608)		0.62
		ORR	0.899 (0.163)	1.486 (0.580)	1.002 (1.324)	2.381 (0.950)	0.019 (0.144)	-0.049 (0.031)	-0.162	0.45
COSTA RICA	1950-1985	OLS	0.451 (2.763)	0.320 (2.071)	-0.390 (-0.454)	0.193 (0.624)	0.691 (0.819)	0.111 (0.388)		0.29
		ORR	0.559 (2.751)	1.781 (2.135)	0.334 (0.7761)	0.739 (0.731)	0.132 (1.507)	0.007 (0.910)	-0.097	0.20
DOM. REP.	1958-1985	COR	0.419 (2.785)	0.556 (3.467)	0.421 (0.945)	-0.309 (-0.983)	-0.038 (-0.080)	0.039 (0.176)		0.43
		ORR	0.387 (2.402)	6.258 (2.042)	0.741 (1.660)	-4.578 (-1.490)	0.030 (0.684)	0.002 (0.176)	-0.191	0.02
EL SALVADOR	1950-1984	COR	0.373 (2.324)	-0.0122 (-0.092)	0.641 (1.117)	0.238 (0.382)	-0.197 (-0.205)	0.054 (0.224)		0.20
		ORR	0.667 (2.625)	0.226 (0.467)	0.776 (2.951)	0.5117 (1.762)	0.035 (1.414)	0.005 (1.385)	-0.031	0.08
GUATEMALA	1950-1985	COR	0.313 (2.235)	0.275 (2.198)	0.978 (0.911)	-0.258 (-0.851)	-0.697 (-0.652)	0.146 (0.511)		0.50
		ORR	0.456 (3.409)	5.311 (2.155)	0.554 (0.845)	-14.083 (-3.249)	0.046 (0.964)	0.050 (2.001)	-0.162	0.54

1. Values in parentheses are T-ratios ($T > 1.96$ = significance at the .05 level).
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5. Where COR is used for the first equation, ORR for the second equation has also been adjusted to control for autocorrelation.

Table 2 - Estimated Coeffcients of the Variables in Equation (11)

COUNTRY	YEARS	METHOD	α	β	δ'_n	δ'_m	θ_n	θ_m	CON.	adj R2
HAITI	1960-1985	OLS	0.160 (0.558)	0.062 (0.231)	-1.458 (-0.816)	0.197 (0.193)	1.907 (1.036)	-0.407 (-0.385)		0.09
		ORR	0.188 (0.702)	1.815 (0.311)	-0.059 (-0.055)	-4.196 (-0.275)	0.231 (1.595)	-0.016 (-0.159)	-0.0332	-0.003
HONDURAS	1950-1985	OLS	0.543 (3.704)	0.319 (2.001)	-0.226 (-0.399)	0.924 (-2.186)	0.285 (0.518)	0.737 (1.858)		0.32
		ORR	0.635 (3.472)	2.933 (1.597)	0.061 (0.103)	-5.831 (-2.130)	0.046 (0.614)	0.043 (1.509)	-0.147	0.22
JAMAICA	1962-1985	COR	0.505 (3.566)	-0.063 (-0.063)	-1.341 (-5.203)	-0.331 (-2.032)	1.241 (4.089)	0.275 (1.042)		0.84
		ORR	0.426 (3.518)	0.017 (0.009)	-5.140 (-3.961)	-10.467 (-1.761)	0.634 (3.594)	0.003 (0.206)	-0.061	0.54
MEXICO	1950-1985	COR	0.662 (4.004)	-0.028 (-0.250)	-0.408 (-1.293)	-0.301 (-0.500)	0.801 (2.756)	0.226 (0.403)		0.63
		ORR	0.475 (3.931)	0.423 (1.051)	-2.737 (-1.581)	-0.617 (-0.045)	0.478 (4.020)	0.005 (0.118)	-0.072	0.39
NICARAG	1961-1984	OLS	0.697 (3.589)	-0.077 (-0.541)	0.036 (0.120)	0.530 (2.585)	0.019 (0.052)	-0.396 (-1.963)		0.67
		ORR	1.126 (4.596)	-0.706 (-0.373)	0.366 (0.575)	1.355 (2.523)	-0.041 (-0.738)	-0.017 (-2.121)	-0.106	0.54

