Title: Imports, Exports, and Total Factor Productivity in Korea

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Abstract

This study investigates the relationship between trade and economic growth in Korea during the period 1980~2003. The empirical results suggest the existence of Granger causality running from imports to total factor productivity (TFP) growth, and the absence of any causal relation between exports and TFP. In light of this causal relationship between imports and TFP growth, TFP growth is regressed on various trade variables, along with R&D investments and government size. The results indicate that imports have significant positive effects on TFP but that exports do not. The results also indicate that the salutary impact of imports on TFP growth stems not only from competitive pressure and new knowledge acquired from foreign rivals in the context of increased imports of final goods but also from technological transfers embodied by imports from developed countries. Most of the empirical results still hold when TFP growth is replaced with GDP growth.

I. Introduction

Many economists initially perceived the rapid economic growth of East Asian countries during the second half of the last century as stemming mainly from an export-driven growth strategy, which accompanied strong protection of domestic markets. Implementing this strategy, East Asian governments were able to hasten their catch-up process by directing limited national resources into a small number of strategically selected industries and opening their markets in order to learn about advanced technologies from developed countries. During this process, export expansion contributed to the economic growth of East Asia not only by facilitating factor mobilization and capital accumulation in a quantitative sense but also by promoting productivity growth through the emulation of advanced technology and through enhanced competition in the foreign market. Furthermore, domestic markets were protected so that they would experience the period of nurturance that was needed for them to build up their infant and strategic industries.

Perceptions about East Asian growth later changed, however, as the Japanese economy succumbed to prolonged depression in the early 1990s and other East Asian developing countries suffered from the financial crisis of the late 1990s. This turn of economic events rekindled the earlier debates about East Asian growth that had revolved around the objectives of estimating the sources of growth and investigating the role of trade. In the context of the productivity debate, accumulationists argued that East Asia's growth was largely driven by input accumulation; assimilationists believed, however, that the rapid economic growth of the region was owing to the high rate of technical change made possible by the diffusion of technology from developed countries. In the context of the trade and growth debate, economists tried to investigate the nexus between trade and growth to analyze the role of trade in economic growth. Some supported the export-led hypothesis, while others argued the importance of market-opening for growth[1].

In *The East Asian Miracle*, the World Bank (1993) suggested that exports and export-promoting policies had been instrumental in the East Asian adoption of frontier technologies, which had enhanced the productivity of exporting firms and whole economies in general, thus accelerating economic growth. In addition, many studies provided empirical evidence in support of the export-led-growth hypothesis by showing that exports had positive significant effects on productivity and economic growth. Contrary to this view, Lawrence and Weinstein (1999) argued that the World Bank (1993) had focused only on the export-growth relationship, and had thus ignored the role of imports in promoting productivity. For Japan, Korea, and the U.S., Lawrence and Weinstein (1999) found that protection was actually harmful to productivity growth and that exports did not boost it, while imports enhanced it. These results suggested that innovation, learning, and competitive pressures resulting from foreign imports are important conduits for growth.

This study investigates the link between trade and productivity growth for the Korean economy, with special attention to the import-productivity nexus. First, the dynamic interaction between trade variables and productivity growth is investigated using a vector error correction model (VECM) to capture both short-run dynamic changes and long-run relationships. The empirical results suggest that imports cause productivity growth but provide no evidence of any causality running from exports to productivity growth. In particular, this direction of causality is apparent in both bivariate and trivariate models that comprise imports, exports, and total factor productivity (TFP). Second, to identify the specific reasons for the import-productivity relationship, a productivity determination equation is estimated, in which various trade variables are included as explanatory variables, along with variables representing government size and research and development (R&D) investments. The empirical results again indicate that imports, but not exports, are a significant determinant of productivity growth. Furthermore, the salutary impact of imports stems not only from competitive pressures and new knowledge gained from foreign rivals in the context of increased imports of final goods but also from technological transfers embodied by imports from developed countries.

Most previous studies analyzing the relationship between trade and growth for the Korean economy have considered exports as trade and investigated the causality between exports and growth. In addition, the role of imports in economic growth has largely been ignored in the literature. This omission is rather surprising in light of theoretical developments that have established imports as an important channel for technological transfers and economic growth. Hence, this study tries to provide a comprehensive analysis of trade and growth, with special emphasis on various import components, in order to identify the explicit forces driving the relationship.

The remainder of the paper is organized as follows. Section 2 presents a literature survey. Section 3 summarizes the variables, investigates the causality between inflation and productivity using a VECM, and estimates the impact of import components on TFP growth. Section 4 concludes.

