XIV INTERNATIONAL ECONOMIC HISTORY CONGRESS

Helsinki, Finland, 21 to 25 August 2006

Session 85

Guns Versus Butter Paradoxes in History

Education, Defense Spending and Economic Growth in Japan: 1868-1940

Understanding the Time Series Dynamics

Claude Diebolt[1] & Magali Jaoul-Grammare[2]

Abstract: This paper is a study of the nature and importance of possible links between the time series dynamics of military expenditure and that of the social system in Japan before World War 2. A triple database drawn from the work of Ohkawa *et al.*, Taeuber and Diebolt was used to determine the pattern of the Granger-causality relation and the outliers. Although the results show that all the expenditure had an impact on Japanese economic growth, military expenditure played a more central role at both the economic and social levels and, like expenditure on education, can be considered as one of the driving forces of the economic growth of the country. Chronologically, Japan therefore seems to have developed its military and educational sectors, enabling a certain degree of growth, and this favoured capital expenditure.

***JEL* Classification**: C32, H50, N15, O53.

Keywords: Causality, outliers, cliometrics, time series analysis, economic growth, education, military expenditure, Japan.

[1]Association Française de Cliométrie (AFC), BETA/CNRS, Université Louis Pasteur de Strasbourg & Humboldt-Universität zu Berlin.

Address: BETA/CNRS, Faculté des Sciences Economiques et de Gestion, 61 Avenue de la Forêt Noire, 67085 Strasbourg Cedex, France. Tel.: 33 (0)3.90.24.21.87, Fax.: 33 (0)3.90.24.20.71, E-mail: cdiebolt@cournot.u-strasbg.fr.

[2]Association Française de Cliométrie (AFC), LAMETA/CNRS, Université Montpellier I.

Address: Faculté des Sciences Economiques, Espace Richter, Avenue de la Mer, C.S. 79606, 34960 Montpellier Cedex 2, France. Tel.: 33 (0)4.67.15.83.16, Fax.: 33 (0)4.67.15.84.67, E-mail: m.jaoul@lameta.univ-montp1.fr.

"*The fascinating growth of certain Asian economies in the past 30 years has been the subject of many analyses in which the influence of expenditure on defense has never been mentioned. However defense economics has studied in great depth the relations between expenditure on defense and economic development. […] This link suggests that there is here an interesting field for reflection for an economic history of these countries.*" (Caro, 1998, p. 141).

1. Introduction

No economic research can present a monistic explanation of growth. Indeed, the effects of many variables overlap to create a favourable texture for economic expansion. Military investment is perhaps an important leaven but it can only have an effect if it is supported by a combination of special political, economic and social circumstances. Analysis of socio-economic activity in Japan from the viewpoint of military investment does not therefore give any prior decisive importance to this factor at the expense of the other structural variables. However, given the fundamental role played by military expenditure in the country's economic growth, we consider that it is important to stress this impact. But is there a connection between the level of development in Japan and the level of military expenditure? The reply seems obvious. Nevertheless, the question of knowing whether military expenditure is the cause or in contrast the result of economic development is far from having been settled by the specialists and the two hypotheses are still opposed.

In a general manner, the pattern of development of Japan's military expenditure clearly shows growth over a long period and threshold effects. This would seem to strengthen Wagner's law of growth of public expenditure (1904, 1913) in which public expenditure increases with economic growth. Furthermore, relatively high growth rates are observed periodically, followed by a period of low growth rates. This definition corresponds to growth in stages consisting of alternate highs and lows. This ratchet phenomenon was first shown by Kendrick and Wehle (1953) in their study of federal expenditures in the United States. However, they provide no explanation for this type of growth and just seek the causes empirically. In a study published in 1961, Peacock and Wiseman refer to the same type of development in stages in the United Kingdom as the 'displacement effect'. The amount of resources likely to be produced by the fiscal system (but without causing discontent) determines the amount of public expenditure. They considered that the displacement effect was a direct result of the war.

As was put forward by Von Ciriacy-Wantrup (1936), the greatest changes seem to be those caused by wars and revolutions through the economic, institutional, legal and population changes that they necessarily cause. According to this analysis, the long periods of good times are basically caused by the vast governmental expenditures relating to preparation for war and the war itself, while the periods of chronic hard times, on the other hand, are caused by the difficult readjustments incident to the sharp curtailment of war expenditures. The best case for this thesis can probably be made with respect to the first long wave (1793/1797-1847/1850). During the long period of the Napoleonic wars, the vast government expenditures which they entailed gave a stimulus to economic expansion and hastened the changes in the economic system ushered in by the Industrial Revolution. There can be no doubt that the impact of these wars played a very considerable role. Similarly, the sharp curtailment of expenditures, together with the necessary readjustments to a peacetime basis after the whole of western Europe had for a quarter of a century adjusted itself to war conditions, goes far toward explaining the difficulties of the long period of chronic hard times from 1817 to the end of the 1840s.

More recently, Goldstein (1988) established a link between the turning points in long cycles of the economy and the periodic outbreak of wars. This seems to be an interesting approach. Wars are special moments in the metamorphosis of economic structures. They take the form of stages during which the economic sphere has to change under the weight of political issues. However, wars deform part of reality. They prevent the apprehending of the overall range of the phenomenon. This being so, they are not just milestones marking the turning points of history. They exist as facts of considerable importance for the economic growth of a country.

Starting from this point, the aim here is to study the nature and importance of the links that may exist between the structural dynamics of military expenditure and that of the socio-economic system (economics, demography, etc.). In other words, the causal relations and interactions between these two systems are analysed, that is to say the extent to which one of them affects the other and how the other has a retroactive effect on the first. The logical outcome of such research will be the determining of a causality relation, if such exists, between the two systems. Does the dynamic of the socio-economic system condition military development or might it rather be the evolution and change in military financing that changed the economic and social system in Japan before World War 2?

The article is in three parts. A succinct description of the state of knowledge is followed by a description of our database and then discussion of the results of our cliometric tests.

2. State of knowledge

The development of the Asian economies has been the subject of numerous analyses in which the influence of military expenditure has not had a clear-cut role. For example, Benoit was the first in 1973 to test empirically a model aimed *a priori* at demonstrating that the slowing of the growth in developing countries results from the scale of the resources devoted to defense.

Nevertheless, the author's resulted showed the opposite. This work is fairly surprising, revealing a positive correlation. Indeed, the countries that had borne the largest expenditure were those with the fastest growth. According to Benoit, expenditure on defense might therefore have favourable effects on growth that are strong enough to make up for the negative effects. He also considers that military expenditure creates a reassuring context that is favourable for investment and hence for growth.

Other authors such as Dunne (1966), Ram (1995), Deger and Sen (1995) and then Caro (1998) subsequently discussed the question. All the research tends to show that military expenditure does not have one particular effect on growth but that the effect tends to vary in time and space. According to Deger and Sen, for example, only two of the nine channels by which expenditure on defense can influence growth display a positive impact: Benoit's positive externalities channel and the Keynesian channel of support for overall demand. According to Ram (1995), although empirical studies do not reveal a positive effect of military expenditure on growth, they do not make it possible to conclude that its has a negative impact. He considers that this indecision results on the one hand from econometric weakness (related to the problem of the measurement and imprecision of the series) and on the other from the heterogeneity of the countries studied. Finally, Caro (1998), in his analysis of the ASEAN countries from 1967 to 1993, highlights the importance of the positive externalities of military expenditure for '*the coherence of the growth strategy*' of these countries. Nevertheless, numerous authors continue to attribute the rapid growth of the Japanese economy (during the post-war period) to the low level of military expenditure (1% of GNP). Concerning other countries, Dunne and Nikolaidou (2001) suggest a positive impact of military burden on growth for Greece and, on the contrary, a negative effect for Spain, while for Portugal, there is no evidence of any causal links. They also show (Dunne, Nikolaidou & Smith, 2002) that military spending does not have a positive effect on growth in the long run, but would appear to have a clear negative short run effect.

