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Super Exogeneity and Export-led Growth Hypothesis

Insang Hwang

1. Introduction

In the development literature, the relationship between trade and growth has been an old and controversial question. There are a number of empirical studies on the industrialization process in the LDCs that have found a strong relationship between a country's trade policy regime and its dynamic performance. Those studies identified two links. First, structural change provided a major link between exports and economic growth in the outward-oriented LDCs. Second, a significant association existed between productivity growth and the share of GDP generated by the manufacturing sector [e.g., The World Bank (1993), Syrquin and Chenery (1989), Kuznets (1988), Chenery (1986), and Kubo (1985)].

The export sector is the initiator of economy-wide structural changes in the form of technical innovations and diffusions of skill-intensity externality of human capital; thus it contributes to a higher level of aggregate productivity. Therefore, the export-led growth hypothesis can be understood by the existence of a causal link between export and output growth: the growth of exports has a stimulating influence across the economy as a whole through their favorable effects on total factor productivity, resource allocation, economies of scale, capacity utilization, and technical change [see Feder (1983) and Balassa (1985)]. Therefore, many economist have argued that, with all other factors assumed to be equal, countries that take "outward oriented policy" (i.e., "export-led growth policy") by reducing their impediments to international trade will outperform those countries that have failed to do so [see Dollar (1992) and Edwards (1992)].

Together with the contributions in development literature, recent endogenous growth theories [e.g., Grossman and Helpman (1991), Young (1991), Lucas (1990), Rivera-Batiz and Romer (1990), and Romer (1986, 1990)] emphasize the role of international trade, which encourages the worldwide exploitation of increasing returns to scale and cause a permanent increase in the long-run rate of growth. It appears that the rapid economic growth of East Asian NICs lends support to the basic premises of the endogenous growth theory: export growth rates are very high and far above GDP growth rates. For example, Korea's merchandise export growth rate of 32.6 percent was accompanied with the real GDP growth of 11.5 percent on the average annual over 1961-1993. Experiences of the other successful NICs in Asia are very similar.

There are a number of empirical studies testing the export-led growth hypothesis. These have been conducted by two different econometric methodologies: first, the single equation (or impact) studies which seek to measure the impact of export expansion on overall economic growth by the method of ordinary least squares (OLS) estimation; and second, the causal analysis which investigates impact directions using Vector Auto-regression (VAR) analysis. However, these studies have not provided coherent evidence supporting the export-led hypothesis. Earlier single-equation studies found overwhelming support for the export-led growth hypothesis [e.g., Pack and Page (1994), Summers and Heston (1991), Ram (1987), and Feder (1983)]. These studies attempted to test whether export growth (or export share to GDP) shows a positive and significant effect on output growth.

Moreover, recent causality investigations using the notions of Granger (1969) or Sims (1972) causality do not yield uniform results. The results of Marlin (1992), Serletis (1992), and Bahmani-Oskooee et al. (1991), for example, appear to favor the export-led growth hypothesis.(1) On the other hand, Kunst and Marlin (1989), and Henriques and Sadorsky (1996) show the evidence of uni-directional causality from output to export growth (i.e., growth driven export), while Chow (1987), and Ahmad and Harnhirun

(1995) seem to support bi-directional causality.[2] Furthermore, Jung and Marshall (1985), and Sharma and Dhakal (1994) reveal no consistent causal pattern and also cast considerable doubt on the validity of the export-led growth hypothesis.

Even though the above empirical studies have contributed to the literature of export-growth linkage, there are two shortcomings: first, the impact studies using the method of least squares estimation may suffer from a simultaneous-equation bias caused by the existence of growth-driven exports; and second, existing causality analyses do not make clear differences between 'causality' and 'exogeneity.' As indicated by Engle et al. (1983), Granger-causality is only one half of 'strong exogeneity' that is more relevant for export-led growth theory; the other half, 'weak exogeneity,' has been neglected.

In addition, current studies could not address the question of whether or not the export-led growth hypothesis is invariant to policy regime changes (i.e., whether or not export-led growth hypothesis is subject to the Lucas critique). Empirical econometric studies often presume that certain parameters of estimated equations are sufficiently constant or invariant to changes in policy rules or regimes. Claims of invariance has been criticized by Lucas (1976) on the ground that the agent's expectation formation should change as policy rules or regimes change, hence, conditional policy simulations would yield misleading inferences in models where the invariant behavioral parameters were not separately estimated from the changing parameters of the expectation process. Testing invariance claims represents an important step for policy analysis, but attempts to test its status in empirical work are scarce. In this respect, Engle and Hendry (1993) have introduced three different kinds of exogeneity tests based on three different definitions of exogeneity (weak, strong and super) as proposed by Engle et al. (1983) that can address the above problems.

The main objective of this study is to examine the exogeneity properties of export growth, the validity of the export-led growth policy, and attempt to provide policy implications to policy makers in developing countries. Within the framework of this analysis, we use Engle and Hendry (1993)'s exogeneity tests to assess the above points in the case of Korea for the period 1954-1993. We adopt the Feder (1983) model as a theoretical model in this study. Previous case studies using Engle and Hendry (1993)'s exogeneity tests under homoscedasticity are as follows; Kwan and Kwok (1995) found that the weak, strong, and super exogenous properties of export growth could not be rejected in the case of China; in contrast, Kwan et al. (1996) reported that the super exogeneity assumption was rejected in the case of Taiwan. But these results seem to be limited in the specific case of error structure: constant variance-covariance structure. However, our empirical results for Korea will provide a new result of exogeneity tests under the assumption of non-constant variance-covariance system, including more general case of error structure.

This study is organized as follows. Section 2 introduces the definitions, formulations and tests of exogeneity. Section 3 describes the empirical modeling of export-led growth model and data used. Section 4 presents the results of exogeneity tests and discusses some policy implications. Finally, we conclude in Section 5.