II. Literature Survey

In theory, the causal relationship between trade and productivity is two-way, but export-led growth theorists generally contend that exports enhance productivity growth (for recent examples, see Bonelli, 1992; Haddad et al., 1996; Weinhold and Rauch, 1997; Yean, 1997; and Sjoeholm, 1999). These theorists argue that firms tend to learn advanced technologies through exports and must adopt them to compete in the foreign marketplace (Balassa, 1978; Krueger, 1980; Nishimizu and Robinson, 1982). Firms also learn by doing, and emulate through the trial and error processes inherent in the production and sale of export goods (Grossman and Helpman, 1991). Furthermore, expansion in production resulting from exports reduces unit production prices and thus increases productivity (Helpman and Krugman, 1985). In addition to these effects, exports also provide a country with foreign exchange, which is often scarce in the early stages of economic development, enabling a country to afford to import capital and intermediate goods. Thus, exports increase productivity growth (Mckinnon, 1964). Contrary to the export-led-growth hypothesis, the reverse causation from productivity growth to exports is also obvious. Productivity growth causes exports, because a country's competitiveness in price and quality is enhanced by an increase in productivity.

An extensive empirical literature exists on the relationship between exports and growth, largely because of its bidirectionality. Empirical studies have tried to determine whether exports cause productivity to increase[2]. However, results in this regard seem to depend on both the sample periods and the countries examined. Some studies have found unidirectional causality running from exports to productivity (Haddad et al., 1996), and others have reported reverse causality between the two variables (Clerides et al., 1998; Pavcnik, 2000). Clerides et al. (1998) argued that only relatively efficient firms engage in exports, and that exports do not bring down unit production costs. Thus, these authors acknowledged only the causality from productivity growth to exports. In their studies of U.S. firms, Bernard and Jensen (1999a, 1999b) also found that firms with high productivity usually export their products, and that exporting firms do not experience productivity and wage increases that are greater than those of non-exporting firms. Meanwhile, many studies have also reported bidirectional causality or an absence of causality between exports and productivity (Hsiao, 1987; Kunst and Marin, 1989; Jin and Yu, 1996).

For the Korean economy, some of the studies have supported the export-led-growth hypothesis (Jung and Marshall, 1985; Xu, 1996; Choi, 2002), and other studies have reported either an absence of causality from growth to exports (Darrat, 1986; Hsiao, 1987; Dodaro, 1993; Dutt and Ghosh, 1996) or bidirectional causality (Hsiao, 1987; Chow, 1987; Bahmani-Oskooee and Shabsigh, 1991; Bahmani-Oskooee and Alse, 1993; Jin, 1995). These studies have thus provided ambiguous conclusions regarding the direction of the causality between exports and growth for Korea, despite widespread belief in the export-led-growth hypothesis in the context of causality tests.

The relationship between imports and productivity appears to be more complicated than that between exports and productivity. Increased imports of consumer products encourage domestic import-substituting firms to innovate and restructure themselves in order to confront foreign rivals; therefore, imports enhance production efficiency. Under perfect competition in the neoclassical model, an industry reduces factor usage in the short-run once its protection is lifted and the market is opened for imports. In the long run, however, the industry becomes more productive and competitive and expands its investments in new technology, shifting the industry supply curve downward to the right (Haddad et al., 1996) [3]. In general, the effect on productivity of opening the market depends on both market structure and institutional factors. Under imperfect competition, an import-substituting domestic market shrinks as imports increase, causing investment to decrease. Thus, productivity eventually deteriorates in this context (Tybout, 2000) [4]. Furthermore, the greater future expected profits are, the more active R&D investment and innovation efforts become, and such R&D efforts may be greater for exporting firms than for import-substituting firms, as the impact of market opening is large. Finally, imports of intermediate goods and capital products that cannot be produced internally enable domestic firms to diversify and specialize, further enhancing the productivity of the firms benefiting from those imports (Grossman and Helpman, 1991; Sjoeholm, 1999; Tybout, 2000).

The causality from productivity to imports may be either positive or negative. Productivity growth triggers economic growth and increases income, and this in turn leads to an increase in imports. In this case, productivity stimulates imports. Meanwhile, increased productivity in an import-substituting industry crowds out imports from the domestic market and thus has a negative impact. Overall, the causal direction and qualitative impact of the interaction between imports and productivity cannot be determined theoretically and remains to be analyzed using actual data.

Lawrence (1999) showed empirically that import competition brought about TFP growth for the U.S. market. In addition, Lawrence and Weinstein (1999) reported, for a Japanese manufacturing panel data set, that imports contributed to TFP increases, mainly because of competition effects. They also found similar results for Korea and the U.S., which suggested the absence of any systematic evidence that greater levels of protection improved productivity for these countries. Muendler (2004) suggested that the effects of intermediate imports on labor productivity were small, but that the competition effects of imports were large, for Brazilian manufacturing industry.

In summary, a survey of the literature reveals ongoing issues in the debate regarding the trade-growth relationship. First, tests of the export-led-growth hypothesis have provided only mixed results, which need further clarification. Second, the role of imports on growth has been elaborated in many theoretical models but has still not been examined empirically.

This study extends previous research on the relationship between trade and inflation on several fronts. First, the cyclical effects that have been known to co-move with business cycles are eliminated from the productivity measures used. This treatment excludes the possibility of a spurious relation resulting from the cyclical biases that exist in productivity measures when the productivity-trade relationship is examined. Second, an extended data set covering recent years up to 2003 is used. Third, a TFP equation is estimated to investigate the macroeconomic relationship between trade and productivity. Finally, imports are decomposed into subcategories to isolate the exact component of imports that drives the productivity-import nexus.