1. Values in parentheses are T-ratios ($T > 1.96$ = significance at the .05 level).
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COUNTRY	YEARS	METHOD	α	β	δ'_n	δ'_m	θn	θm	CON.	adj. R2
PANAMA	1962-1985	OLS	0.141 (0.631)	0.303 (1.444)	-0.423 (-0.485)	-0.301 (-0.440)	0.785 (0.894)	0.638 (0.991)		0.41
		ORR	0.118 (1.142)	3.923 (2.216)	0.241 (0.674)	1.462 (0.371)	0.185 (1.708)	0.047 (1.746)	-0.093	0.29
TRIN.&TOB.	1963-1985	OLS	-0.151 (-0.622)	-0.099 (-0.448)	0.975 (0.703)	0.031 (0.062)	-0.327 (-0.246)	0.204 (0.458)		0.19
		ORR	-0.051 (-0.319)	-0.800 (-0.592)	0.872 (2.506)	-0.157 (-0.038)	0.078 (1.904)	0.008 (0.930)	0.023	0.05
U.S.A.	1950-1985	OLS	0.842 (7.832)	0.252 (2.188)	0.160 (0.421)	0.233 (0.598)	0.097 (0.249)	-0.093 (-0.289)		0.69
		ORR	1.115 (7.986)	1.787 (2.134)	0.236 (0.920)	0.136 (0.636)	0.011 (0.621)	0.005 (0.266)	-0.234	0.62
ARGENTINA	1959-1985	COR	1.019 (6.241)	-0.405 (-2.639)	-1.562 (-4.055)	-1.916 (-2.238)	1.105 (2.899)	1.516 (1.881)		0.67
		ORR	1.052 (6.337)	-22.459 (-2.552)	-2.636 (-3.638)	-13.881 (-1.675)	0.192 (2.856)	0.147 (1.083)	0.102	0.44
BOLIVIA	1956-1985	OLS	0.434 (4.401)	-0.197 (-2.252)	0.900 (5.815)	0.078 (0.545)	-0.659 (-4.740)	0.019 (0.138)		0.85
		ORR	0.484 (5.036)	-4.162 (-2.201)	2.011 (5.903)	1.043 (0.358)	-1.107 (-4.607)	0.007 (0.314)	0.057	0.80

1. Values in parentheses are T-ratios ($T > 1.96$ = significance at the .05 level).
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COUNTRY	YEARS	METHOD	α	β	δ'_n	δ'_m	θn	θm	CON.	adj. R2
BRAZIL	1955-1984	OLS	0.503 (2.453)	-0.167 (-0.645)	0.201 (0.277)	0.043 (0.102)	-0.010 (-0.016)	-0.075 (-0.176)		0.18
		ORR	0.441 (2.637)	-0.682 (-0.345)	0.644 (1.219)	-0.527 (-0.199)	0.118 (1.113)	-0.014 (-0.142)	-0.031	0.02
CHILE	1957-1985	COR	0.881 (7.021)	-0.193 (-0.878)	1.125 (0.850)	0.204 (0.969)	-0.746 (-0.628)	-0.089 (-0.210)		0.86
		ORR	0.687 (5.064)	-5.327 (-1.794)	1.795 (2.515)	1.606 (1.072)	0.056 (0.380)	-0.025 (-1.604)	-0.087	0.67
COLOMBIA	1950-1985	COR	0.752 (4.213)	-0.194 -1.645)	-0.528 (-0.271)	-0.034 (-0.097)	0.669 (0.344)	0.273 (0.892)		0.40
		ORR	0.404 (2.536)	-0.509 (-1.413)	0.743 (2.269)	-0.091 (-0.052)	0.075 (2.058)	0.012 (1.606)	-0.026	0.20
EQUADOR	1955-1984	COR	0.376 (1.794)	0.241 (1.019)	1.295 (2.097)	0.317 (1.597)	-0.855 (-1.479)	0.073 (0.436)		0.31
		ORR	0.323 (1.276)	0.684 (0.176)	1.112 (1.748)	1.917 (1.953)	0.059 (0.681)	-0.001 (-0.108)	-0.059	0.23
GUYANA	1966-1985	COR	0.900 (3.513)	-0.353 (-1.801)	0.175 (0.683)	-0.008 (-0.042)	0.138 (0.469)	-0.074 (-0.297)		0.78
		ORR	0.513 (4.426)	-2.126 (-1.416)	0.088 (0.875)	0.227 (0.131)	0.135 (1.909)	-0.015 (-0.586)	-0.133	0.67