2. Definitions, Formulations and Tests of Exogeneity

2. 1 Definitions of Exogeneity

Engle et al. (1983) suggests three different definitions of exogeneity; ***weak***, ***strong*** and ***super exogeneity***. Consider a joint distribution of y_t and x_t conditional on the information set I_t, consisting of the past values of both series and the current and past values of valid conditioning variables. This can be expressed as follows:

$$f(y_t, x_t | I_t; \lambda_t) = g(y_t | x_t, I_t; \lambda_{1t}) h(x_t | I_t; \lambda_{2t}) \ , \qquad (1)$$

where $f(.)$, $g(.)$ and $h(.)$ refer respectively to the joint density, the conditional density of y_t given x_t, and the marginal density of x_t, and $\lambda_t = (\lambda_{1t}', \lambda_{2t}')'$ when λ_{1t} and λ_{2t} are parameters; all the densities are conditional on I_t, which we'll not state explicitly through this study.

According to Engle et al. (1983), a variable x_t is said to be ***weakly exogenous*** for the parameter of interest θ if : (i)θ is a function of the parameters λ_{1t} alone, and (ii)λ_{1t} and the parameters of λ_{2t} of the marginal model for x_t are variation free.(3) Thus, inference on θ conditional on x_t involves no loss of information since the marginal model for x_t provides no information for θ. In addition, if x_t is weakly exogenous and is not Granger caused by y_t, then x_t is defined as ***strongly exogenous*** for θ. Finally, Engle et al. (1983) define x_t as ***super exogenous*** for θ if x_t is weakly exogenous for θ and λ_{1t} is invariant to changes in λ_{2t}. Consequently, the test of super exogeneity may be a test of weak exogeneity, a test of invariance or both.

2. 2 Formulations of Exogeneity

We now introduce three distinct concepts when formulating exogeneity tests for the conditional model of y_t given x_t: ***weak exogeneity***, ***constancy***, and ***invariance***. Consider now the joint distribution of two random variables y_t and x_t conditional on an information set I_t, which includes the past of y_t and x_t, and the current and past of other conditioning variables z_t. We assume throughout that the data generation process of (y_t, x_t) is a joint normal distribution (so regressions are linear), given by

$$\begin{pmatrix} y_t \\ x_t \end{pmatrix} | I_t \sim N\left[\begin{pmatrix} \mu_t^y \\ \mu_t^x \end{pmatrix}, \begin{pmatrix} \sigma_t^{yy}\sigma_t^{yx} \\ \sigma_t^{xy}\sigma_t^{xx} \end{pmatrix}\right] = N(\mu_t, \Sigma_t), \tag{2}$$

where $N(\mu_t, \Sigma_t)$ denotes a normal distribution with mean μ_t and covariance matrix Σ_t. Each component of the means and covariances is allowed to depend on the information set I_t, and thus allowed to be time-variant.

The expectation of y_t conditional on x_t is given by

$$E(y_t|x_t, I_t) = \delta_t(x_t - \mu_t^X) + \mu_t^Y, \quad \delta_t \equiv \sigma_t^{YX}/\sigma_t^{XX}, \tag{3a}$$

with

$$y_t - E(y_t|x_t, I_t) \equiv \varepsilon_t, \text{ where } \varepsilon_t|x_t, I_t \sim IN[0, \omega_t], \tag{3b}$$

and IN (0, ω_t) denotes independent normal with mean 0 and variance ω_t, and

$$\omega_t \equiv \text{var}[\varepsilon_t|x_t, I_t] = \text{var}[y_t - E(y_t|x_t, I_t)|x_t, I_t] = \sigma_t^{YY} - (\sigma_t^{YX})^2/\sigma_t^{XX}. \quad (4)$$

The parameters of interest in the analysis are β_t and γ in the theoretical behavioral relationship:

$$\mu_t^Y = \beta_t(\lambda_{2t})\mu_t^X + z_t'\gamma, \quad (5)$$

where $\beta_t(\lambda_{2t})$ means that β_t may be a function of λ_{2t}. Which equation relates the mean of y_t to x_t and to the set of variables $z_t \in I_t$. We maintain the assumption that γ does not vary with λ_{2t}, since otherwise z_t can be re-classified as part of an extended vector x_t.

From (3a, 3b) and (5), the following conditional model results:

$$y_t = \beta_t(\lambda_{2t})x_t + z_t'\gamma + (\delta_t - \beta_t(\lambda_{2t}))(x_t - \mu_t^x) + \varepsilon_t \text{ where } \varepsilon_t \sim IN[0, \omega_t]. \quad (6)$$

To have a constant-parameter, policy-invariant conditional model, we impose the following 3 conditions.

(i)Weak exogeneity of x_t for the parameters of interest. This requires that μ_t^x and σ_t^{xx} do not enter the conditional model (6). Thus, a necessary condition for the weak exogeneity of x_t for β_t is $\delta_t = \beta_t(\lambda_{2t})$.

(ii)Constancy of the regression coefficients. Given $\delta_t = \sigma_t^{yx}/\sigma_t^{xx}$, we assume $\delta_t = \delta\ \forall_t$.(4) From the definition of δ_t, the ratio of error covariance to the variance of x_t must be constant over t, and therefore $\omega_t = \omega\forall_t$, if $\sigma_t^{yy} = \omega + \delta\sigma_t^{yx}$; otherwise, (7) below would be heteroscedastic. We maintain homoscedasticity for simplicity; although generalizations to heteroscedasticity will be considered later.

(iii)Invariance of parameter β_t to changes in λ_{2t}. This requires $\beta_t(\lambda_{2s}) = \beta_t\ \forall s, t$, where the set of parameters β_t may vary over time without depending on variations in λ_{2t}. If *(i)*, *(ii)*, and *(iii)* are satisfied, then the conditional model (6) becomes

$$y_t = \beta x_t + z_t'\gamma + \varepsilon_t \text{ where } \varepsilon_t \sim IN[0, \omega], \quad (7)$$

and hence yields the conventional constant parameter regression model. Note that by the definition of ε_t, the structural error ε_t and the reduced error η_t (defined by $x_t - \mu_t^x \equiv \eta_t \sim IN[0, \sigma_t^{xx}]$ given I_t) are uncorrelated with each other.