III. Empirical Analysis of the Relationship between Trade and Productivity

1. Variables

The previous section surveyed the existing literature on the theoretical relationship between imports, exports, and productivity. This section analyzes this relationship empirically for the Korean economy.

Many studies on the trade-productivity nexus have used labor productivity as a productivity measure, but this partial measure does not allow for consideration of the impact of factor substitution between capital and labor. This effect is especially important for the Korean economy, which has experienced continuous capital deepening and adopted new production technologies. Measures of labor productivity generally include the effects of capital deepening, along with those of technological progress and structural efficiency changes, as measured by TFP. It has recently been argued that Korean economic growth was driven mostly by factor accumulation rather than by productivity growth. Thus, this study considers TFP, separately from capital deepening or labor productivity growth resulting from trade-induced economies-of-scale, as a productivity measure in the estimation of the effects of trade on both structural and technological changes.

Data on TFP are constructed from various sources in the Bank of Korea database and used to estimate Solow residuals for the period 1985Q1-2002Q4. The capital stock is taken to be the real amount of tangible fixed assets, adjusted for the capital utilization rate. In addition, labor inputs are proxied by the number of work hours, and gross domestic product (GDP) is used as the measure of output[5]. All variables are converted into constant real prices for 1995.

The measured Solow residual is generally not a genuine measure of productivity growth unless the conditions of perfect competition, constant-returns-to-scale technology, and the full employment of labor and capital are all satisfied. Thus, in reality, the measured Solow residual may be affected by demand-side variables (Hall, 1989; Mankiw, 1989). In particular, one study has reported that the Solow residual for Korea is not a strictly exogenous variable and, instead, co-moves with demand shocks (Kim and Lim, 2004). Thus, if measured productivities are, in fact, affected by cyclical movements, an empirical correlation between trade and productivity may reflect a spurious relation between trade and business cycles. For this reason, cyclical bias should be eliminated from the productivity measures employed.

To address this problem, this study uses the method suggested by Basu and Kimball (1997) and Ball and Moffitt (2001). According to this method, the log difference of the measured Solow residual is first regressed on that of the capital utilization rate, which is a proxy for business cycles. Next, the average of the regression error term is adjusted, so that it equals the original productivity measure in the case that productivity measure is adjusted for cyclical factors.

The estimation results indicate that the effect of the business cycle on the measured Solow residual is significant[6]. The estimation results for the Solow residual are presented in Equation (1), where CU represents the capital utilization rate and where t-statistics are provided in parentheses[7]. After removing cyclical effects from the measured Solow residual, we find that the residual's overall movement is not affected but that its variation is considerably reduced[8].

$$\Delta \log(TFP)_t = 0.02 + 0.26 \Delta \log(CU)_{t-1}, \qquad (1)$$
$$(8.11) \quad (3.89) \qquad \overline{R}^2 = 0.16, \; D.W. = 2.20.$$

Figure 1 presents, for the Korean economy, the growth rates of the measured Solow residual, and the TFP estimates obtained after eliminating the cyclical effects from the residual. TFP increased steeply after the mid 1980s but slowed somewhat in the 1990s, exhibiting a huge drop during the financial crisis of 1997-1998. It recovered from the crisis shortly thereafter but then dropped again after 2000.

Figure 2 illustrates the temporal pattern of imports and exports for the Korean economy. The Korean economy has sustained a relatively high ratio of international trade, considering the size of its economy. The export (EXP) share in GDP fell below 30% during the late 1980s and mid-1990s but was near or greater than 40% during other periods. Imports (IMP) fluctuated cyclically on a fairly large scale, but their share in GDP remained within the range of 30-40%. Overall, the share of imports declined in the early 1980s and bounced back after the early 1990s, exhibiting a U-shaped trend.

Before empirical analysis, augmented Dickey-Fuller (ADF), Phillips-Peron (PP), and Kwiatkowski, Phillips, Schmidt and Shin (KPSS, 1992) unit root tests are carried out to examine whether the time-series of the variables follow stochastic trends. Table 1 reports the test results in both levels and first differences. The tests unambiguously suggest the existence of one unit root for every variable, indicating that the time-series are integrated of order 1, I(1).

To treat this problem, the existence of long-run relationships among the variables is checked. It is possible to derive a long-run equilibrium that does not suffer from the statistical problem of spurious regression. Table 2 presents the maximum-likelihood ratio statistics, which indicate the number of long-run relationships and, thus, how many cointegration vectors exist in the parameter matrix. Johansen's cointegration test is conducted on three sets of variables that include log values of, respectively, the two variables exports (LEXP) and TFP (LTFP), the two variables imports (LIMP) and TFP (LTFP), and the three variables exports, imports, and TFP.

The test results indicate that a restricted constant, which allows a non-zero drift in the unit root process, is included in the multivariate system of equations. The lag values of the VECMs are set equal to two. The null hypothesis of r =0 is rejected at the one-percent level (see Osterwald and Lenum, 1992, for critical values), but the null hypothesis of r<=1 cannot be rejected. Thus, the estimated likelihood ratio tests indicate the presence of one cointegration vector, and that a long-run relationship is present in the underlying data-generating process of the time-series variables.