1. Values in parentheses are T-ratios (T>1.96 = significance at the .05 level).
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COUNTRY	YEARS	METHOD	α	β	δ'_n	δ'_m	θn	θm	CON.	adj. R2
PARAGUAY	1961-1983	COR	1.861 (3.178)	0.094 (0.278)	0.245 (0.214)	-0.574 (-0.343)	-0.199 (-0.183)	0.604 (0.343)		0.46
		ORR	0.222 (1.744)	2.157 (0.688)	-0.549 (-0.573)	-10.487 (-2.578)	0.177 (1.619)	0.071 (2.049)	-0.034	0.11
PERU	1950-1981	OLS	0.312 (1.821)	-0.129 (-0.774)	-1.028 (-1.174)	0.199 (0.428)	1.362 (1.584)	-0.202 (-0.442)		0.22
		ORR	0.251 (1.708)	-0.479 (-1.014)	-0.439 (-0.606)	1.828 (0.708)	0.241 (2.068)	-0.022 (-0.546)	0.015	0.12
URUGUAY	1961-1985	COR	0.401 (1.193)	-0.043 (-0.123)	-1.073 (-0.509)	0.094 (0.114)	1.254 (0.588)	0.049 (0.059)		-0.09
		ORR	0.150 (0.883)	-1.780 (-0.757)	0.408 (0.885)	3.235 (0.813)	0.110 (1.352)	0.052 (0.998)	-0.044	-0.04
VENEZUELA	1950-1985	COR	0.077 (0.345)	0.349 (1.881)	-0.033 (-0.119)	0.485 (-1.549)	-0.101 (-0.374)	0.332 (1.087)		0.13
		ORR	-0.111 (-0.814)	6.017 (4.419)	-0.767 (-1.013)	-5.248 (-1.606)	0.012 (0.214)	0.040 (1.157)	-0.168	0.191
AUSTRALIA	1950-1985	OLS	0.686 (4.150)	-0.049 (-0.359)	0.277 (0.407)	0.299 (0.451)	-0.722 (-1.087)	0.589 (-0.883)		0.51
		ORR	0.466 (4.483)	-0.340 (-0.442)	-1.199 (-1.006)	-0.598 (-0.387)	--0.235 (-1.814)	-0.062 (-1.235)	-0.087	0.44

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COUNTRY	YEARS	METHOD	α	β	δ'_n	δ'_m	θn	θm	CON.	adj. R2
FIJI	1968-1985	COR	0.827	0.396	1.327	1.128	-0.935	-1.089		0.76
			(5.028)	(2.813)	(1.890)	(2.593)	(-1.351)	(-2.670)		
		ORR	1.030	5.108	3.452	166.219	-0.248	-0.234	-0.305	0.41
			(3.766)	(2.081)	(1.959)	(2.026)	(-0.752)	(-1.844)		
INDONESIA	1962-1985	OLS	0.197	0.304	0.069	0.777	0.097	-0.580		0.39
			(0.802)	(1.524)	(0.061)	(1.615)	(0.087)	(-1.237)		
		ORR	0.189	7.43	0.286	6.485	0.031	-0.018	-0.141	0.25
			(1.692)	(1.671)	(0.950)	(1.963)	(0.955)	(-0.778)		
NEW ZEAL.	1950-1985	COR	0.091	0.388	-4.098	1.911	4.653	-1.492		0.37
			(0.715)	(3.227)	(-1.606)	(1.830)	(1.678)	(-1.768)		
		ORR	0.334	1.435	-6.788	3.748	1.700	-0.093	-0.066	0.151
			(1.807)	(2.337)	(-3.409)	(3.077)	(3.450)	(-3.432)		