A broad alternative model for a general test of super exogeneity must recognize that, in addition, the behavioral model in (5) may not have constant parameters because β may be affected by λ_{2t}. Specifically, Engle and Hendry (1993) consider how variations in the moments of x_t might influence β, but maintain that this is a time invariant relationship. This would allow a class of tests of the Lucas critique assertions to be conducted for historical interventions associated with $\{x_t\}$ together with both constancy tests (of *(ii)* above) and weak exogeneity tests (of *(i)*). Thus, Engle and Hendry (1993) allow $\beta_t(\lambda_{2t})$ in (6) to be a function of (μ_t^x, σ_t^{xx}) and approximate $\beta_t(\lambda_{2t})$ by

$$\beta_t = \beta_0 + \beta_1\mu_t^x + \beta_2\sigma_t^{xx} + \beta_3\left(\frac{\sigma_t^{xx}}{\mu_t^x}\right), \tag{8}$$

assuming $\mu_t^x \neq 0 \ \forall t$. Tests for super exogeneity can now be constructed by substituting (8) into (5)

$$\mu_t^y = \left[\beta_0 + \beta_1\mu_t^x + \beta_2\sigma_t^{xx} + \beta_3\left(\frac{\sigma_t^{xx}}{\mu_t^x}\right)\right]\mu_t^x + z_t'\gamma\ , \tag{9}$$

or in terms of conditional model:

$$y_t = \beta_0 x_t + z_t'\gamma + (\delta_t - \beta_0)(x_t - \mu_t^x) + \beta_1(\mu_t^x)^2 + \beta_2(\mu_t^x)\sigma_t^{xx} + \beta_3\sigma_t^{xx} + \varepsilon_{1t}\ , \tag{10}$$

where $\varepsilon_{1t} \sim IN\ [0,\ \omega_1]$. Even if $\delta_t = \delta$, x_t cannot be super exogeneous for β_0 if the moments of x_t appear in the regression of y_t on x_t.

2. 3 Tests of exogeneity

Here we provide a brief outline of the testing procedure employed in order to assess the relevance of the Lucas critique. In order to implement the testing strategy suggested by equation (10), both conditional and marginal models for the conditioning variables are required. There are two different types of test procedure of Engle and Hendry (1993) depending on whether Σ_t is constant or not (i.e., whether Σ_t is homoscedastic or not). For the convenience, we only shows the test procedures of non-constant Σ_t because the case of non-constant Σ_t is more general.

2. 3. 1 Σ_t is non-constant

In this more general case, Engle and Hendry (1993) consider that the coefficient of x_t is potentially varying. Note that if, for example, σ_t^{xx} is constant within regimes but not between, then one might find weak exogeneity within the regime but no superexogeneity. Therefore, Engle and Hendry (1993) explicitly consider the case where Σ_t is nonconstant. Thus, they use linear expansion to express $\sigma_t^{yx}/\sigma_t^{xx}$ as

$$\sigma_t^{yx}/\sigma_t^{xx} = \delta_t = \delta_0 + \delta_1\sigma_t^{xx}. \tag{11}$$

Using both (8) and (11) to rearrange the conditional model (6) yields the expanded test regression which allows for non-constant Σ_t:

$$y_t = \beta_0 x_t + z_t'\gamma + (\delta_0 - \beta_0)(x_t - \mu_t^x) + \delta_1(x_t - \mu_t^x)\sigma_t^{xx} + \beta_1(\mu_t^x)^2 + \beta_2(\mu_t^x)\sigma_t^{xx} + \beta_3\sigma_t^{xx} + \varepsilon_{3t}, \tag{12}$$

where $\varepsilon_{3t} \sim IN\ [0, \omega_{3t}]$. Equation (12) requires a marginal model for the conditioning variables in order to obtain measures for $\hat{\eta}_t$, $\hat{x}_t$ and $\hat{\sigma}_t^{xx}$. In addition, marginal models must be proposed for σ_t^{xx} in the case of non-constant Σ_t. Engle and Hendry (1993) suggest the construction of var (η_t/I_t) for the case of non-constant σ_t^{xx}, such as an ARCH process, as one possible alternative.

Using marginal model for $\hat{\eta}_t$, $\hat{x}_t$ and $\hat{\sigma}_t^{xx}$, the final test regression equation for super exogeneity may be expressed as

$$y_t = \beta_0 x_t + z_t'\gamma + (\delta_0 - \beta_0)\hat{\eta}_t + \delta_1\hat{\sigma}_t^{xx}\hat{\eta}_t + \beta_1\hat{x}_t^2 + \beta_2\hat{x}_t\hat{\sigma}_t^{xx} + \beta_3\hat{\sigma}_t^{xx} + \varepsilon_t. \tag{13}$$

Then, the null hypothesis of weak exogeneity of x_t for β will be rejected if each single variable of $\hat{x}_t$ and $\hat{\sigma}_t^{xx}$ augmented in equation (7) as additional regressors are significant respectively. Furthermore, the null of super exogeneity of x_t for β will be rejected if the constructed variables added in the conditional model (13) are significant both in single and joint variables.

3. Empirical Output Growth Model and Data Used

3. 1 Empirical Output Growth Model

We employ the theoretical model of export-led growth suggested by Feder (1983). However, we do not aim to test the Feder (1983) model or other endogenous growth model themselves. Instead, we aim to investigate only the exogenous property of export growth which is a fundamental and central issue in these theories. Feder (1983)'s model incorporating externalities will be described in the following model formulation:

$$\frac{\dot{y}}{y} = a \cdot \frac{I}{y} + b \cdot \frac{\dot{L}}{L} + \phi \cdot \frac{\dot{x}}{x}, \quad (14)$$

where y, x, L, and I are output, exports, labor input, and investment, respectively. Thus, we adopt equation (14) as the basic output growth model in this study. Now, we transform equation (14) as an empirical conditional model by using econometric terms and data employed as follows

$$DGDP_t = \gamma_1 + \beta DEX_t + \gamma_2 DL_t + \gamma_3 IG_t + \varepsilon_t, \quad (15)$$

where $DGDP_t$ is real output growth ($\dot{y}/y$), DEX_t is real export growth ($\dot{x}/x$), DL_t is the growth rate of labor force($\dot{L}/L$), IG_t is the ratio of domestic investment to total output (I/y), and ε_t is the usual residual term.