2. Causality between Trade and Productivity

Based on the test results of the previous section, a vector error correction model (VECM) is estimated on the set of variables, and Granger causality is tested based on the coefficient estimates of the model in this section. A VECM model consisting of the variables of IMP, EXP, and TFP may be written as follows:

$$y_t = \sum_{t=1}^{p} \Phi_i y_{t-1} + \varepsilon_t, \ \ \Delta y_t = \alpha\beta' y_{t-1} + \sum_{j=1}^{p-1} \Phi_i^* \Delta y_{t-1} + Z_t + w_t \ ,$$

where $\Phi_i^* = -\sum_{j=i+1}^{p} \Phi_j$, $\alpha\beta' = -\Phi(1) = -I_k + \Phi_1 + \Phi_2 + \cdots\cdots + \Phi_p$, (2)

$w_t \sim N(0,\Sigma)$, and Σ is a non-diagonal symmetric matrix.

In a VECM, all variables included in y_t must satisfy I(1), and residuals from a long-run cointegrating relationship are used as lagged error correction terms in a VAR. If $\beta' y_t = c$ represents a long-run cointegrating relationship and there is a deviation from long-run equilibrium, the error $\beta' y_t - c$ is removed to restore equilibrium at adjustment speed α .

VECM models consisting of two variables, either IMP and TFP or EXP and TFP, and of the three variables IMP, EXP, and TFP, are considered. The chosen ordering of variables is EXP, TFP and IMP, TFP for the bivariate models, and EXP, IMP, and TFP for the trivariate model; this ordering reflects the degree of exogeneity of the variables. However, changes in the order of these variables do not significantly affect the estimation results. Thus, y_t' = [LEXP (LIMP), LTFP] or y_t' = [LEXP, LIMP, LTFP], depending on the number of variables considered. To consider economic abnormalities in the aftermath of the financial crisis and to eliminate any spurious correlation between trade and productivity growth, a dummy for the period 1998Q1~1998Q3 is included as the exogenous variable (Z_t) in Equation (2). VECM systems with a lag length of two are estimated, and these lags are chosen to minimize Akaike Information Criteria (AIC); however, changes in the lag length do not affect the results.

Table 3 reports parameter estimates for the VECM of three variables, along with a VAR model on the levels of the variables. Although an autoregressive unit root characterizes every variable in the system, a VAR is also estimated to avoid any possible loss of valuable information owing to differencing[9]. In particular, a VAR is expected to elucidate the long-run relationship among the variables. Qualitatively, there are few differences in the coefficient estimates resulting from the VECM and the VAR. The most salient estimation result in both models is that, of the two trade variables considered, only imports have a significant positive impact on TFP

Figure 3 reports the impulse response functions in the VAR model, which are the simulated responses of TFP to trade variables, to investigate the long-run relationship between these variables. The time period of the impulse response functions extends over ten quarters and is measured in terms of standard deviations. The effect of a one-standard-deviation shock to imports on TFP is positive and significant in the initial quarters and subsequently diminishes to zero. The effect of a shock to exports on TFP is positive but insignificant over the whole period. The responses of TFP to the shocks of the trade variables imply that TFP is correlated with imports but not with exports.

Table 4 reports Granger-causality tests based on the coefficient estimates for the three different models. The estimated models comprise two-variable VECMs, a three-variable VECM, and a three-variable VAR model. The test results indicate that causality between exports and TFP growth is not present in every model. However, the estimation results suggest that imports Granger-cause TFP growth in every model, and that the reverse causation from TFP growth to imports is also present in the VAR model.

The result of no correlation between exports and productivity growth is consistent with the work of Darrat (1986), Hsiao (1987), Dodaro (1993) and Dutt and Ghosh (1996). These studies did not find causality running from exports to productivity growth in the case of Korea. In particular, their empirical results suggested that the export-led-growth strategy had not been as successful in raising productivity growth through technological and institutional progress as much as it had been through a quantitative expansion of the economy, which resulted from factor mobilization. Insignificant causality from productivity growth to exports may thus have reflected the fact that exports grew as a result of cheap labor and massive investments, combined with a government push, despite exporting firms' mediocre productivity and efficiency. Thus, the results of this study support previous empirical studies, which negated the exports-and-productivity correlation.

Meanwhile, the presence of an import-productivity correlation suggests that opening the market has been particularly important for Korean economic growth since 1980. Imports have contributed to the economy not only by stimulating industrial innovation, by forcing domestic firms to compete with foreign imports, but also by providing diverse high-quality intermediate goods to the domestic market for firms to use in the process of diversifying and upgrading their products. These findings suggest that competitive pressure, a potential basis for improvements in knowledge, and advanced technologies are delivered through imports. The specific mechanism underlying the import-productivity nexus can be investigated if imports are divided into their various components, such as final goods and intermediates, or imports from developed countries and from others. This issue is elaborated in the following section.