1. Values in parentheses are T-ratios ($T > 1.96$ = significanceat the .05 level).
2. COR is the Cochran - Orcutt Generalized Least Squares regression procedure.
3. OLS is the Ordinary Least Squares regression procedure.
4. ORR is the Ordinary Ridge Regression procedure.
5. Where COR is used for the first equation, ORR for the second equation has also been adjusted to control for autocorrelation.

Table 3 - Summary of Results for Equation (11)

	α	β	δ'_n	δ'_m	θn	θm
Positive Significant Coefficients	46	14	22	7	28	8
Negative Significant Coefficients	1	8	8	5	5	2
Total	47	22	30	12	33	10

Total Sample size = 105

Works Cited

Ball, Nicole (1988) Security and Economy in the Third World. Princeton: Princeton University Press.

----, (1983) Third World Security Expenditure: A statistical Compendium. Stockholm: Swedish National Defense Research Institute.

Benoit, Emile (1978) "Growth and Defense in Developing Countries." Economic Development and Cultural Change. vol. 26, 271-80.

----, (1973) Defense and Economic Growth in Developing Countries. Lexington, Mass.: D.C. Health.

Biswas, Bausudeb and Rati Ram (1986) "Military Expenditures and Economic Growth in Less Developed Countries: An Augmented Model and Further Evidence." Economic Development and Cultural Change. vol. 34, 361-72.

Brzoska, Michael (1981) "The Reporting of Military Expenditures." Journal of Peace Research. vol. 18, 261-75.

Cappelen, Adne; Nils Petter Gleditsch, and Olav Bjerkholf (1984) "Military Spensing and Economic Growth in OECD Countries." Journal of Peace Research. vol. 21, no. 4, 361-373.

Carr, Jack (1989) "Government Size and Economic Growth: A New Framework and Some Evidence from Cross-Section and Time-Series Data: Comment." The American Economic Review. vol. 79, no. 1, 267-71.

Chan, Steve (1984) "The Impact of Defense Spending on Economic Performance: A Survey of Evidence and Problems." Orbis. vol. 29, 403-434.

Chenery, Hollis, Hazel Elkington, and Christopher Sims (1970) "A Uniform Analysis of Development Patterns." Economic Development Report no. 148. Harvard University, Cambridge MA.

Chowdhury, Abdur (1991) "Acausual Analysis of Defense Spending and Economic Growth." Journal of Conflict Resolution. vol. 35, 80-97.

Deger, Saadet (1986) Military Expenditure in Third World Countries: The Economic Effects. London: Routledge & Kegan Paul.

----, (1985) "Human Resources, Government Education Expenditure, and the Military Burden in Less Developed Countries." The Journal of Developing Areas. vol. 20, 37-48.

----, and Somnath Sen (1983) "Military Expenditure, Spin-Off and Economic Development." Journal of Development Economics. vol. 13, 67-83.

----, and Ron Smith (1983) "Military Expenditure and Growth in Less Developed Countries." Journal of Conflict Resolution. vol. 27, pp. 335-353.

Degrasse, R. W. (1983) Military Expansion and Economic Decline: The Impact of Military Spending on U.S. Economic Performance. Armonk, NY: Sharpe.

Denison, Edward F. (1985) Trends in American Economic Growth, 1929-1982. Washington D.C.: The Bookings Institution.

----, (1967) "Why Growth Rates Differ: Postwar Experience in Nine Western Countries." Washington, D.C.: Brookings Institution.