3. Database and methodology

A triple base of original data drawn from the work of Ohkawa *et al.* (1957, 1968, 1974), Taeuber (1958) and Diebolt (2003) is used to analyse the evolution of the Japanese economy before World War 2.

The following indicators (in logarithms) are considered between 1881 and 1940:

- total expenditure on education (DEDUC);
- military expenditure (DMILI);
- capital expenditure (DCAP);
- gross national product (GNP);
- population (POP);
- total school attendance (SCO).

Analysis of causality involves the use of VAR (Vector Auto-Regressive) modelling that enables us to envisage all the causal relations between two variables without *a priori* exogenising one of them.

Proposed in the 1980s by Sims, VAR modelling was initially opposed by 'classic' econometrists (in favour of the formalisation generated by the Cowles Commission). Indeed, the latter category tended to favour theory, constructed their models on theoretical bases and considered that it was essential to put forward hypotheses concerning relations between variables. Those in favour of the empirical approach considered that the model should be based on solid statistical results, making it possible to reveal the structure of markets.

The advantages of over classic modelling non-structural VAR modelling are first that it allows better dynamic analysis of the systems, taking into account the intrinsic structure[3] of the series and the dynamic effects between the variables and secondly that it makes it possible to envisage all causal relations between two variables without any *a priori* assumptions with regard to the exogeneity of any of them.

The VAR models form a continuation of the work of Granger (1969) on the causal relation between two variables. Using this viewpoint, Sims proposes modelling that extends analysis of causality to a system of several variables. For this, he proposes to treat all the variables in an identical manner without a condition of exclusion or exogeneity and selecting the same delay for each of them in all the equations.

VAR models nevertheless have their limits. The first is the problem of the number of variables to be included in the model and the resulting estimation problem. Indeed, VAR models differ from theory-based structural models in the greater scope left for empiricism, but how many variables should be chosen in this case? The number of variables to be included in the model thus brings the problem of vanishing degrees of freedom. Indeed, considering 20 variables and 4 delays leads to estimating 80 coefficients per equation and the number of unknown coefficients often approaches the size of the sample analysed.

Another criticism often aimed at VAR models is the small amount of theory to which they refer, describing them as atheoretical models. This 'theory versus measurement' debate had already opposed economists in the 1920s following the work of Mitchell (1913)[4] and reappeared in the 1980s with that of Sims. However, this debate is far from settled, and if VAR models are criticised for their lack of theory, the theoretical models of supporters of the Cowles Commission are also criticised for their lack of flexibility (Lucas, 1976)[5]. In the face of these differences of opinion, our cliometric approach (research in quantitative history structured by economic theory and fed by econometric methods) proposes the reconciliation of theory and measurement in proportions providing both the theoretical and empirical debate required in economics.

The use of this type of modelling requires the prior testing of certain hypotheses. The work must be performed with stationary variables. An Xt process is said to be stationary if all its moments are invariant for any change in the time origin. There are two types of stationary process: TS processes (Trend Stationary Processes) that display deterministic non-stationarity and DS processes (Difference Stationary Processes) with random stationarity. These processes are stationarised respectively by deviations from trend and by a differences filter. In the latter case, the number of differences filters is used to determine the order to integrate the variable. A variable will be said to be integrated in order 'd' if it is necessary to differentiate it d times to render it stationary.

[3]The intrinsic structure of the series is related to its identification in the ARIMA classification (Box and Jenkins, 1976).

[4]The 'theory versus measurement' debate started in the analysis of Mitchell cycles (1913) that laid the empirical foundations of modern macroeconomic theory.

[5]Lucas (1976) used strong theoretical bases to argue that these models are fundamentally imperfect for assessing the consequences of the results of political alternatives. He puts forward the reason that, for example, their functioning plans little advice for political managers with regard to predicting changes of effect in economic policy because it is improbable that the parameters of the models remain stable under alternative economic policies.

In this paper, the variables are stationarised using Dickey-Fuller tests, simply because we found no changes in the results by using another (more recent) methodology (see especially Elliott, Rothenberg and Stock, 1996, Kwiatkowski, Phillips, Schmidt, Shin, 1992, Ng and Perron, 2001).[6]

This procedure consists of estimating equation (1):

$$(1 - L)\, X_t = a_0 + a_1 T + b_0 X_{t-1} + \sum_{j-1}^{k} b_j\, (1 - L)\, X_{t-j} + u_t \quad (1)$$

where L is a lag operator, T is a trend and u_t is a disturbance term. Practicaly we reject the null hypothesis of non-stationarity (i.e. $b_0 = 0$) if b_0 is sufficiently negative. Critical value are obtained from Dickey and Fuller (1979) and Mac Kinnon (see Engle & Granger 1991).

Afterwards we must test if series are cointegrated or not[7].

The term 'cointegration' first appeared in 1964 in Sargan's work but only received true theoretical coverage in 1987 by Engle and Granger. Cointegration encompasses the idea that two or more series evolve together in time and generate statistical equilibrium in the long term, whereas the variables may move in different directions in the short term. However, if they continue to move far from each other in the long term, economic forces such as a market mechanism or government intervention makes it possible to bring them towards each other.

To test that two series X_t and Y_t, forming the vector Z_t, are cointegrated, we use the methodology developed by Johansen (1998, 1992, see also Engle & Granger 1991). This method is based upon an error correction representation of a VAR(p) model with a Gaussian error term:

$$\Delta Z_t\, \alpha + \sum_{k=1}^{p-1} ß_k\, \Delta Z_{t-k} + \delta \Delta Z_{t-p} + \mu_t \quad (2)$$

[6]«*Following the seminal work of Fuller and Dickey and Fuller, numerous procedures haven been developed for testing the hypothesis that a univariate time series contains a unit root against the alternative hypothesis that it is level or trend stationary, called "standard unit root tests". However, the power of these unit root tests has been questioned. Evidence has been provided indicating that these unit root tests have size distorsions and low power against meaningful stationary alternatives. Therefore, some useful modifications of these tests have been suggested to solve these problems. Moreover, these standard unit root tests have a common feature of including a constant and/or deterministic trend in their regression. However, some studies showed that elimination of deterministic components may bring an efficiency gain to the unit root tests, and this type of tests is called "efficient unit root tests". Nevertheless, the tests mentioned above are all based on the null hypothesis of a unit root, which assures that the hypothesis will be accepted (at conventional significance level of 5%) unless there is strong evidence against it. As a result, "stationarity tests" have been proposed for which the null hypothesis is level or trend stationary against the unit root alternative. Besides, some studies have shown that the presence of breaks in the time series can also bias the unit root and stationarity tests. Therefore, some tests taking into account structural breaks have been developed "unit root tests with structural changes" and "stationarity tests with structural breaks"*». (Darné and Diebolt, 2005).

[7]A necessary condition for cointegration is that the variables must be integrated on the same order. Johansen's test is used here to test cointegration together with, if necessary, the resulting VECM (Vector Error Correcting Model). The subsequent analysis of causality is not modified.

where Z_t is an m ⊗ 1 vector of I(0) variables (in our case, $m = 2$), β_k and δ are m % m matrixes of unknown parameters, and μ_t is a Gaussian error term.

This equation is estimated by a maximum likelihood procedure under the hypothesis of a reduced rank $r < m$ of δ,

$$H(r): \delta = - \Gamma\Omega' \quad (3)$$

where Γ and Ω are $m \otimes r$ matrixes. Johansen has demonstrated that under certain conditions these reduced rank condition of matrix implies that $\Omega' Z_t$ is stationary.