Finally, as was discussed in the literature survey, the opposing effects of productivity growth on imports may cancel each other out, as productivity growth raises imports through income increases but also lowers them by supplying import substitutes to the domestic market. The result that Granger causality from productivity to imports is significant only in the VAR model reflects this complication.

To check the sensitivity of the results to the specification of economic growth, TFP growth was substituted with GDP growth in various VECM and VAR models, and the tests were implemented again. Table A1 in the Appendix reports the Granger-causality tests based on the coefficient estimates of these models[10]. The test results remain exactly the same as the previous results; no causality exists between exports and GDP, and imports Granger-cause GDP growth in every model. Similarly, reverse causation from GDP growth to imports was also found in the VAR model. The empirical results show that imports cause growth and exports are not robust to the inclusion of GDP growth. The export-led-growth hypothesis is thus again negated from the standpoint of GDP growth for Korea, for the period 1980-2003.

3. Effects of Import Components on Productivity

The previous section presented empirical results suggesting that causality runs from productivity growth to inflation. Based on these empirical results, imports are further divided into various components and included in a productivity determination equation for the purpose of investigating the import-TFP relationship.

To determine the short-run dynamics of productivity determination, TFP growth is regressed on import components, exports, and other variables, such as government size and R&D investments. The TFP equation employed may be written as:

$$\Delta LTFP_t = \beta_0 + \sum_{i=0}^{l} \beta_{1i} \Delta LIMP_{t-i} + \sum_{i=0}^{m} \beta_{2i} \Delta LEXP_{t-i} + \sum_{i=0}^{n} \beta_{3i} \Delta LGOV_{t-i} + \sum_{i=0}^{p} \beta_{4i} \Delta LRD_{t-i} + \varepsilon_t \quad . (3)$$

As explanatory variables, government size (GOV) and R&D investments (R&D), which have been widely considered in the productivity literature, are used to represent institutional and technological factors, respectively. Government consumption expenditure is used as a proxy for GOV to capture the inefficiency arising from government failure. The number of patents registered in the U.S. is used as a measure of R&D.

These variables are included, along with the trade variables used in the causality tests of the previous section, to estimate the dynamic impact of trade variables on productivity. The variable for imports is classified according to country-of-origin, as imports from developed G7 countries (DIMP) and those from other countries (OIMP), and according to processing stages, as imports of raw materials (RIMP), capital goods (KIMP), and consumer products (CIMP). The specified trade data are available from KOTIS only for the period after 1988Q1.

Seasonality is eliminated from the variables by means of an X12-ARIMA, and unit root tests are conducted on the variables. Every variable is integrated of order 1, I(1), so first differences are used in the actual estimation. Lags of the explanatory variables are chosen by means of the "general-to-specific" method, in which the most insignificant lagged variable is eliminated iteratively from a set of lagged variables. In addition, AIC criteria are also applied in the selection of appropriate lagged variables. To incorporate the effects of economic abnormalities following the financial crisis, the period 1998Q1~Q3 is represented with a dummy and included in the estimation.

Table 5 presents the coefficient estimates for equation (3), for each of the various models incorporating different import components. Prior to estimation, the existence of a linear correlation among the import variables is examined, and it is found that import components are strongly correlated with each other. For example, the correlations between (RIMP, KIMP), (RIMP, CIMP), and (KIMP, CIMP) are 0.965, 0.888, and 0.916, and that between DIMP and OIMP is 0.966. The high correlation between import components causes multicollinearity, and the significance of all import variables thus disappears when they are regressed together[11]. Thus, import variables are not simultaneously included in a model.

The empirical results indicate that exports do not have a significant effect on TFP growth, and for all models except Model 2 their coefficients are negative. These results also negate the export-led-growth hypothesis in the context of TFP growth in Korea. However, these results do not imply that exports have no beneficial effect for developing economies, because exports may affect an economy through conduits other than TFP growth. For example, exports provide economies-of-scale and foreign exchange to a country, possibly speeding up its growth through capital deepening. This issue is discussed in detail later.

The coefficients on GOV changes are all negative but insignificant, except in the case of Model 1, implying that increases in spending may slow down the overall TFP growth of an economy. TFP is a measure that captures productivity resulting from institutional factors, and increased government spending may create inefficiency in an economy in the form of new regulations and bureaucracies as government size increases. Because of the overall insignificance of its impact, however, conclusions should be drawn cautiously from this result.

All of the coefficient estimates on R&D are positive and significant. Moreover, the results suggest that R&D galvanizes innovation and technical progress, which lead to TFP growth.

Each import component coefficient is positive, but its significance depends on both its product type and country-of-origin. For example, increased imports of capital goods (KIMP) and consumer goods (CIMP) have positive and significant effects on TFP, but the impact of raw-material imports (RIMP) is insignificant. In addition, the coefficient estimates on increased imports from developed G7 countries (DIMP) are positive and significant, but those from others (OIMP) are insignificant. Among the various imports considered, consumer imports (CIMP) are the most significant, and imports from developed countries have the coefficients of the greatest magnitude. The significant coefficient magnitudes of these imports range from 0.042 to 0.058, suggesting that imports have a strong impact on TFP growth.