We first estimate the basic output growth model of Feder (1983) as a conditional model shown in equation (15). The estimated results are as follows

$$DGDP_t = \underset{(0.141)}{-0.198} + \underset{(0.018)}{0.042 IG_t^{*}} + \underset{(0.053)}{0.044 DEX_t} + \underset{(3.128)}{4.910 DL_t},$$

$R^2 = 0.153$, F (3, 35) = 2.119, DW = 1.50, σ =0.071,

$SERIAL[1]$	F(1, 34) = 2.058,	$SERIAL[2]$	F(2, 34) = 2.450,
$ARCH[1]$	$\chi^2(1)$ = 0.001,	$ARCH[2]$	$\chi^2(2)$ = 0.023,
$HETERO$	$\chi^2(6)$ = 3.362,	$NORMALITY$	$\chi^2(2)$ = 8.646*,
$RESET[1]$	F(1,34) = 0.495,	$RESET[2]$	F(2,33) = 0.240,

where values in parentheses are standard errors. * shows statistical significance at 5 percent level. The value of multiple correlation squared R^2 shows very low value and a poor fit of the regression line. In addition, the F-test of R^2 is not significant, and implies that the explanatory variables do not jointly explain the variation of $DGDP_t$.

In testing the assumption of exogeneity, Engle and Hendry (1993) suggested that careful diagnostic checking must be carried out to ensure the correct specification and representation of the conditional model. The above results of diagnostic tests indicate no obvious model inadequacy with the exception of the Jaque-Bera (1980) test for normality (*NORMALITY*). The F-test of R^2 and the normality test seem to show the possibilities of outliers and structural shifts in the data, which will appear as a problem of parameter non-constancy. Inclusion of dummy variables will be an alternative for curing these problems. Before we include adequate dummy variables, it is reasonable to figure out when the possible shocks or structural shifts happened.

We modified the output growth model by including possible outliers and structural shifts in the data caused by the oil price shocks in 1973 and 1979 and severe internal shocks in 1979 and 1980 in order to maintain parameter constancy. The modified output growth model is reported in Table 2 and is slightly different from that of equation (15). Among the possible combination of dummy variables considered, we report the impulse dummy variables for 1974 ($I74_t$) and 1980 ($I80_t$), which indicate negative and significant impulses on GDP growth. The ratio of investment to GDP (IG_t) and current population growth (DL_t) have positive coefficients and are significant respectively at the 1 and 5 percent levels. We also found that the step dummy for 1965 enters interactively with export growth, which aims to reflect the full lagged effect of export growth on GDP growth after 1961 export-oriented regime changes. While the coefficient of real export growth (DEX_t) shows a negative but not a significant effect on GDP growth, however, the interactive effects of $DEXDM65_t$ have a positive and significant effect on export growth supporting export-led growth hypothesis. By using these dummy variables, Table 2 describes that the value of multiple correlation squared R^2 shows higher value than the original model of equation (22). The F-test of R^2 is significant, and none of the miss-specification tests including even the normality test show obvious model inadequacy.

3. 2 Data Used and Unit Root Tests

Before proceeding to test the assumption of exogeneity, we examine the nonstationarity of real GDP and real export. To examine the nonstationarity of export and GDP, augmented Dickey Fuller (ADF) tests are applied. Table 1 shows the results of unit root test. The ADF test fails to reject the presence of a unit root for each series in levels but not in the first differences.(5) Thus, both the level of real GDP and export are found to be first difference stationary [i.e., integrated order one, I(1)].

The sample period is 1954-1993. The data used are annual and real data from National Accounts (Bank of Korea, 1994) and Korean Statistical Year Book (various issues). Due to data unavailability, real GDP and exports are processed respectively by deflating nominal GDP and total exports by the producer price index of at 1990 constant prices. The population data from the Korean Statistical Yearbook (various years) is adopted as a proxy for labor force. The 1990 constant producer index data are collected from Price Statistics Summary published by Bank of Korea (1993). In addition, real US GNP data series at 1987 constant price are downloaded from the Economic Bulletin Board located on inter-net.

4. Exogeneity Tests and Policy Implications

4. 1 Exogeneity Tests

In order to apply Engle and Hendry (1993)'s exogeneity tests, the conditional model for $DGDP_t$ is rewritten as follows:

$$DGDP_t = \beta DEX_t + z_t'\gamma + \varepsilon_t , \qquad (16)$$

with $DGDP_t$ and DEX_t jointly i.i.d. normal, conditional on the information set I_t. Furthermore, a marginal model for DEX_t which takes the form $DEX_t = Z_t'\pi_{DEX} + \eta_t$ in order to obtain measures for $\hat{\eta}_t$, $D\hat{E}X_t$ and $\hat{\sigma}_t^{DEX}$. In addition, we suppose that there exists a set of instruments $Z_t \in I_t$, including z_t, which can express the mean of DEX_t through the least squares regression $DEX_t = Z_t'\hat{\pi}_{DEX} + \hat{\eta}_t$. Thus, the mean vector of DEX_t (i.e., μ_t^{DEX}) can be represented as $D\hat{E}X_t = Z_t'\hat{\pi}_{DEX}$.