The problem induced by cointegration is the spurious regression due to the linear combination and so all cointegrated relations must first be eliminated. Moreover, the existence of cointegration between variables implies that the framework within which the causality is examined is modified with a VECM (Vector Error Correcting Model).

The Johansen test is generally used to test cointegration. This test excludes alternative hypotheses concerning the number r of cointegration relations. First, one test of Ho: r = 0 against H_1: r >0. If Ho is accepted, the test stops; if not the next stages is H'o r = 1 against r > 1. This process continues along Ho is rejected. If testing Ho: r = k against r >k, and rejecting Ho, this means that the series are not cointegrated.

At the theoretical level, demonstrating causal relations between the economic variables enables better understanding of economic phenomena and brings supplementary information with regard to the anteriority of the events. This also engenders the establishment of an optimised economic policy.

Finally, to test for causality between time series X_t and Y_t, components of the vector Z_t, we follow the classical procedures of Engle and Granger (1991). The methodology applied differs whether time series are cointegrated or not. If they are not, we use the standard methodology developed by Granger (1969). This test is based on the estimation of dynamic relationships before first differentiated variables (if their levels are not stationary). These relationships are:

$$(1 - L)\, X_t = \gamma_0 + \sum_{i=1}^{m} \lambda_i (1 - L)\, X_{t-i} \quad (4)$$

$$+ \sum_{k=1}^{p} \sigma_k (1 - L)\, Y_{t-k} + \nu_t$$

$$(1 - L)\, Y_t = \eta_0 + \sum_{i=1}^{n} \varphi_i (1 - L)\, Y_{t-i} \quad (5)$$

$$+ \sum_{k=1}^{q} \tau_k (1 - L)\, X_{t-k} + \mu_t$$

where (ν_t, μ_t) is a random vector with mean 0 and finite covariance matrix.

To ascertain the presence of one (or more) causal relationship(s), we have to test for the joint significance of the causal variables, i.e. lagged Y_t in equation (4) and lagged X_t in equation (5) by means of a classical *F* test. For instance, if $\sigma_k \neq 0$ and $\tau = 0$, we conclude that *Y* Granger-causes *X*. However, if the time series appear to be cointegrated, causality has to be investigated within the framework of an error correction model. The latter links short-run variations of the series to the disequilibrium error (i.e. the gap between actual behaviour and the long-run relationship given by the cointegrating vector).

The error correction model is given by:

$$(1 - L)\, Z_t = \alpha_0 + \sum_{i-1}^{p-1} \beta_i (1 - L)\, Z_{t-i} - \Gamma\Omega'\, Z_{t-p} + \nu_t \quad (6)$$

The existence of one cointegrating relationship between the two variables ensures that there exists at least on causality link between them. Testing for causality is therefore equivalent to testing for joint significance of the parameters on the assumed causal variables.

The causality notion developed by Granger is used here: variable y_{1t} causes variable y_{2t} if the forecasting of the latter is improved by incorporating in the analysis information concerning y_{1t} and its past.

With two variables, the VAR(p) model is as follows[8]:

$$\begin{bmatrix} y_{1,t} \\ y_{2,t} \end{bmatrix} = \begin{bmatrix} A_0^1 \\ A_0^2 \end{bmatrix} + \begin{bmatrix} A_1 & B_1 \\ C_1 & D_1 \end{bmatrix} \begin{bmatrix} y_{1,t-1} \\ y_{2,t-1} \end{bmatrix} + \begin{bmatrix} A_2 & B_2 \\ C_2 & D_2 \end{bmatrix} \begin{bmatrix} y_{1,t-2} \\ y_{2,t-2} \end{bmatrix} + \ldots + \begin{bmatrix} A_p & B_p \\ C_p & D_p \end{bmatrix} \begin{bmatrix} y_{1,t-p} \\ y_{2,t-p} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \end{bmatrix}$$

- Ho is tested: y_{2t} does not cause y_{1t}, that is to say that the coefficients of the matrix blocks B are nil.
- H'o is tested: y_{1t} does not cause y_{2t}, that is to say that the coefficients of the matrix blocks C are nil.
- If the two alternative hypotheses H_1 et H'_1 are accepted, the term retroactive loop is used.

---

[8]In the general maner :

$$\begin{bmatrix} Y_{1,t} = \Phi_{11}^1 . Y_{1,t-1} + \ldots + \Phi_{11}^p . Y_{1,t-p} + \ldots + \Phi_{1n}^1 . Y_{n,t-1} + \ldots + \Phi_{1n}^p . Y_{n,t-p} + \varepsilon_{1t} \\ \ldots \\ \ldots \\ \ldots \\ Y_{n,t} = \Phi_{n1}^1 . Y_{1,t-1} + \ldots + \Phi_{n1}^p . Y_{1,t-p} + \ldots + \Phi_{nn}^1 . Y_{n,t-1} + \ldots + \Phi_{nn}^p . Y_{n,t-p} + \varepsilon_{nt} \end{bmatrix}$$

with n = number of variables ;
p = number of lags ;
ϕ^p_{ij} = coefficient of the variable j with lag p in the equation of the variable i.

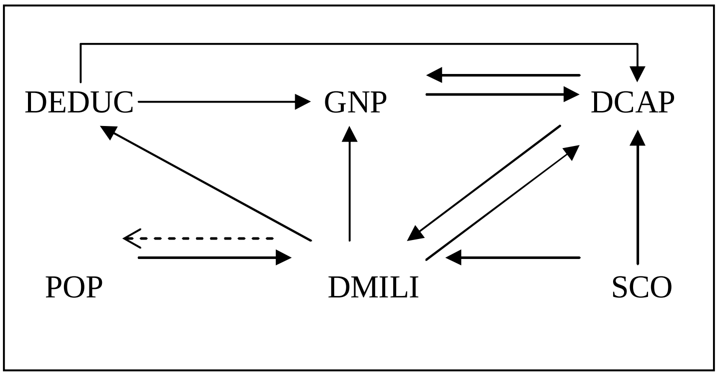
4. Empirical results

4.1. Causality

Augmented Dickey-Fuller tests lead to stationarising all the variables by first differences except for school attendance figures that were handled using a mixed process with stationarisation and elimination of the series trend by first differences. The entire system is taken into consideration for study of the socio-economic relations between the variables to determine the most favourable sectors of the economy for growth. The Johansen test gives the conclusion that there is no relation of cointégration between the various variables. This means that there is no long-term relations between them and the analysis will be performed with a VAR model.

The system as a whole: GNP, education expenditure, military expenditures, capital expenditure, population, school attendance numbers.

The causality pattern can be represented as follows:



------ Significant at 10%

All expenditures play a role in the Japanese economic system:

- expenditure on education influences economic growth, as put forward in the theories of human capital and endogenous growth;
- capital expenditure fosters close links between the GNP on the one hand and military expenditure on the other, being both the cause and the result of these two indicators;
- military expenditure nevertheless plays a more central role from both the economic and social points of view. They are linked with all the variables in the system. On the one hand, they appear to be more the consequence of social variables (population, school attendance) and on the other seem to be one of the causes of economic indicators (expenditure on education, GNP). The loop formed with capital expenditure highlights the narrow role of these two types of expenditure for the Japanese economy. One can therefore wonder about the respective roles of each type of expenditure with regard to Japanese growth.

4.2. Outliers

As an extension to the causality pattern, we introduce here another econometric technique for shock analysis: the outliers methodology.[9] Our basic assumption is to say that the regular shocks we observe for the Japanese socioeconomic development are superposed by irregular shocks which appear rarely. This includes the question whether the long-term economic development of Japan is caused by such extraordinary shocks and wars especially. If this was the case, economic growth could probably not be explained as a systematic process but would have to be traced back to specific historical events.