These empirical findings suggest that increased imports of final goods intensify market competition, inducing import-substituting firms to engage in innovative activities. The findings also suggest that increased imports of intermediate goods supply otherwise non-existent intermediate goods and parts to domestic manufacturers, who use these to improve their product qualities and diversify their products. Finally, the findings suggest that the technologies of advanced countries embodied in imports are transferred to an importing country, enhancing its productivity, irrespective of the relevant product categories. For capital imports, however, both competition and technological transfer effects can coexist, as capital goods include both final and intermediate goods.

With regard to the trade-growth nexus, the results suggest that exports do not cause TFP growth and that imports have a significant positive impact. Thus, the export-led-growth hypothesis is negated in the case of Korean TFP growth during the period 1980-2003. Thus, the economy would certainly have grown faster if tariffs and other protection had been lifted during the development period. In addition, the domestic market should be further opened to promote TFP growth, so that firms might take advantage of the competitive and technological transfer effects that would result.

To check the sensitivity of the empirical results to the specification of economic growth, a GDP growth equation has been estimated instead of that for productivity growth. The results of the TFP growth regression reveal that exports do not contribute significantly to growth. However, the results do not imply that exports have no beneficial effect for a developing economy, because exports may affect an economy through mechanisms other than TFP growth. For example, exports allow an economy to realize economies-of-scale and provide it with foreign exchange, both of which act as catalysts for the accumulation of capital in a country, possibly speeding up growth. Thus, exports may contribute to growth through capital deepening in East Asia, just as accumulationists, who assert that East Asian growth was mostly input-driven rather than productivity-driven, have suggested. In short, exports may not cause TFP growth but, nonetheless, bring about economic growth through the capital deepening of a country. In this sense, GDP growth regressions should provide an answer to the question of whether exports contribute to the Korean economy.

Table 6 reports the coefficient estimates for these models. The empirical results again support the basic conclusion of the previous TFP growth estimation, in the sense that imports stimulate economic growth, and that opening the market for consumer products could promote growth.

Imports as a whole (IMP) and consumer-goods imports (CIMP) retain a significant, positive impact on growth. In addition, all import components have positive effects on GDP growth, but their significances falls in two cases; specifically, imports from developed countries (DIMP) and capital-goods imports (KIMP) become insignificant. Thus, the technological transfer effect of imports on GDP growth is not as apparent as in the case of TFP growth. However, the overall impact of exports seems to increase, as the coefficient signs all become positive, with the exception of that on consumer-goods imports in Model 10. The coefficients are still all insignificant, except for that on raw-material imports in Model 8. The empirical results indicate that imports have a significant influence on GDP growth as a whole, but that only consumer imports preserve their significance when divided into components. Exports seem to have a slightly greater impact on GDP growth than on TFP growth, but the overall impact of exports on growth appears too fragile and insignificant to support the export-led-growth hypothesis. The results thus challenge the idea that exports cannot only raise TFP growth but also accelerate economic growth through other means, on a large scale, as export-led growth theorists have suggested.

The coefficients on R&D are all insignificant, implying that the impact of R&D investments on GDP growth is less apparent than their effect on TFP growth, which generally includes the direct effects of investment. Government spending (GOV) coefficients are all insignificant and negative, except in Model 9.

VI. Conclusion

This study investigates the relationship between trade and TFP growth for the Korean economy using quarterly data for the period 1980Q1~ 2003Q3. Causality tests indicate a unidirectional causality running from imports to TFP growth, with no correlation between exports and TFP growth. Even though many economists believe that exports have been the main vehicle for Korean economic growth, the results suggest that TFP growth has been driven, in the main, by the increasingly open market.

Taking into consideration the results of these causality tests, the study estimates various productivity equations to investigate the macroeconomic relationship between import components and productivity. The empirical results suggest that, when imports are sorted into product types, the imports of final goods and capital goods exert significant positive impacts on TFP, while the effects of raw-material imports on TFP are insignificant. The results also indicate that when imports are classified by their country of origin, imports from G7 countries have a significant positive influence but those from others do not. These findings imply that the salutary impact of imports generally stems not only from competitive pressures and the acquisition of new knowledge from foreign rivals that occurs with increased imports of final goods, but also from technological transfers embodied in imports from developed countries. A GDP growth regression, however, suggests that the beneficial effect of imports results mainly from the competitive pressure provided by final-good imports.

This study differs from earlier studies on the trade-growth nexus, which suggested that exports enhance productivity growth because firms exposed to international competition tend to absorb best-practice technology. This argument served as one in rational support of trade protection. The empirical results of this study suggest that this argument is problematic, at least when it comes to TFP growth, by showing that higher imports would have been particularly beneficial for Korea during the period 1980-2003.