Domar, Evsey (1946) "Capital Expansion, Rate of Growth and Employment." Econometrica. vol. 14, 137-47.

Dommen, Edward and Alfred Maizels (1988) "The Military Burden in Developing Countries." The Journal of Modern African Studies. vol. 26, 377-401.

Feder, Gershon (1982) "On Exports and Economic Growth." Journal of Development Economics. vol. 12, 1959-73.

Faini, R., P. Arnez, and L. Taylor (1984) "Defense Spending, Economic Structure and Growth: Evidence Among COuntries and Over Time." Economic Development and Cultural Change. vol.32, 487-498.

Grobar, L.M. and R.C. Porter (1989) "Benoit Revisited: Defense Spending and Economic Growth in LDC's." Journal of Conflict Resolution. vol. 33, 318-345.

Hacche, Graham (1979) The Theory of Economic Growth: An Introduction. New York: St. Martin's Press.

Hogendorn, Jan (1987) Economic Development. New York: Harper & Row.

Harrod, Roy (1939) "An Essay in Dynamic Theory." Economic Journal. Vol. 49. 14-33.

Kaldor, Mary (1981) The Boroque Arsenal. New York: Hill and Wang.

Keesing (1979)

Kennedy, Gavin (1983) Defense Economics. New York: St. Martin's Press.

----, (1974) The Military in the Third World. New York: Charles Scribner's Sons.

Lebovic, J. and A. Ishaq (1987) "Military Burden, Security Needs, and Economic Growth in the Middle East." Journal of Conflict Resolution. vol. 31, 106-38.

Lim, David (1983) "Another Look at Growth in Developing Countries." Economic Development and Cultural Change. vol. 31, 377-384.

Lindgren, G. (1984) "Armaments and Economic Performance." Journal of Peace Research. 21, 375-87.

Looney, Robert (1991) "The Impact of Military Expenditures on Human Capital Development in the Arab Gulf States." in Alex Mintz and Steve Chan (eds.)

----, (1988) Third World Military Expenditure and Arms Production. New York: St. Martin's Press.

Maizels, Alfred and Machiko Nissanke (1987) "The Causes of Military Expenditure in Developing Countries." in Saadet Deger and Robert West, Defense, Security and Development. New York: St. Martin's Press.

Mintz, Alex and Chi Huang (1991a) "Ridge Regression Analysis of the Defense-Growth Trade-off in the United States." Defense Economics. (forthcoming, January 1991).

----, (1991b) "Guns vs. Butter: The Indirect Link." American Journal of Political Science. (forthcoming, August 1991).

----, (1991c) "Defense Expenditures and Economic Growth: The Externality Effect: A note." Texas A&M University, College Station, TX., mimeograph.

----, (1991d) "Benoit Revisited? Defense Expenditures and Economic Growth, 1960-1988." Texas A&M University, College Station, TX., mimeograph.

Mok, Jin and Robert Duval (1991) "Guns, Butter and Debt: Balancing Spending Tradeoffs Between Defense, Social Programs, and Budget Deficits." in Alex Mintz (ed.) The Political Economy of Military Spending in the United States. London: Harper Collins.

Mosely, Hugh G. (1985) The Arms Race: Economic and Social Congruences. Lexington Mass: Lexington Books.

Neuman, Stephanie (1978) "Security, Military Expenditures and Socioeconomic Development: Reflections on Iran." Orbis. vol.22, 569-94.

Pryor, F. (1968) Public Expenditure in Communist and

Capitalist Countries. Homewood, IL.: Irwin.

Ram, Rati (1989) "Government Size and Economic Growth: A New Framework and Some Evidence from Cross-Section and Time-Series Data: Reply." The American Economic Review. vol. 79, no. 1, 281-284.