«*Outliers represent sudden temporary or permanent shifts in the level of a time series. There are several methods for the detection of outliers based on intervention analysis as originally proposed by Box and Tiao (1975). An often used procedure is that of Tsay (1988). This method was also used by Balke and Fomby (1994), althought with some modifications. Here we will use an improved algorith by Chen and Liu (1993), which is readily available, with slight modifications, in the computer program TRAMO developed by Gómez and Maravall (1997, 2001)*».[10]

Consider a univariate time series y_t^* which can be described by the ARIMA(p, d, q) model:

$$\alpha(B)\phi(B)y_t^* = \theta(B)a_t \quad (7)$$

where B is the lag operator, a_t is a white noise process, $\alpha(B), \phi(B), \theta(B)$ are the lagged polynomials with orders *d, p, q*, respectively. The outliers can be modelled by regression polynomials as follows:

$$y_t = y_t^* + \sum_I \omega_i v_i(B) I_t(\tau) \quad (8)$$

where y_t^* is an ARIMA process, $v_i(B)$ is the polynomial characterizing the outlier occuring at time t = τ, ω_i represents its impact on the series and $I_t(\tau)$ is an indicator function with the value 1 at time t = τ and 0 otherwise.

In this paper, three main outliers are classified as:

– Additive Outliers (AO) that affect only a single observation at some points in time series and not its future values. In terms of regression polynomials, this type can be modelled by setting: $v_1(B) = 1$.

[9]For the reader interested in the complete mathematical and statistical presentation of the outlier methodology, please cf. Darné and Diebolt, 2004, 2006.

[10]Darné and Diebolt, 2004, p. 1452.

$-$Level Shifts (LS) that increase or decrease all the observations from a certain time point onward by some constant amount. In this case, the polynomial: $\nu_i(B) = 1/(1-B)$.

$-$Temporary Changes (TC) that allow an abrupt increase or decrease in the level of a series which then returns to its previous level exponentially rapidly. Their speeds of decay depend on the parameter $\nu_i(B) = 1/(1-\delta B)$, where 0<δ<1.

It is considered that AOs are outliers which are related to an exogenous and endogenous change in the series, respectively, and that TCs and LSs are more in the nature of structural changes. TCs represent ephemeral shifts in a series whereas LSs are more the reflection of permanent shocks.

An ARIMA model is fitted to y_t^* in (7) and the residuals are obtained:

$$\hat{a}_t = \pi(B)Y_t, (9)$$

$$\text{where } \pi(B) = \frac{\alpha(B)\phi(B)}{\theta(B)} = 1 - \pi_1 B - \pi_2 B^2 - \ldots$$

For the three types of outliers in (8), the equation in (9) becomes:

$$\text{AO: } \hat{a}_t = a_t + \omega_1 \pi(B) I_t(\tau)$$

$$\text{TC: } \hat{a}_t = a_t + \omega_2 \left[\frac{\pi(B)}{(1-\delta B)} \right] I_t(\tau)$$

$$\text{LS: } \hat{a}_t = a_t + \omega_3 \left[\frac{\pi(B)}{(1-B)} \right] I_t(\tau)$$

These expressions can then be viewed as a regression model for $\hat{a}_t$, i.e.,

$$\hat{a}_t = \omega_i x_{i,t} + a_t$$

With:

for all i and $t < \tau$: $\quad x_{i,t} = 0$

for all i and $t = \tau$: $\quad x_{i,t} = 1$

$$x_{1,t+k} = -\pi_k \qquad \text{(AO)};$$

for $t > \tau$ and $k \geq 1$: $\quad x_{2,t+k} = \delta^k - \sum_{j=1}^{k-1} \delta^{k-j} \pi_j - \pi_k \qquad$ (TC);

$$x_{3,t+k} = 1 - \sum_{j=1}^{k} \pi_j \qquad \text{(LS)}.$$

The test statistics for the types of outliers are given by:

$$\text{AO: } \hat{\tau}_1(\tau) = [\hat{\omega}_1(\tau)/\hat{\sigma}_a] \Big/ \left(\sum_{t=\tau}^{n} x_{1,y}^2 \right)^{1/2}$$

$$\text{TC: } \hat{\tau}_2(\tau) = [\hat{\omega}_2(\tau)/\hat{\sigma}_a] \Big/ \left(\sum_{t=\tau}^{n} x_{2,t}^2 \right)^{1/2}$$

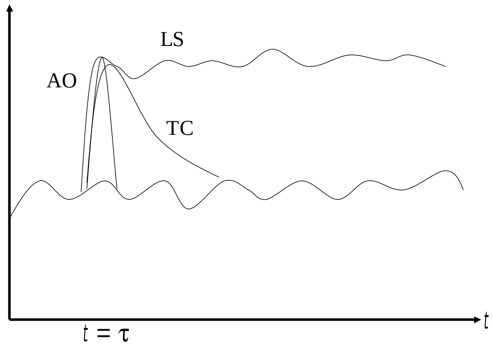
$$\text{LS: } \hat{\tau}_3(\tau) = [\hat{\omega}_3(\tau)/\hat{\sigma}_a] \Big/ \left(\sum_{t=\tau}^{n} x_{3,t}^2 \right)^{1/2}$$

$$\hat{\omega}_i(\tau) = \sum_{t=\tau}^{n} \hat{a}_t x_{i,t} \Big/ \sum_{t=\tau}^{n} x_{i,y}^2 \quad \text{for } i = 1, 2, 3.$$

where $\hat{\omega}_i(\tau)(i = 1-3)$ denotes the estimation of the outlier impact at time $t = \tau$, and $\hat{\sigma}_a$ is an estimate of the variance of the residual process.

An outlier is identified at time $t = \tau$ when the test statistics $\hat{\tau}_i(\tau)$ exceeds a critical value. In TRAMO (Time Series Regression with ARIMA Noise, Missing Observations, and Outliers) the critical value is determined by the number of observations in the series based on simulation experiments. The different test statistics at time $t = \tau$ are compared in order to identify the type of outlier. The one chosen has the greatest significance such as $\hat{\tau}_{max} = \max|\hat{\tau}_i(\tau)|$. When an outlier is detected, we can adjust the observation Y_t at time $t = \tau$ to obtain the corrected Y_t^* via (8) using the $\hat{\omega}_i$, i.e. $Y_t^* = Y_t - \hat{\omega}_i v_i I_t(\tau)$. Finally, the procedure is repeated until no outlier is detected. A multiple regression on Y_t^* is performed on the various outliers detected to identify spurious outliers.

Type of outliers



Outlier detection[11]

Total education expenditure

Year	Nature	Event
1895	AO	Sino-Japanese War
1905	AO	Russo-Japanese War
1915	AO	World War 1

Gross national product

Years	Nature	Event
1890	TC	First Bank Regulation Act
1898	AO	Japan adopted the Gold standard

National income

Years	Nature	Event
1890	TC	First Bank Regulation Act
1898	AO	Japan adopted the Gold standard
1919	AO	End of World War 1

Total government expenditure

Years	Nature	Event
1872	LS	The government promulgated the National Bank Act to encourage the private sector to create national banks.
1896	AO	Sino-Japanese War

[11]The demographic time series is excluded from our test for the main reason that growth and change in the population dynamics rarely have an instantaneous effect.

Military expenditure

Years	Nature	Event
1872	TC	Meiji Restoration
1894	TC	Sino-Japanese War
1897	TC	Sino-Japanese War
1904	AO	Russo-Japanese War
1937	LS	Japan’s invasion of China

National debt

Years	Nature	Event
1877	LS	Satsuma Rebellion
1906	LS	Russo-Japanese War

Capital expenditure

Years	Nature	Event
1871	AO	Creation of the Yen
1892	AO	First Bank Regulation Act

Price index

Years	Nature	Event
1899	AO	All government and national bank notes were redeemed and replaced by Bank of Japan notes

With the outliers methodology it became clear that the dynamic of the process that led to economic growth and development in Japan was dependent of political events, especially the Sino-Japanese and the Russo-Japanese Wars (Diebolt, 2003).