Korean economic growth has depended, to a large extent, on factor input increases, as argued in many recent studies, and exports have delivered a massive mobilization of inputs by extending economies-of-scale and supplying much-needed, precious foreign exchange to the economy. Thus, much of the growth explained by factor accumulation would not have been possible without exports. If this inference is correct, then exports may contribute to growth through factor mobilization. To investigate this possibility, this study replaces TFP growth with GDP growth to test the sensitivity of the empirical results to the growth specification. The same conclusions are drawn; imports cause and contribute significantly to GDP growth, but exports do not. Thus, the empirical results are robust with respect to the inclusion of GDP growth, and the export-led-hypothesis is again negated.

Many researchers have recently argued that East Asia's growth was largely driven by input accumulation, and that productivity increases were negligible, based on a decomposition of Asian economic growth into factor-accumulation and productivity-growth components. They have come to the conclusion that the region's growth will eventually slow down, as massive factor mobilization becomes impossible. In the context of the debate on East Asian growth, the results of this study thus suggest that East Asia should be more receptive to foreign imports in order to accelerate its growth, because imports enhance productivity growth. The East Asian countries pursuing TFP growth to boost their economy should open their markets, because import growth brings institutional and technological change into a country.

The import-growth nexus seems robust, as it is supported from various standpoints, including causality tests, productivity determination regressions, and various growth specifications. Further studies should use industry panel data to investigate the industry-specific effects of trade on productivity growth, and data sets from other countries to replicate the results.

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Table 1. Unit Root Tests of the Variables for the Relationship between Trade and Productivity Growth for Korea during 1980Q1~2003Q3

	ADF		PP		KPSS	
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
LIMP	-2.18	-5.59*	-2.52	-8.36*	0.16**	0.06
LEXP	-1.96	-4.53*	-2.15	-9.58*	0.18**	0.04
LTFP	0.15	-4.53*	-0.32	-12.19*	0.28*	0.13***

Notes: Test regressions contain a constant and a linear time trend, and lags of the dependent variable are chosen by AIC. *, ** and *** reject the null hypothesis at the 1, 5, and 10% significance level, respectively. The null hypothesis is the existence of unit root for ADF and PP tests, and the non existence of unit root for KPSS test.

Table 2. Johansen's log likelihood test for cointegration of the Variables for the Relationship between Trade and Productivity Growth for Korea during 1980Q1~2003Q3

H_0 : rank=r	Eigenvalue	Max-Eigen stat	5 % Critical	Trace stat.	5 % Critical
LTFP, LEXP					
None	0.134	13.31	14.26	17.19**	15.49
R≤1	0.041	3.877**	3.841	3.877**	3.841
LTFP, LEXP					
None	0.298	32.63**	15.89	34.85**	20.26
R≤1	0.023	2.223	9.164	2.223	9.164
LTFP, LIMP, LEXP					
None	0.354	40.30**	22.29	56.35**	35.19
R≤1	0.139	13.86	15.89	16.04	20.26

Notes: Test regression includes a constant and a linear deterministic trend in the data. **, and *** denote a rejection of the hypothesis at the 5 and 10% significance level, respectively. The test indicates 1 cointegrating equation at the 5% significance level for every set of the variables.

Table 3. Coefficient Estimates of the VECM for the Relationship between Trade and Productivity Growth for Korea (1980Q1~2003Q3)

Independent variables	VECM			VAR		
	LTFP	*LIMP*	*LEXP*	*LTFP*	*LIMP*	*LEXP*
EC(-1)	-0.001 (0.038)	0.493 (3.985)	0.028 (0.254)			
LTFP(-1)	-0.330 (2.987)	-0.627 (1.500)	-0.664 (1.737)	0.602 (6.139)	0.090 (0.237)	-0.389 (1.119)
LTFP(-2)	0.113 (1.085)	-0.482 (1.215)	-0.354 (0.976)	0.413 (4.201)	0.360 (0.941)	0.393 (1.127)
LIMP(-1)	0.064 (2.253)	0.068 (0.635)	0.102 (1.044)	0.066 (2.338)	0.825 (7.426)	0.073 (0.730)
LIMP(-2)	-0.016 (0.526)	0.005 (0.044)	0.209 (1.933)	-0.074 (2.696)	-0.052 (0.491)	-0.046 (0.483)
LEXP(-1)	0.047 (1.400)	0.120 (0.940)	-0.063 (0.542)	0.043 (1.322)	0.086 (0.679)	0.955 (8.225)
LEXP(-2)	-0.022 (0.663)	0.205 (1.606)	0.014 (0.121)	-0.047 (1.451)	-0.111 (0.868)	0.018 (0.161)
C	0.016 (5.701)	0.036 (3.299)	0.038 (3.815)	0.060 (1.523)	0.524 (3.400)	0.004 (0.030)
dummy	-0.015 (2.223)	-0.114 (4.433)	0.013 (0.564)	-0.013 (2.326)	-0.103 (4.491)	-0.004 (0.210)
R^2	0.276	0.313	0.066	0.999	0.996	0.997

Notes: For VECM, all variables are first differenced for estimation. T-statistics are in parentheses.