Based on the modified output growth model (as the conditional model) in Table 2, we proceed to test its exogeneous properties. In order to construct tests for weak and super exogeniety, $\hat{\eta}_t$, $D\hat{E}X_t$ and $\hat{\sigma}_t^{DEX}$ must be quantified. These are done by using a marginal model for export growth where DEX_t is regressed on a set of selected instruments including dummy variables. In an effort to search for the most appropriate marginal model for export growth, we considered a number of combinations of economic variables as instruments.(6) In Table 3, we report the marginal model for export growth, which shows the best results of model specification and fitting reasonably well over the sample period. In order to test super exogeneity, possible regime change should be included in the marginal model. The step dummy for the 1961 export oriented policy regime change (*DM61*) shows positive and significant effects on export growth as expected.(7) Furthermore, we also found that the step dummy for 1961 enters interactively with US GNP growth rate (*DUSGDM61*), the ratio of investment to GDP(*IGDM61*), and agricultural production growth rate (*DARDM61*), which probably captures the unwinding economic effects after export-oriented policy regime change. All these variables turn out to be highly significant, indicating the structural breaks in export growth model with the exception of *DUSGDM61*. Interestingly, the coefficients of *HEVDM74* (for full lagged effect of HEV_t after 1974; *HEV* means the share of heavy industry in manufacturing) and *DARDM61* have positive and significant effects on export growth at the 5 percent level.(8) However, the negative effect of *IGDM61* is puzzling, since Korea's export-led growth policy was accompanied by the high growth in investments on the export sectors, especially manufacturing industries.

In Table 4, we report the results of weak and super exogeneity tests in the case of constant variance-covariance matrix ($\Sigma_t = \Sigma\ \forall_t$). A test for the null hypothesis of weak exogeneity of DEX_t (for its regression coefficient) is formulated in the modified output growth model of Table 2. This is equivalent to a test of significance for the coefficient of $D\hat{E}X_t$ in the modified output growth model of Table 2. The coefficient of $D\hat{E}X_t$ is not statistically significant at the 5 percent level. This indicates that the export-growth variable is weakly exogenous in the output-growth model. The null hypothesis of super exogeneity of $D\hat{E}X_t$ is formulated as the tests of single and joint significances of the regression coefficients for $D\hat{E}X_t$ and $D\hat{E}X_t^2$. Both the single and joint variable test statistics are not significant and thus do not lead to rejection of the null hypothesis of super exogeneity.

Furthermore, in Table 5, the results of weak and super exogeneity tests (in the case of non-constant variance-covariance matrix) show that none of the constructed variables added to the modified output growth model are significant. In particular, in order to model the variance, $\hat{\sigma}_t^{DEX}$, we initially fitted the first and second order ARCH model for $\hat{\eta}_t$. However, as the results from the ARCH tests on the marginal model in Table 3 indicate, ARCH terms were uniformly insignificant. Thus, we ultimately chose to allow for variance effects ($\hat{\sigma}_t^{DEX}$) representing a moving average of the variance of $\hat{\eta}_t$.(9)

Furthermore, we perform the Granger causality test in order to check the existence of a causal relationship between output growth and export growth. Table 6 indicates that there exists a unidirectional causality from lagged *DEX* to *DGDP*. Furthermore, the positive sum of the lagged coefficients of *DEX* implies that a change in lagged export growth helps forecast current output growth. However, the hypothesis of Granger non-causality from lagged *DGDP* to *DEX* cannot be rejected. Taking this into consideration together with the property of weak exogeneity, we conclude that the export variable is strongly exogenous.

Considering these results of exogeneity tests, we found that real export growth variable appeared to satisfy the weak, strong and super exogenous properties in the output growth model. Consequently, the weak exogenous property of real export-growth variable justifies the use of a single-equation regression in estimating the impact of export growth on output growth. In addition, the strong exogeneity test results provide a sound basis for accepting the causal direction from export growth to output growth. These results imply that export growth provides a positive and significant effect on output growth in the case of Korea, which is fundamentally required by Feder (1983) model and other endogenous growth theories. In particular, the super exogeneity test results further imply that 1961 regime change for export promotion is not subject to the Lucas critique, and that there exists a structurally invariant relationship between export growth and output growth. In conclusion, we found that both export growth and export-oriented policy started early 1960s provide a positive and significant effect on Korean economic growth as main engines of its long-run growth. On the other hand, super exogenous property implies that economic agents do not alter their expectation formation due to the 1961 regime change. In the next Section, we discuss and provide some policy implications from the super exogenous property of export growth by comparing it with the results of previous studies.

4. 2 Policy Implications

Here, we review the results of super exogeneity tests in the case of Korea by comparing it with those of two previous tests for Taiwan and China in order to provide policy implications. It has a great meaning for policy planner of developing countries to analyzing the reasons of differences among the three countries. Our results of exogeneity tests are in accord with the case of China by Kwan and Kwok (1995) but is different with the case of Taiwan by Kwan et al. (1996). As implied by Kwan et al (1996), one possible reason for the difference between China and Taiwan is that the Chinese economy is more rigid than Taiwan. For the same reason, we may consider the Korean economy to be more rigid than Taiwan. Now, let us turn to evaluate the causes of rigidity among three countries. As indicated by Hurn and Muscatelli (1992), the rigidity of an economy induce economic agents to form expectations without models; namely, they form their expectation using data-based predictors where there are no empirically detectable parameter changes.[(10)] Such a situation might arise because of high costs of information collection and processing. In this sense, the burden associated with information costs (as it relates to a rigid economy) may oblige Chinese and Korean economic agents to form their expectations of the future evolution of time series by using data-based predictors, instead of model based ones. Therefore, it implies that economic agents of China and Korea do not follow an expectation model based on forward-looking behavior as is the case of Taiwan.

Furthermore, the possible explanations about the origins of rigidity (or high information costs) in the cases of China and Korea will have to be analyzed by the differences in the economic system and growth experience as follows. First, China's rigidity appears to relate to the planned and controlled economic system. Under an economy planned and controlled by the central government, the role of model-based expectations in the economic agents' decision making is ruled out. In the absence of a market oriented economy, the central government's expectation may represent the economic agents' expectation. Thus, economic agents have no flexibility to alter their expectation even in the face of policy regime changes. Second, we can also infer that the higher associated information costs prevent Korea's economic agents from forming their forecasts based on the forward-looking expectation model. However, the origins of rigidity in the case of the market oriented economy of Korea seem to be different from those in the case of China. Park (1990) explains that the extent of rigidity of an economy will depend on the nature of government role and also on the pattern of industrial growth during the process of implementing export-led growth strategy. The Korean government has been collaborative and even coercive in relations with the private sector. As economic planners (government) encourage increasing returns technologies, Korean industries were concentrated in the hands of a few conglomerates.[11] A few conglomerates expectation formation seems to be affected directly by the policies of government planners without any consideration and expectation of market activities. In this context, the export-led growth strategy of Korea can be understood as a government-led growth strategy.