The Sino-Japanese War broke out in 1894. There may be several explanations for this war. Mutually related factors, such as the need to find new markets is probably a crucial one. The war resulted in provoking further nationalism, stimulating national unification, and gradually changing the industrial structure. The victory is also the result by superior spirit and equipment which may be ascribed to the development of education and the foundation of the industrialisation since the early Meiji period. From a purely economic perspective, the Sino-Japanese War enlarged the domestic financial and capital market through rising military expenditures based on public loans, stimulated military technology and general industry (by the distribution of military expenses). The war also reinforced the foundation for the development of light industry by assuring it connection with the Chinese market, and provided a foundation for the growth of heavy industry. The experience of the war was immediately related to demands for domestic steel production, extending railways, reinforcement of the number of vessels, promotion of shipbuilding etc. Responding to such progress in industrialisation, secondary and higher education began to be consolidated. It is also significant that the Gold Standard was established in 1897 as a result of the reparations paid to Japan after the war.

Within only ten years after the Sino-Japanese War, the Russo-Japanese War started. The competitive invasion into China stimulated the Boxer Rebellion in 1899. In 1901, the Peking Protocol was concluded, but during the process, opposition arose between Russia and the United States and England. In 1902, the Anglo-Japanese Alliance was formed and the Russo-Japanese War started in 1904. This event was far larger in scale then the Sino-Japanese War in military expenditures, the number of mobilised military forces and the duration of the war. The scale of the war influenced education as well as the whole economy. The Ministry of education summarised the influence of the war upon school children and parents in the following account: the war made them realise the importance of education and academic skills, and stimulating their ambitions for learning; world and nationalistic concepts were clarified, and knowledge of economics, geography, science, military affairs etc. was provided; the war offered an opportunity for cultivation of the virtues of patriotism, public spirit, chivalry, sympathy, obedience, self-respect and progressiveness; the war made them realise the importance of business; the war made the parents and communities accept the necessity of the establishment of schools as basic assets. This war, in contrast to the Sino-Japanese War, was developed in an abnormal situation. Japan was inferior in the number of soldiers and arms, but was superior in the quality of the soldiers. Before country acquired a decisive victory either politically or militarily, the Peace Treaty was conducted through Roosevelt’s mediation during the 1905 Revolution in Russia. This victorious war probably the turning point for Japanese politics and its economy, initiating its rapid conversion to imperialism!

5. Conclusion

The work discussed here shows the impact of exogenous factors (wars) on Japanese long-term development. Endogenously, all the sectors have an impact on the economic growth of Japan, in a direct manner for educational and capital expenditure and indirectly—via the two latter—for the military sector. Military and educational expenditure can therefore be considered as driving forces behind the economic growth of the country. In contrast, capital expenditure must be addressed from another angle. Although they have a direct effect on GNP, they are also the consequence of economic growth (the relation between GNP and capital expenditure can be shown in the form of a retroactive loop).

Moreover, the amount of military expenditure governs those of educational and capital expenditure. This being so, even if the level of the former is a direct cause of the level of economic growth, it is clear that although it is true that the level of capital expenditure encourages economic growth it is initially governed by the growth level attained. Chronologically, Japan therefore seems to have developed its military and educational sectors, enabling a certain degree of growth, and this favoured capital expenditure. The latter then played the determinant role of driving force behind growth.

References

Barnhart, M. (1987) *Japan Prepares for Total War. The Search for Economic Security, 1919-1941*, Cornell University Press, Ithaca, New York.

Beasley, W. (1972) *The Meiji Restoration*, Stanford University Press, Stanford.

Beasley, W. (1987) *Japanese Imperialism, 1894-1945*, Oxford University Press, Oxford.

Benoit, E. (1973) *Defense and Economic Growth in Developing Countries*, Lexington Books, Lexington.

Caro, J.-Y. (1998) Croissance et dépenses de défense dans les pays de l'Asean, *Revue Economique*, 49, pp. 139-149.

Chowdhury, A. (1991) A Causal Analysis of Defense Spending and Economic Growth, *Journal of Conflict Resolution*, 35, pp. 80-97.

Ciriacy-Wantrup, S. von (1936) *Agrarkrisen und Stockungsspannen. Zur Frage der langen Welle in der wirtschaftlichen Entwicklung*, P. Parey, Berlin.

Darné, O. & Diebolt, C. (2004) Unit Roots and Infrequent Large Shocks: New International Evidence on Output, *Journal of Monetary Economics*, 51, pp. 1449-1465.

Darné, O. & Diebolt, C. (2005) Non-Stationarity Tests in Macroeconomic Time Series, in Diebolt, C. & Kyrtsou, C. in collaboration with Darné, O. Eds., *New Trends in Macroeconomics*, Springer, Berlin, pp. 173-194.

Darné, O. & Diebolt, C. (2006) Chocs temporaires et permanents dans le PIB de la France, du Royaume-Uni et des Etats-Unis, *Revue d'Economie Politique*, 116, pp. 65-78.

Deger, S. & Sen, S. (1995) Military Expenditure and Developing Countries, in Hartley, K. & Sandler, T. Eds., *Handbook of Defense Economics*, North-Holland, Amsterdam, pp. 275-307.

Dickey, D. & Fuller, W. (1979) Distribution of the Estimators for Autoregressive Time Series with a Unit Root, *Journal of the American Statistical Association*, 74, pp. 427-431.

Dickey, D. & Fuller, W. (1981) Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root, *Econometrica*, 49, pp. 1057-1072.

Diebolt, C. (2003) Accounting Expenditures on Education. Japan from the Meiji Restoration to the Second World War, *Historical Social Research*, 28, pp. 290-305.

Diebolt, C. & Jaoul, M. (2004) Les dépenses militaires, moteur de la croissance économique japonaise? Une analyse cliométrique: 1868-1940, *Revue Economique*, 55, pp. 439-447.

Dritsakis, N. (2004) Defense Spending and Economic Growth: An Empirical Investigation for Greece and Turkey, *Journal of Policy Modelling*, 26, pp. 249-264.

Dunne, J.-P. (1996) Economic Effects of Military Expenditure in Developing Countries: A Survey, in Gleditsch, N.; Bjerkholt, O.; Cappalen, A.; Smith, R. & Dunne, J.-P. Eds., *The Peace Dividend*, North-Holland, Amsterdam, pp. 439-464.

Dunne, J.-P. & Nikolaidou, E. (2001) Military Spending and Economic Growth in the Peripherical Economies of Europe: A Causal Analysis for Greece, Spain and Portugal, *Economics Discussion Papers*, 100, Middlesex University, Business School, pp. 1-27.

Dunne, J.-P.; Nikolaidou, E. & Smith R. (2002) Military Spending, Investment and Economic Growth in Small Industrialising Economies, *The South African Journal of Economics*, 70, pp. 1-27.

Duus, P. (1976) *The Rise of Modern Japan*, Houghton Mifflin, Boston.

Elliott, G.; Rothenberg, T. & Stock, J. (1996) Efficient Tests for an Autoregressive Unit Root, *Econometrica*, 64, pp. 813-836.

Engle, R. & Granger, C. (1987) Co-Integration, and Error Correction: Representation, Estimation, and Testing, *Econometrica*, 55, pp. 251-276.

Engle, R. & Granger, C. Eds. (1991) *Long-Run Economic Relationships. Readings in Cointegration*, Oxford University Press, Oxford.