Ram, Rati (1986) "Government Size and Economic Growth: A New Framework and Some Evidence from Cross-Section and Time-Series Data." The American Economic Review. vol. 76, no. 1, 191-203

Rao, V.V. Bhanoji (1989) "Government Size and Economic Growth: A New Framework and Some Evidence from Cross-Section and Time-Series Data: Comment." The American Economic Review. vol. 79, no. 1, 183-204

Rasler, Karen A. and William R. Thompson (1988) "Defense Burdens, Capital Formation, and Economic Growth: The Systemic Leader Case." Journal of Conflict Resolution. vol. 32, 61-86.

Russett, Bruce (1982) "Defense Expenditure and National Well-Being." American Political Science Review. vol. 71, 767-77.

----, (1970) What Price Vigilance? The Burdens of National Defense. New Haven, CT.: Yale University Press.

----, (1969) "Who Pays for Defense?" American Political Science Review. vol. 63, 412-426.

Schiller, Bradley (1985) The Economy Today, 2nd ed.. New York: Random House.

Smith, Ron P. (1980) "Military Expenditure and Investment in OECD Countries, 1954-1973." Journal of Comparative Economics. vol. 4, 19-32.

Solow, Robert (1988) "Growth Theory and After." Nobel Lecture, delivered December 8, 1987, in Robert Solow, i[Growth Theory: An Exposition].

Stockholm International Peace Research Institute [SIPRI] (1974, 1979, 1980, 1989) World Armaments and Disarmament, SIPRI Yearbook. Cambridge Mass.: Oelgeschlager, Gunn, & Hain Publishers.

Summers, Robert and Alan Heston (1984) "Improved International Comparisons of Real Product and It's Composition: 1950-80." Review of Income and Wealth. vol. 30, 207-62.

Summers, Robert and Alan Heston (1988) "Improved International Comparisons of Real Product and Price Levels Estimates for 130 Countries, 1950-85." Review of Income and Wealth. vol. 34, 1-25.

Tobin J. (1955) "A Dynamic Aggregative Model." Journal of Political Economy. vol. 63, 103-15.

Swan, T. W. (1956) "Economic Growth and Capital Accumulation." Economic Record. vol. 32, 334-61.

United States Buereau of the Census (various years) Statistical Abstract of the United States. Washington D.C.: Government Printing Office.

Ward, Michael, et al. (1991a) Economic Growth, Investment, and Military Spending in India, 1950-1988." in Alex Mintz and Steve Chan (eds.) Defense, Welfare, and Growth. London: HarperCollins.

----, (1991b) "Ridge Regression with AR1." University of Colorado at Boulder, Boulder CO., mimeograph.

Wan, Henry (1971) Economic Growth. New York: Harcourt Brace Jovanovich, inc.

Weede, Erich (1983) "Military Participation Ratios, Human Capital Formation, and Economic Growth: A Cross-National Analysis." Journal of Political and Military Sociology. vol.11, 11-19.

West, Robert (1987) "Improved Measures of the Defense Burden in Developing Countries." in Saadet Deger and Robert West, Defense, Security and Development. New York: St. Martin's Press.

APPENDIX

This is an Excerpt from Mintz and Huang (1991a) which explains Ridge Regression in detail.

The Ridge Regression Estimator

The literature on ridge regression virtually always assumes that the original variables in the regression equation are being transformed in the way discussed below.[1] This transformation involves first the standardization of variables so that each variable has a sample mean 0 and a sample standard deviation 1, and then the division of each standardized variable by the square root of (T-1), where T represents the effective sample size.[2] One purpose of this procedure is to make the cross-product matrix of the transformed independent variables a correlation matrix. The linear regression equation with p independent variables then becomes:

$$Y_t = \beta_1 X_{t1} + \dots + \beta_p X_{tp} + e_t , \qquad t=1,\dots T, \qquad (1)$$

or, in matrix notation, $\mathbf{Y} = \mathbf{X}\boldsymbol{\beta} + \mathbf{e}$, where $\mathbf{X}$ is a (Txp) matrix of transformed independent variables and $\boldsymbol{\beta}$ is a (px1) vector of standardized regression parameters.[3]