5. Conclusion

This study examined the exogeneity properties of export growth and the validity of export-led growth hypothesis by using the exogeneity tests proposed by Engle and Hendry (1993). We employ the output growth model of Feder (1983) as the conditional model for testing the exogenous property of real export growth. Our empirical evidence for Korea indicates that real export growth appears to satisfy the weak, strong and super exogeneity assumptions even considering the more general case of heteroscedasticity. The weak exogeneity test results justify the use of single-equation method between export growth and output growth. In addition, the strong exogeneity test results provide a sound basis for the causal direction from export growth to output growth. These results imply that export growth provides a positive and significant effect on output growth in the case of Korea, which is fundamentally required by the Feder (1983) model and other endogenous growth. In particular, the results of the super exogeneity test imply that the Lucas critique does not apply to the early 1960s regime changes for export promotion policy, and that there exists structurally invariant relationship between export growth and output growth. In conclusion, our results support the positive and significant roles of export growth and the validity of the export-led growth hypothesis in the case of Korea. These findings are similar to the results of Kwan and Kwok (1995) for the case of China, but different from those of Kwan et al. (1996) for the case of Taiwan. These differences in the results appear to stem form the differences in economic systems and in the patterns of industrial growth among the three countries. However, we cannot provide a more precise evaluation of the role of economic agent's expectation formation in economic growth because the issue goes beyond the scope of this study. In this context, further research should investigate the effect of economic agent's expectation formation in economic growth in the case of developing countries including the other East Asian NICs. Such studies may lead to new insights in explaining factors of economic growth and development or clarify some patterns of economic systems among different countries which could or could not be validated by the export-led growth hypothesis.

Notes

(1) Marlin (1992) investigated the relationship between exports, productivity, the terms of trade and world output for four developed market economies (United States, Japan, United Kingdom, and Germany) on the cointegration and causality concept. And Serletis (1992) examined the relationship between exports, imports and GNP in the case of Canada.

(2) Kunst and Marlin (1989) investigated the causal linkages between exports and productivity in the case of Austria. Henriques and Sadorsky (1996) investigated the linkages between the following variables in the case of Canada: real Canadian exports, real Canadian GDP, and real Canadian terms of trade. Chow (1987) investigated the relationship between export growth and industrial development by using Sims' causality for eight Newly Industrializing Countries (NICs). Ahmad and Harnhirun (1995) analyzed the long-run relationship between exports and economic growth in the ASEAN economies based on cointegration and error-correction representation methodology.

(3) λ_{1t} and λ_{2t} are "variation free" if the parameter space (i.e., admissible values) of λ_t is the Cartesian product of the individual parameter spaces.

(4) Constancy is a property of time independence of parameters, and invariance is constancy across interventions.

(5) ADF test should be performed by the following regression:

$$\Delta X_t = \mu + \rho X_{t-1} + at + \sum_{s=1}^{k} d_s \Delta X_{t-s} + \varepsilon_t \ .$$

The null hypothesis is H_0 : $\hat{\rho}$ = 0; a rejection of this hypothesis implies that X_t is integrated order one [i.e., I (1)]. A failure to reject implies that ΔX_t is stationary.

(6) We consider other instruments for the export equation as follows: lagged x, lagged y, the ratio of agricultural production, the ratio of government services to GDP, and the growth rates of agricultural, construction and government sector respectively.

(7) A military coup led by General Park Chung Hee toppled the short-lived Chang Myon government in May 1961, and the nation witnessed the emergence of a political leadership committed to economic development. This commitment was translated into economic actions and policies such as the adoption of export-led growth strategy, active inducement of foreign capital, and various institutional reforms.

(8) With the beginning of the third five year economic development plan(1972-1976), the Korean government began to promote "heavy and chemical" industries, and actually implemented various tax-cum incentives for these industries.

(9) The variance for η_t (i.e., σ_t^2) can be estimated by

$$\hat{\sigma}_t^2 = \sqrt{\frac{1}{T-K}\sum_{t=1}^{T}\hat{\eta}_t^2}, \text{ with } \hat{\eta}_t = DEX_t - D\hat{E}X_t ,$$

where T and K represent the number of observations and of parameters respectively.

(10) Data-based predictors simply require the economic agent to know the order of integration (d) of a series, x_t, and unbiased estimates will be obtained by making forecasts on the basis of the expression $\Delta^{d+1}X_t^e = \Delta^{d+1}X_t$.

(11) The Taiwan government has been supportive rather than interventionist. It did not adopt increasing returns technologies as the Korean planners did. The difference in production technology induce different patterns of industrial growth; the dominance of small and medium-sized firms continued in Taiwan's major export industries.

Appendix

Data Definitions and Sources

The sample period in this study is 1954-1993. All data used are annual and real data collected from National Accounts (Bank of Korea, 1994) and Korean Statistical Year Book (various issues). Due to data unavailability, real GDP and export are processed respectively by deflating nominal GDP and export by 1990 constant producer price index. The population from Korean Statistical Yearbook is adopted as a proxy for labor force. In addition, the real US GNP data series based on 1987 constant price are downloaded from Economic Bulletin Board located in inter-net.

$DGDP_t$: Real GDP growth;

DEX_t : Real export growth;

IG_t : The ratio of investment to GDP

DL_t : The population growth rate

HEV_t : The share of heavy industry in manufacturing

DAR_t : The agricultural production growth rate

$DEXDM65_t$: Export growth (DEX_t) interaction with dummy for 1965 ($DM65_t = 1$ for $t \geq 1965$ and $DM65_t = 0$, otherwise).