Granger, C. (1969) Investigation Causal Relations by Econometric Models and Cross-Spectral Methods, *Econometrica*, 37, pp. 424-438.

Granger, C. (1988) Causality, Cointegration, and Control, *Journal of Economic Dynamics and Control*, 12, pp. 551-560.

Granger, C. & Newbold, P. (1974) Spurious Regressions in Econometrics, *Journal of Econometrics*, 2, pp. 111-120.

Goldstein, J. (1988) *Long Cycles. Prosperity and War in the Modern Age*, Yale University Press, New Haven.

Hamilton, J. (1994) *Time Series Analysis*, Princeton University Press, New Jersey, 1994.

Hsiao, C. (1979) Causality Tests in Econometrics, *Journal of Economic Dynamics and Control*, 2, pp. 321-346.

Johansen, S. (1988) Statistical Analysis of Cointegration Vectors, *Journal of Economic Dynamics and Control*, 12, pp. 231-254.

Johansen, S. (1992) Determination of Cointegration Rank in the Presence of a Linear Trend, *Oxford Bulletin of Economics and Statistics*, 54, pp. 383-397.

Kelley, A. & Williamson, J. (1974) *Lessons from Japanese Development. An Analytical Economic History*, The Chicago University Press, Chicago.

Kendrick, S. assisted by M. Wehle (1953) *A Century and a Half of Federal Expenditures*, N.B.E.R., Princeton.

Klein, L. & Ohkawa, K. Eds. (1968) *Economic Growth. The Japanese Experience since the Meiji Era*, Richard D. Irwin, inc., Homewood.

Kwiatkowski, D.; Phillips, P.; Schmidt, P. & Shin, Y. (1992) Testing the Null Hypothesis of Stationary against the Alternative of a Unit Root: How sure are we that Economic Time Series have a Unit Root?, *Journal of Econometrics*, 54, pp. 159-178.

Lucas, R. (1976) Econometric Policy Evaluation: A Critique, *Carnegie-Rochester Conference Series on Public Policy*, 1, pp. 19-46.

Maddison, A. (1995) *Monitoring the World Economy, 1820-1992*, OECD, Paris.

Mitchell, W. (1913) *Business Cycles*, University of California Press, Berkeley.

Myers, R. & Pettie, M. Eds. (1984) *The Japanese Colonial Empire, 1895-1945*, Princeton University Press, Princeton.

Nelson, C. & Plosser, C. (1982) Trend and Random Walks in Macroeconomic Time Series, *Journal of Monetary Economics*, 10, pp. 139-162.

Ng, S. & Perron, P. (2001) Lag Length Selection and the Construction of Unit Root Tests with Good Size and Power, *Econometrica*, 69, pp. 1519-1554.

Ohkawa, K. (1957) *The Growth Rate of the Japanese Economy since 1878*, Kinokuniya Bookstore Co., Ltd., Tokyo.

Ohkawa, K.; Takamatsu, N. & Yamamoto, Y. (1974) *National Income* (Volume 1: *Estimates of Long-Term Economic Statistics of Japan since 1868*) Keizai Shinposha, Tokyo.

Peacock, A. & Wiseman, J. assisted by J. Veverka (1961) *The Growth of Public Expenditure in the United Kingdom*, N.B.E.R., Princeton.

Perron, P. (1988) Trends and Random Walks in Macroeconomic Time Series: Further Evidence from a New Approach, *Journal of Economic Dynamics and Control*, 12, pp. 297-332.

Ram, R. (1995) Defense Expenditure and Economic Growth, in Hartley, K. & Sandler, T. Eds., *Handbook of Defense Economics*, North-Holland, Amsterdam, pp. 251-273.

Sargan, J. (1964) Wages and Prices in the United Kingdom: A Study in Econometric Methodology (with discussion), in Hart, P.; Mills, G. & Whitaker, J. Eds., *Econometric Analysis for National Economic Planning*, Colston Papers, 16, Butterworth and Co., London, pp. 25-63.

Sims, C. (1980) Macroeconomics and Reality, *Econometrica*, 48, pp. 1-48.

Taeuber, I. (1958) *The Population of Japan*, Princeton University Press, Princeton.

Tolliday, S. (2001) *The Economic Development of Modern Japan, 1868-1945. From the Meiji Restoration to the Second World War*, 2 Volumes, Edward Elgar, Cheltenham.

Wagner, A. (1904) *Les fondements de l'économie politique*, vol. 3, Girard & Brière, Paris.

Wagner, A. (1913) *Traité de la science des finances. Histoire de l'impôt depuis l'antiquité jusqu'à nos jours*, vol. II: *depuis 1815 jusqu'à 1910*, Girard & Brière, Paris.

Annex 1

Statistical Database

	Expenditures on Education						
	State	Local			Total		
		Prefectures	Cities, Towns and Villages	Total		Gross National Product	National income
	(1) (Thousand Yen)	(2) (Thousand Yen)	(3) (Thousand Yen)	(4) = (2)+(3) (Thousand Yen)	(5) = (1)+(2)+(3) (Thousand Yen)	(6) (Thousand Yen)	(7) (Thousand Yen)
1868							
1869							
1870							
1871							
1872							
1873							
1874							
1875							
1876							
1877							
1878						417000	401000
1879						635000	611000
1880						829000	799000
1881	872	1230	6470	7700	8572	845000	813000
1882	913	1228	7013	8241	9154	742000	713000
1883	954	1226	7557	8783	9737	600000	575000
1884	995	1224	8100	9324	10319	514000	492000
1885	1036	1222	8643	9865	10901	649000	621000
1886	1015	1215	8412	9627	10642	712000	682000
1887	994	1208	8181	9389	10383	692000	661000
1888	973	1202	7949	9151	10124	706000	675000
1889	952	1195	7718	8913	9865	726000	691000
1890	931	1188	7487	8675	9606	983000	937000
1891	1064	1325	8144	9469	10534	880000	837000
1892	1198	1462	8801	10263	11461	948000	901000
1893	1331	1600	9458	11058	12389	988000	936000
1894	1465	1737	10115	11852	13316	1226000	1163000
1895	1598	1874	10772	12646	14244	1294000	1222000
1896	2445	3268	13887	17155	19600	1305000	1232000
1897	3292	4662	17002	21664	24957	1576000	1490000
1898	4140	6057	20117	26174	30313	2207000	2073000
1899	4987	7451	23232	30683	35670	1892000	1768000
1900	5834	8845	26347	35192	41026	2165000	2024000
1901	5800	8878	26706	35585	41385	2253000	2112000
1902	5767	8912	27065	35977	41744	2047000	1915000
1903	5733	8945	27425	36370	42103	2441000	2262000
1904	5700	8979	27784	36762	42462	2530000	2348000
1905	5666	9012	28143	37155	42821	2373000	2204000
1906	6335	10377	34609	44985	51320	2863000	2691000
1907	7004	11741	41075	52816	59819	3327000	3102000
1908	7672	13106	47540	60646	68319	3361000	3128000
1909	8341	14470	54006	68477	76818	3268000	3033000
1910	9010	15835	60472	76307	85317	3181000	2940000
1911	9321	16100	60865	76965	86286	3883000	3581000
1912	9632	16364	61258	77622	87255	4509000	4148000
1913	9944	16629	61651	78280	88223	4574000	4248000
1914	10255	16893	62044	78937	89192	4253000	3948000
1915	10566	17158	62437	79595	90161	4204000	3882000
1916	17266	24883	90061	114944	132210	5169000	4716000
1917	23966	32608	117685	150293	174259	6834000	6200000
1918	30666	40333	145310	185643	216309	10052000	9152000
1919	37366	48058	172934	220992	258358	14924000	13593000
1920	44066	55783	200558	256341	300407	13125000	11962000
1921	55330	63143	210338	273481	328811	12140000	11037000
1922	66595	70503	220118	290621	357215	12355000	11177000
1923	77859	77862	229898	307760	385620	13053000	11808000
1924	89124	85222	239678	324900	414024	14403000	12979000
1925	100388	92582	249458	342040	442428	15112000	13652000
1926	108974	95188	240368	335556	444531	14670000	13195000
1927	117561	97794	231279	329073	446634	14611000	13097000
1928	126147	100400	222189	322589	448736	14852000	13349000
1929	134734	103006	213100	316106	450839	14799000	13297000
1930	143320	105612	204010	309622	452942	13850000	11598000
1931	144876	105110	211784	316894	461770	12520000	10583000
1932	146432	104608	219557	324165	470597	13043000	11835000
1933	147988	104106	227331	331437	479425	14334000	13588000
1934	149544	103604	235104	338708	488252	15672000	14161000