It is well known that the OLS estimator is obtained by the method of least squares (LS), i.e., by unconstrained minimization of the sum of squared deviations from its expected value, i.e., $S=(\mathbf{Y}-\mathbf{X}\boldsymbol{\beta})'(\mathbf{Y}-\mathbf{X}\boldsymbol{\beta})$. By taking the partial derivatives of S with respect to each of the p parameters in (1), the following p equations (called normal equations) are obtained:

$$
\begin{aligned}
1\ b_1 + r_{12}b_2 + \dots + r_{1,p}b_p &= r_{Y1} \\
r_{21}b_1 + 1\ b_2 + \dots + r_{2,p}b_p &= r_{Y2} \\
\vdots \qquad\qquad\qquad\qquad & \quad \vdots \\
r_{p,1}b_1 + r_{p,2}b_2 + \dots + 1\ b_p &= r_{Yp}
\end{aligned}
\tag{2}
$$

where r_{ij} is the correlation between the ith and jth variables.

Or, in matrix notation, this system of normal equations can written as $(\mathbf{X'X})\mathbf{b}=\mathbf{X'Y}$, where the (pxp) matrix $\mathbf{X'X}$ is now the correlation matrix of p independent variables with 1's on its diagonal and correlations of pairs of independent variables off the diagonal. The OLS estimator, $\mathbf{b}$, is obtained by solving this system of equations simultaneously, that is,

$$\mathbf{b} = (\mathbf{X'X})^{-1}\mathbf{X'Y}. \tag{3}$$

If all the standard assumptions of the linear regression model are met, then the OLS estimator is the best linear unbiased estimator (BLUE) with the following covariance matrix:

$$\mathrm{Cov}(\mathbf{b}) = \sigma^2 (\mathbf{X'X})^{-1}. \tag{4}$$

The effect of multicollinearity on OLS estimates is clear. When perfect multicollinearity exists, $\mathbf{X'X}$ cannot be inverted (because it is singular) and therefore the OLS estimator cannot be uniquely defined. If near-extreme multicollinearity exists, then the diagonal elements of $(\mathbf{X'X})^{-1}$ become very large and thus tend to inflate some OLS estimates obtained from (3) and inflate the variances of some OLS regression coefficients obtained from (4).

In order to control variance inflation and general instability associated with OLS when near-perfect multicollinearity occurs, Hoerl and Kennard (1970a: 58-59) suggested a modification of the least squares method by minimizing S (the sum of squared deviations from its expected value) subject to the <u>constraint</u> that the sum of the squared values of the true parameters β's equals a positive given number, say ϕ, i.e., $\boldsymbol{\beta}'\boldsymbol{\beta}=\phi$. The partial derivatives of this Lagrangian problem with respect to each p parameters produces a system of p normal equations slightly different from (2):

$$\begin{array}{l} (1+k)\ b(k)_1 + r_{12}\ b(k)_2 + \dots + r_{1,p}\ b(k)_p = r_{Y1} \\ r_{21}\ b(k)_1 + (1+k)\ b(k)_2 + \dots + r_{2,p}\ b(k)_p = r_{Y2} \\ \vdots \\ r_{p,1}\ b(k)_1 + r_{p,2}\ b(k)_2 + \dots + (1+k)\ b(k)_p = r_{Yp} \end{array} \tag{5}$$

where k>0 is a constant inversely related to ϕ, and sometimes called the "shrinkage" parameter since it pulls the OLS estimates toward the origin.[4] Since k is added to the diagonal of the correlation matrix $\mathbf{X'X}$, this system of normal equations can be written in matrix notation as $(\mathbf{X'X} + k\mathbf{I})\, \mathbf{b}(k) = \mathbf{X'Y}$. The ordinary ridge regression (ORR) estimator, $\mathbf{b}(k)$, is obtained by solving this system simultaneously, that is:

$$\mathbf{b}(k) = (\mathbf{X'X} + k\mathbf{I})^{-1}\mathbf{X'Y} \tag{6}$$

Intuitively, ridge regression deals with the multicollinearity problem in the following way. When independent variables are linearly independent of each other, the correlation matrix $\mathbf{X'X}$ is an identity matrix $\mathbf{I}$, with 1's on its diagonal and 0's off the diagonal. However, when near-extreme multicollinearity exists, some off-diagonal elements of $\mathbf{X'X}$ become substantially close to one. The ordinary ridge regression estimator in equation (6) tackles this problem by adding a positive and relatively small constant k to the diagonal elements of $\mathbf{X'X}$ in order to augment their size relative to the off-diagonal elements.

Obviously, when k=0, the ridge regression estimator $\mathbf{b}(k)$ collapses to the OLS estimator $\mathbf{b}$, which is known to be unbiased. When k is greater than zero, $\mathbf{b}(k)$ becomes biased because k, a constant, remains after we take the expected value of $\mathbf{b}(k)$. Therefore, k sometimes is also called the biasing parameter. More specifically, when k>0 and nonstochastic then the expected value and the covariance matrix of **b**(k) are:

$$E[\mathbf{b}(k)] = (\mathbf{X'X}+k\mathbf{I})^{-1}\mathbf{X'X}\boldsymbol{\beta} \tag{7}$$

and

$$Cov[\mathbf{b}(k)] = \sigma^2(\mathbf{X'X}+k\mathbf{I})^{-1}\mathbf{X'X}(\mathbf{X'X}+k\mathbf{I})^{-1}. \tag{8}$$

Hoerl and Kennard (1970a: 60-61) showed that the larger the value of k, the larger the bias. At the same time, the larger the value of k, the smaller the variance. The tradeoff between the size of the variance and the amount of bias hinges therefore on the value of k. Hoerl et al. (1970a: 62-63) proved that there always exists a $k>0$ such that **b**(k) has a smaller mean square error (MSE) than **b**.[5] The ORR estimator achieves this MSE gain over the OLS estimator by trading a small bias for a large reduction in the variances.

Since k can be any positive value within a certain range, the crucial question is how to find an "optimal" value of k which minimizes the variance with the smallest bias. Hoerl and Kennard (1970a, 1970b) suggested a method of ridge trace to search for the optimal value of k. Ridge trace is a two-dimensional plot of the values of the p estimated ridge standardized regression coefficients for different values of k, usually between 0 and "some reasonable upper limit." The researcher examines the ridge trace and chooses the smallest value of k when the regression coefficients become stable.[6] Unfortunately, the choice of k by visually inspecting ridge traces is highly subjective and it is difficult to define when stability is first reached.[7]

Numerous methods have therefore been suggested as a solution to the problem of subjectivity involved in ridge regression. An algorithm for the selection of k which performs quite well in simulations (Lin and Kmenta, 1982: 493; Amemiya, 1985: 66) was developed by Hoerl, Kennard, and Baldwin (1975). This formula is based on an earlier findings by Hoerl and Kennard (1970a) that, if **X'X=I**, then a minimum mean square error is obtained if $k=p\sigma^2/\boldsymbol{\beta}'\boldsymbol{\beta}$. Hoerl et al. showed (1975: 106-107) that a reasonable choice for the selection of k is an estimate of $p\sigma^2/\boldsymbol{\beta}'\boldsymbol{\beta}$, that is,

$$\hat{k} = p \cdot s^2/\mathbf{b'b} = p \cdot s^2/\sum_{i=1}^{p} b_i^2, \qquad (9)$$

where p denotes the number of independent variables, s^2 is the OLS estimate of the variance of the error term, and **b** refers to the OLS estimates of standardized regression coefficients. Hoerl et al. (1975) conducted simulations and found that the ORR estimator in equation (6) with biasing parameter k computed from formula (9) has a high probability of producing estimates superior to OLS in terms of mean square error.[8] Using ridge regression, one can therefore separate the effects of individual variables in a regression equation <u>and</u> is likely to get estimates superior to those produced by OLS.