$I74_t$: Impulse dummy variable ($I74_t = 1$ for $t = 1974$ and $I74_t = 0$, otherwise)

$I80_t$: Impulse dummy variable ($I80_t = 1$ for $t = 1980$ and $I80_t = 0$ otherwise)

$DM61_t$: Step dummy for 1961 export-oriented regime changes ($DM61_t = 1$ for $t \geq 1961$ and $DM61_t = 0$ otherwise).

$DUSGDM61_t$: US GDP growth interaction with a step dummy for 1961 ($DM61_t = 1$ for $t \geq 1961$ and $DM61_t = 0$ otherwise).

$IGDM61_t$: The ratio of investment to GDP interaction with a step dummy for 1961 ($DM61_t = 1$ for $t \geq 1961$ and $DM61_t = 0$ otherwise).

$HEVDM74_t$: The share of heavy industry in manufacturing interaction with a step dummy for 1974 ($DM74_t = 1$ for $t \geq 1974$ and $DM74_t = 0$, otherwise)

Table 1

Tests for Unit Roots

Variables	Lags	ADF	Variables	Lags	ADF
GDP	1	-2.86	Δ *GDP*	0	-4.57**
EX	2	-0.67	Δ *EX*	1	-4.27**

Notes: The equations for the ADF tests were estimated with a constant and a linear trend. The lag length for the dependent variable in the ADF tests were based on the significance of the last lagged variables. ** indicates statistical significance at the 1 percent level.

Table 2

The Modified Output Growth Model (Conditional Model)

Estimated Equation

$$DGDP_t = \underset{(0.096)}{-0.203^*} \underset{(0.042)}{-0.051 DEX_t} \underset{(0.012)}{+0.042^{**} IG_t} \underset{(2.141)}{+5.382^* DL_t} \underset{(0.059)}{+0.18^{**} DEXDM65_t}$$

$$\underset{(0.050)}{-0.108^{**} I74_t} \underset{(0.050)}{-0.254^{**} I80_t}$$

$$R^2 = 0.639,\ F(6,32) = 9.437^{**},\ DW = 1.86,\ \sigma = 0.048$$

Diagnostic Checking:

SERIAL[1]	F(1, 31) = 0.054;	*SERIAL*[2]	F(2, 30) = 0.031;
ARCH[1]	$\chi^2(1) = 0.622$;	*ARCH*[2]	$\chi^2(2) = 3.601$;
HETERO	$\chi^2(10) = 8.812$;	*NORMALITY*	$\chi^2(2) = 1.323$;
RESET[1]	F(1,30) = 2.967;	*RESET*[2]	F(2,29) = 1.487;

Notes: Values in parentheses are standard errors. $DGDP_t$, DEX_t, IG_t, and DL_t, are respectively real *GDP* growth, real export growth, the ratio of investment to GDP, and the population growth rate. $DEXDM65_t$ shows the interaction of *DEX* with the step dummy of $DM65_t$ (i.e., $DM65_t = 1$ for $t \geq 1965$ and $DM65_t = 0$ otherwise). $I74_t$ and $I80_t$ are impulse dummy variables respectively (with $I74_t = 1$ for $t = 1974$ and $I74_t = 0$ otherwise; $I80_t = 1$ for $t = 1980$ and $I80_t = 0$ otherwise). * and ** indicate statistical significance at the 5 and 1 percent level respectively.

Table 3

The Export Growth Model (Marginal Model)

Estimated Equations

$$DEX_t = \underset{(1.696)}{-6.579^{**}} + \underset{(0.634)}{2.626^{**}}IG_t \underset{(6.675)}{-16.997^{*}}DL_t + \underset{(1.145)}{1.499}DUSGDM61_t$$

$$\underset{(0.646)}{-2.787^{**}}IGDM61_t + \underset{(0.113)}{2.265^{**}}HEVDM74_t \underset{(0.945)}{-4.035^{**}}DAR_t$$

$$+\underset{(0.999)}{4.219^{**}}DARDM61_t + \underset{(1.782)}{7.944^{**}}DM61_t$$

$R^2 = 0.749$, $F(8, 30) = 11.162^{**}$, $DW = 2.28$, $\sigma = 0.127$

Diagnostic Checking:

SERIAL[1]	$F(1,29) = 0.875$;	*SERIAL*[2]	$F(2, 28) = 1.852$;
ARCH[1]	$\chi^2(1) = 0.582$;	*ARCH*[2]	$\chi^2(2) = 0.770$;
HETERO	$\chi^2(15) = 16.463$;	*NORMALITY*	$\chi^2(2) = 3.571$;
RESET [1]	$F(1, 29) = 0.270$;	*RESET* [2]	$F(2, 28) = 0.133$;

Notes: Values in parentheses are standard errors. HEV_t is the share of heavy industry in manufacturing. $DM61_t$ is an intercept dummy (with $DM61_t = 1$ for $t \geq 1961$ and $DM61_t = 0$ otherwise). $DUSGDM61_t$, $IGDM61_t$, $HEVDM74_t$, and $DARDM61_t$ show the interactions of the growth rates of U.S. GDP, IG_t , HEV_t , and DAR_t (agricultural production growth rate) with the step dummies (i.e., $DM61_t = 1$ for $t \geq 1961$ and $DM61_t = 0$ otherwise; $DM74_t = 1$ for $t \geq 1974$ and $DM74_t = 0$ otherwise). * and ** indicate statistical significance at the 5 and 1 percent level respectively.