	Total Government Expenditures	Military Expenditures	National Debt	Capital Expenditures	Other General Services	Price Index 1934-36 = 100	Population
	(8)	(9)	(10)	(11)	(12) = (8)-(9)-(10)-(11)	(13)	(14)
	(Thousand Yen)	(Thousand Yen)	(Thousand Yen)	(Thousand Yen)	(Thousand Yen)		(Thousand)
1868	31000	5000	1000	2000	23000		
1869	21000	3000	2000	2000	14000		
1870	20000	2000	3000	4000	11000		
1871	19000	3000	2000	3000	11000		
1872	58000	10000	4000	7000	37000		34592
1873	63000	10000	3000	7000	43000		34769
1874	82000	14000	3000	9000	56000		34937
1875	69000	12000	5000	10000	42000		35098
1876	59000	10000	5000	8000	36000		35336
1877	48000	9000	17000	7000	15000		35649
1878	61000	10000	27000	7000	17000		36390
1879	82000	11000	22000	10000	39000	27,4	36603
1880	87000	13000	22000	11000	41000	31,5	36986
1881	105000	12000	28000	11000	54000	34,7	37186
1882	110000	13000	23000	13000	61000	31,9	37492
1883	116000	20000	29000	13000	54000	27,4	37864
1884	111000	18000	20000	12000	61000	24,9	38225
1885	90000	16000	14000	13000	47000	26,1	38484
1886	117000	21000	24000	12000	60000	23,9	38663
1887	111000	23000	21000	14000	53000	24,2	38948
1888	115000	23000	21000	14000	57000	24,4	39362
1889	114000	24000	18000	18000	54000	26,0	39795
1890	119000	21000	18000	19000	61000	29,0	40164
1891	116000	24000	19000	27000	46000	27,3	40444
1892	118000	25000	19000	19000	55000	28,2	40772
1893	121000	26000	20000	30000	45000	28,6	41072
1894	216000	129000	21000	23000	43000	29,9	41453
1895	286000	118000	26000	23000	119000	32,6	41883
1896	215000	76000	33000	41000	65000	35,1	42278
1897	331000	113000	34000	60000	124000	40,9	42765
1898	401000	115000	32000	56000	198000	44,4	43275
1899	491000	117000	41000	66000	267000	40,9	43736
1900	465000	137000	44000	78000	206000	45,8	44231
1901	447000	110000	49000	82000	206000	44,9	44125
1902	505000	90000	57000	74000	284000	46,4	45401
1903	509000	155000	51000	80000	223000	48,8	45988
1904	872000	678000	47000	67000	80000	50,4	46499
1905	1040000	741000	59000	65000	175000	52,1	46934
1906	1117000	409000	172000	70000	466000	54,6	47322
1907	1195000	242000	185000	133000	635000	59,3	47828
1908	1072000	239000	198000	162000	473000	56,9	48407
1909	1054000	203000	189000	134000	528000	55,7	49027
1910	1491000	211000	202000	161000	917000	55,9	49685
1911	1205000	232000	180000	207000	586000	59,6	50396
1912	1256000	227000	166000	177000	686000	63,9	51123
1913	1360000	220000	172000	180000	788000	65,4	51856
1914	1264000	250000	175000	164000	675000	60,0	52574
1915	1161000	268000	150000	145000	598000	58,2	53310
1916	1269000	303000	165000	137000	664000	64,3	53975
1917	1528000	421000	177000	203000	727000	81,9	54588
1918	2073000	673000	196000	263000	941000	105,3	54960
1919	3211000	1016000	152000	418000	1625000	131,6	55363
1920	3947000	987000	141000	660000	2159000	145,9	55963
1921	4188000	904000	176000	668000	2440000	134,0	56666
1922	4557000	754000	201000	767000	2835000	134,2	57390
1923	4592000	574000	263000	757000	2998000	128,2	58119
1924	5020000	582000	316000	809000	3313000	128,2	58576
1925	4549000	543000	402000	783000	2821000	124,5	59737
1926	4653000	524000	486000	905000	2738000	119,8	60741
1927	5368000	598000	785000	925000	3060000	118,3	61659
1928	5451000	622000	612000	933000	3284000	115,4	62595
1929	5269000	601000	554000	906000	3208000	112,7	63461
1930	5578000	550000	700000	631000	3697000	100,7	64450
1931	4967000	564000	549000	560000	3294000	91,3	65458
1932	5904000	815000	647000	715000	3727000	92,5	66434
1933	7343000	998000	1322000	785000	4238000	97,1	67432
1934	7788000	1067000	1015000	683000	5023000	98,3	68309

Annex 2

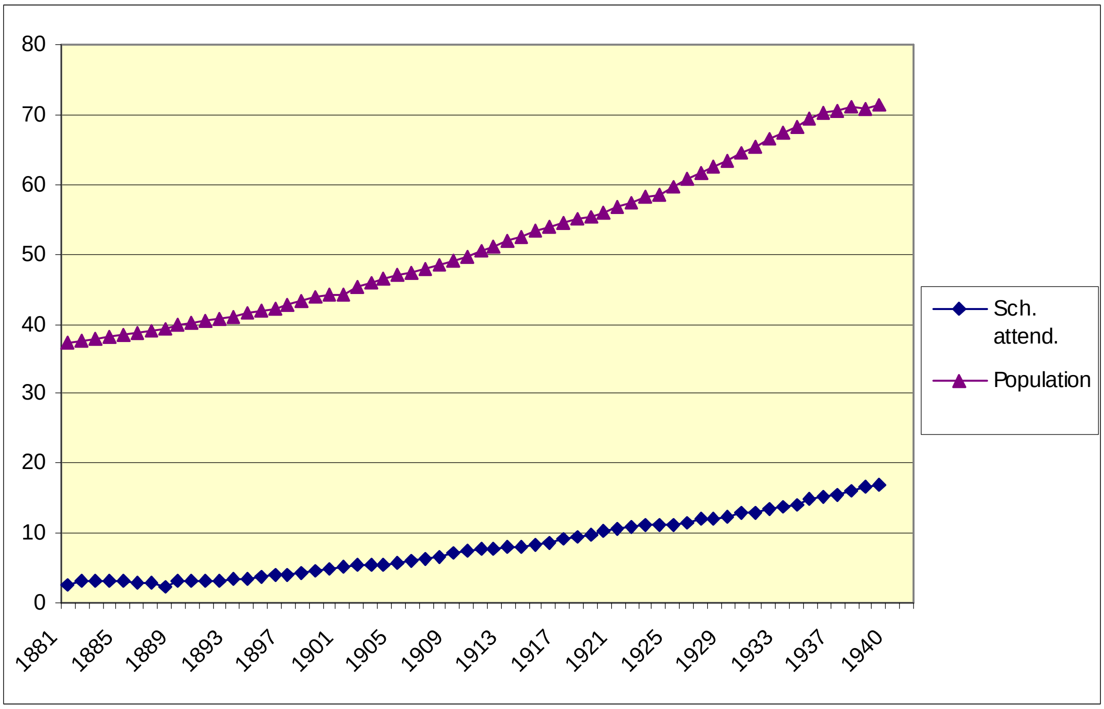
Augmented Dickey Fuller Test			
	Statistical Values	**Critical Value**	**Decision**
DCAP	T_6-stat = -2,28	-3,47	
	F6 = 2,62	[6,49 ; 6,73]	
	F5 = 4,98	[4,88 ; 5,13]	
	T_5-stat = -0,71	-2,9	
	F4 = 4,79	[4,71 ; 4,86]	
	M -stat = 58,79	1,96	DS
DEDUC	T_6-stat = 2,56	-3,47	
	F6 = 3,44	[6,49 ; 6,73]	
	F5 = 4,16	[4,88 ; 5,13]	
	T_5-stat = -0,69	-2,9	
	F4 = 2,81	[4,71 ; 4,86]	
	M -stat = 57,26	1,96	DS
GNP	T_3-stat = -3,23	-3,47	
	F3 = 5,68	[6,49 ; 6,73]	
	F2 = 6,97	[4,88 ; 5,13]	
	β -T stat = 1,16	1,96	
	α -T stat = 0,79	1,96	DS
DMILI	T_6-stat = 3,15	-3,47	
	F6 = 5,18	[6,49 ; 6,73]	
	F5 = 4,74	[4,88 ; 5,13]	
	T_5-stat = -0,77	-2,9	
	F4 = 1,98	[4,71 ; 4,86]	
	M -stat = 59,32	1,96	DS
POP	T_3-stat = -2,42	-3,47	
	F3 = 4,31	[6,49 ; 6,73]	
	F2 = 132,06	[4,88 ; 5,13]	
	β -T stat = 1,59	1,96	DS
SCO	T_3-stat = -0,87	-3,47	
	F3 = 1,04	[6,49 ; 6,73]	
	F2 = 10,38	[4,88 ; 5,13]	
	β -T stat = 0,66	1,96	
	α -T stat = 0,79	1,96	Mixt process

Annex 3

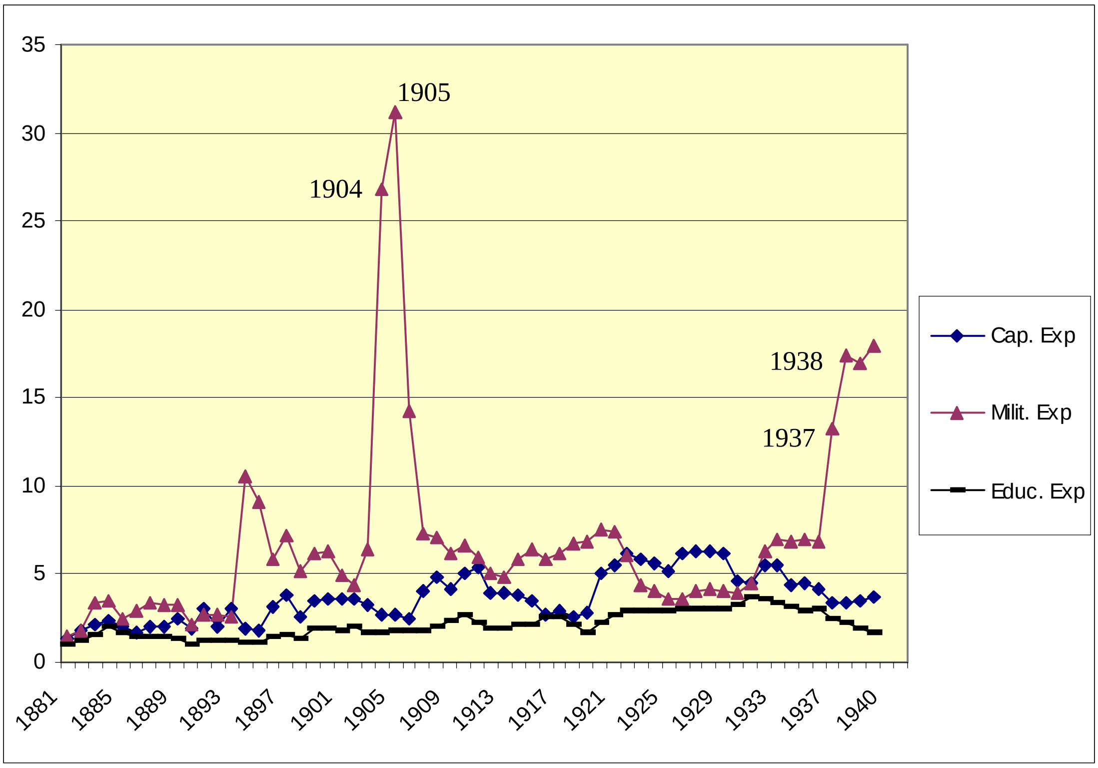
PAIRWISE GRANGER CAUSALITY TESTS			
Sample: 1881 1940			
Null Hypothesis:	Obs	F-Statistic	Probability
DEDUC does not Granger Cause DGNP	53	2.36595	**0.04751**
DGNP does not Granger Cause DEDUC		1.26147	0.29677
DCAP does not Granger Cause DGNP	53	2.99934	**0.01627**
DGNP does not Granger Cause DCAP		3.49484	**0.00714**
DMILI does not Granger Cause DGNP	53	2.17441	**0.06578**
DGNP does not Granger Cause DMILI		0.64654	0.69247
DPOP does not Granger Cause DGNP	53	0.40053	0.87424
DGNP does not Granger Cause DPOP		1.78748	0.12636
DSCO does not Granger Cause DGNP	53	1.04546	0.41097
DGNP does not Granger Cause DSCO		1.27074	0.29252
DCAP does not Granger Cause DEDUC	53	1.32212	0.26992
DEDUC does not Granger Cause DCAP		2.40976	**0.04410**
DMILI does not Granger Cause DEDUC	53	3.05142	**0.01491**
DEDUC does not Granger Cause DMILI		0.28371	0.94129
DPOP does not Granger Cause DEDUC	53	0.40154	0.87358
DEDUC does not Granger Cause DPOP		1.60641	0.17064
DSCO does not Granger Cause DEDUC	53	0.59729	0.73064
DEDUC does not Granger Cause DSCO		1.36107	0.25380
DMILI does not Granger Cause DCAP	53	2.46807	**0.03994**
DCAP does not Granger Cause DMILI		2.14086	**0.06963**
DPOP does not Granger Cause DCAP	53	1.12454	0.36571
DCAP does not Granger Cause DPOP		1.25265	0.30086
DSCO does not Granger Cause DCAP	53	2.53546	**0.03562**
DCAP does not Granger Cause DSCO		1.56901	0.18144
DPOP does not Granger Cause DMILI	53	1.94031	**0.09776**
DMILI does not Granger Cause DPOP		1.86336	0.11128
DSCO does not Granger Cause DMILI	53	4.90739	**0.00076**
DMILI does not Granger Cause DSCO		1.44677	0.22130
DSCO does not Granger Cause DPOP	53	0.54266	0.77255
DPOP does not Granger Cause DSCO		0.61983	0.71319

Annex 4

Evolution of the population and school attendance (in millions): 1881-1940



Share of state expenditure in relation to the GNP (percentages): 1881-1940[12]



[12]The 1904 peak was caused by the Japanese attack of the Russian installations at Port Arthur. The Russian-Japanese war (won by Japan) was the first conflict between major powers since 1870. The phase of strong increase in defense expenditure that began in 1937 corresponds to Japan's invasion of China.