Table 4

Results of Weak and Super Exogeneity Test (Σ_t is constant)

i) ***Test of Weak Exogeneity***

$$DGDP_t = \underset{(0.097)}{-0.205} \underset{(0.075)}{-0.042DEX_t} + \underset{(0.012)}{0.042^{**}IG_t} + \underset{(2.161)}{5.315^{*}DL_t} + \underset{(0.059)}{0.181^{**}DEXDM65_t}$$

$$\underset{(0.051)}{-0.112^{*}I74_t} \underset{(0.051)}{-0.249^{**}I80_t} + \underset{(0.083)}{0.056D\hat{E}X_t}$$

R^2 =0.664, F(7,31) = 8.017**, DW = 1.89, σ = 0.049

Single variable test of significance for $D\hat{E}X_t$: F(1, 31) = 0.056

ii) ***Test of Super Exogeneity***

$$DGDP_t = \underset{(0.104)}{-0.239^{*}} \underset{(0.075)}{-0.092DEX_t} + \underset{(0.014)}{0.049^{**}IG_t} + \underset{(2.166)}{5.322^{*}DL_t} + \underset{(0.060)}{0.178^{**}DEXDM65_t}$$

$$\underset{(0.051)}{-0.105^{*}I74_t} \underset{(0.051)}{-0.249^{**}I80_t} + \underset{(0.100)}{0.004D\hat{E}X_t} + \underset{(0.213)}{0.198D\hat{E}X_t^2}$$

R^2 =0.654, F(8,30) = 7.903**, DW = 1.77, σ = 0.049

Single variable tests of significance:

$D\hat{E}X_t$	F(1, 30) =0.002
$D\hat{E}X_t^2$	F(1, 30) =0.866

Joint variable test of significance

$D\hat{E}X_t$ and $D\hat{E}X_t$: F(2, 30) =0.661

Notes: Values in parentheses are standard errors. * and ** indicate statistical significance at the 5 and 1 percent level respectively .

Table 5

Results of Weak and Super Exogeneity Test (Σ_t is non-constant)

i) ***Test of Weak Exogeneity***

$$DGDP_t = -0.142 \underset{(0.231)}{} -\underset{(0.040)}{0.072}DEX_t + \underset{(0.015)}{0.033^{*}}IG_t + \underset{(2.458)}{2.591}DL_t + \underset{(0.062)}{0.234^{**}}DEXDM65_t$$

$$-\underset{(0.049)}{0.148^{**}}I74_t - \underset{(0.047)}{0.255^{**}}I80_t + \underset{(0.007)}{0.009}\hat{\sigma}_t^{DEX}$$

$R^2 = 0.662$, $F(7,30) = 8.425^{**}$, $DW = 1.97$, $\sigma = 0.045$

Single variable test of significance for $\hat{\sigma}_t^{DEX}$ — $F(1,30) = 1.922$

ii) ***Test of Super Exogeneity***

$$DGDP_t = -0.115 \underset{(0.156)}{} -\underset{(0.156)}{0.248}DEX_t + \underset{(0.021)}{0.032}IG_t + \underset{(2.888)}{3.504}DL_t + \underset{(0.081)}{0.285^{**}}DEXDM65_t$$

$$-\underset{(0.056)}{0.120^{*}}I74_t - \underset{(0.049)}{0.252^{**}}I80_t + \underset{(0.193)}{0.120}\hat{\eta}_t + \underset{(1.201)}{0.007}\hat{\sigma}_t^{DEX}\hat{\eta}_t + \underset{(0.238)}{0.063}D\hat{E}X_t^2$$

$$+\underset{(1.081)}{1.329}D\hat{E}X_t\hat{\sigma}_t^{DEX} - \underset{(0.375)}{0.003}\hat{\sigma}_t^{DEX}$$

$R^2 = 0.683$, $F(11, 26) = 5.107^{**}$, $DW = 1.83$, $\sigma = 0.047$

Single variable tests of signficances:

$\hat{\eta}_t$,	$F(1, 26) = 0.391$
$\hat{\sigma}_t^{DEX}\hat{\eta}_t$,	$F(1, 26) = 0.000$
$D\hat{E}X_t^2$,	$F(1, 26) = 0.072$
$D\hat{E}X_t\hat{\sigma}_t^{DEX}$	$F(1, 26) = 1.511$
$\hat{\sigma}_t^{DEX}$	$F(1, 26) = 0.000$

Joint tests of significances:

$D\hat{E}X_t^2$, $\hat{\sigma}_t^{DEX}$	$F(2, 26) = 0.035$
$\hat{\eta}_t$, $\hat{\sigma}_t^{DEX}\hat{\eta}_t$, $D\hat{E}X_t^2$, $D\hat{E}X_t\hat{\sigma}_t^{DEX}$, $\hat{\sigma}_t^{DEX}$	$F(5, 26) = 1.187$

Notes: Values in parentheses are standard errors. * and ** indicate statistical significance at the 5 and 1 percent level respectively.

Table 6

Results of Granger non-causality

H_0:	*DEX* does not cause *DGDP*	*DGDP* does not cause *DEX*
Optimal lags:	(j=1, k=3)	(l=3, m=4)
Test statistic:	F (3, 30) = 4.381 (0.011)*	F (4, 27) = 2.390 (0.076)
SUM:	0.206	-0.171
Serial [1]	0.015 (0.904)	0.033 (0.855)
Serial [2]	0.216 (0.806)	0.036 (0.964)

Note: Values in parentheses are P-value. SUM is the summation of the lagged coefficients of DEX and DGDP. * indicates statistical significant at the 5 percent level.

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超外生性と輸出主導型成長仮説

〈要　約〉

黄　　仁相

この論文は、ルカス批判を計量経済学の手法によって応用し、輸出主導型経済成長仮説を再評価することを目的とする。その結果、1954年から1993年までの韓国経済における輸出成長変数は、弱、強、そして超外生性を満たす変数であることが実証された。特に、韓国における輸出成長の超外生性は、輸出成長と経済成長との間には、構造的に影響されない関係であることを示唆している。同時に、1960年代初期から始まった韓国の輸出主導型経済成長政策はルカス批判には属さないことも意味している。これらの結果は、韓国における輸出主導型経済成長政策の妥当性も支持している。また、政策含意として、各国の固有な経済システムの違いにより、経済成長に対する経済参加者の期待形成も違うことが示唆されている。