Table 4. Granger Causality Tests for the Relationship between Trade and TFP Growth for Korea (1980Q1~2003Q3)

Null Hypothesis (H_0)	Test statistics (χ^2)	Probability	Results
Bi-variate (VECM)			
$\Delta LIMP \neq\triangleright \Delta LTFP$	18.04*	0.0001	Reject
$\Delta LTFP \neq\triangleright \Delta LIMP$	1.176	0.555	Do not reject
$\Delta LEXP \neq\triangleright \Delta LTFP$	4.088	0.129	Do not reject
$\Delta LTFP \neq\triangleright \Delta LEXP$	1.366	0.505	Do not reject
Tri-variate (VECM)			
$\Delta LIMP \neq\triangleright \Delta LTFP$	5.987*	0.050	Reject
$\Delta LEXP \neq\triangleright \Delta LTFP$	2.595	0.273	Do not reject
$\Delta LTFP \neq\triangleright \Delta LIMP$	2.765	0.250	Do not reject
$\Delta LEXP \neq\triangleright \Delta LIMP$	3.213	0.200	Do not reject
$\Delta LTFP \neq\triangleright \Delta LEXP$	3.154	0.206	Do not reject
$\Delta LIMP \neq\triangleright \Delta LEXP$	4.235	0.120	Do not reject
Tri-variate (VAR)			
$LIMP \neq\triangleright LTFP$	7.282*	0.026	Reject
$LEXP \neq\triangleright LTFP$	2.228	0.328	Do not reject
$LTFP \neq\triangleright LIMP$	12.84*	0.001	Reject
$LEXP \neq\triangleright LIMP$	1.199	0.548	Do not reject
$LTFP \neq\triangleright LEXP$	1.299	0.522	Do not reject
$LIMP \neq\triangleright LEXP$	0.595	0.742	Do not reject

Note: Test statistics are Wald statistics, and test results denote if the test rejects the null at the 1% significance level.

Table 5. Coefficient Estimates of TFP Growth Equation for Korea (1988Q1~2003Q3)

Independent Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Intercept	0.013 (6.603)*	0.013 (6.113)*	0.013 (6.161)*	0.013 (6.092)*	0.013 (6.645)*	0.013 (6.337)*
Δ*LIMP*	0.079 (3.420)*					
Δ*LRIMP*		0.012 (0.562)				
Δ*LKIMP*			0.042 (1.855)***			
Δ*LCIMP*				0.042 (2.045)**		
Δ*LDIMP*					0.058 (1.983)***	
Δ*LOIMP*						0.045 (1.644)
Δ*LEXP*	-0.012 (0.398)	0.020 (0.617)	-0.002 (0.954)	0.004 (0.136)	-0.012 (0.352)	-0.006 (0.184)
Δ*LGOV*	-0.130 (2.509)**	-0.085 (1.502)	-0.074 (1.352)	-0.079 (1.505)	-0.075 (1.395)	-0.085 (1.617)
Δ*LR&D*	0.036 (1.956)***	0.039 (1.870)***	0.040 (1.993)***	0.036 (1.787)***	0.037 (1.858)***	0.041 (2.033)**
Dummy	-0.009 (2.216)*	-0.015 (3.564)*	-0.013 (3.098)*	-0.013 (3.051)*	-0.013 (2.891)*	-0.014 (3.059)*
$\overline{R}^2$	0.381	0.254	0.283	0.287	0.286	0.275
D.W.	2.467	2.456	2.506	2.403	2.489	2.487

Notes: Absolute values of t-statistics are in parentheses. *, ** and *** are statistically significant at the 1, 5 and 10% significance level, respectively.

Table 6. Coefficient Estimates of GDP Growth Equation for Korea (1988Q1~2003Q3)

Independent Variables	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
Intercept	0.010 (4.304)*	0.012 (2.657)*	0.012 (3.705)*	0.014 (3.096)*	0.013 (2.914)*	0.013 (2.911)*
$\Delta LIMP$	0.202 (7.216)*					
$\Delta LRIMP$		0.021 (0.884)				
$\Delta LKIMP$			0.041 (1.723)			
$\Delta LCIMP$				0.129 (3.212)*		
$\Delta LDIMP$					0.043 (1.342)	
$\Delta LOIMP$						0.041 (1.378)
$\Delta LEXP$	0.026 (0.684)	0.109 (2.044)**	0.077 (1.445)	-0.038 (0.695)	0.085 (1.533)	0.087 (1.586)
$\Delta LGOV$	-0.098 (1.559)	-0.013 (0.100)	0.039 (0.467)	-0.030 (0.228)	-0.012 (0.095)	-0.037 (0.279)
$\Delta LR\&D$	0.021 (0.955)	0.030 (0.917)	0.024 (0.789)	0.021 (0.670)	0.022 (0.550)	0.024 (0.597)
Dummy	-0.015 (3.041)*	-0.032 (4.677)*	-0.029 (4.367)*	-0.024 (3.351)*	-0.030 (4.209)*	-0.030 (4.416)*
$\overline{R}^2$	0.674	0.376	0.399	0.413	0.384	0.385
D.W.	2.089	1.839	1.971	1.987	1.923	1.878

Notes: Absolute values of t-statistics are in parentheses. *, ** and *** are statistically significant at the 1, 5 and 10% significance level, respectively.

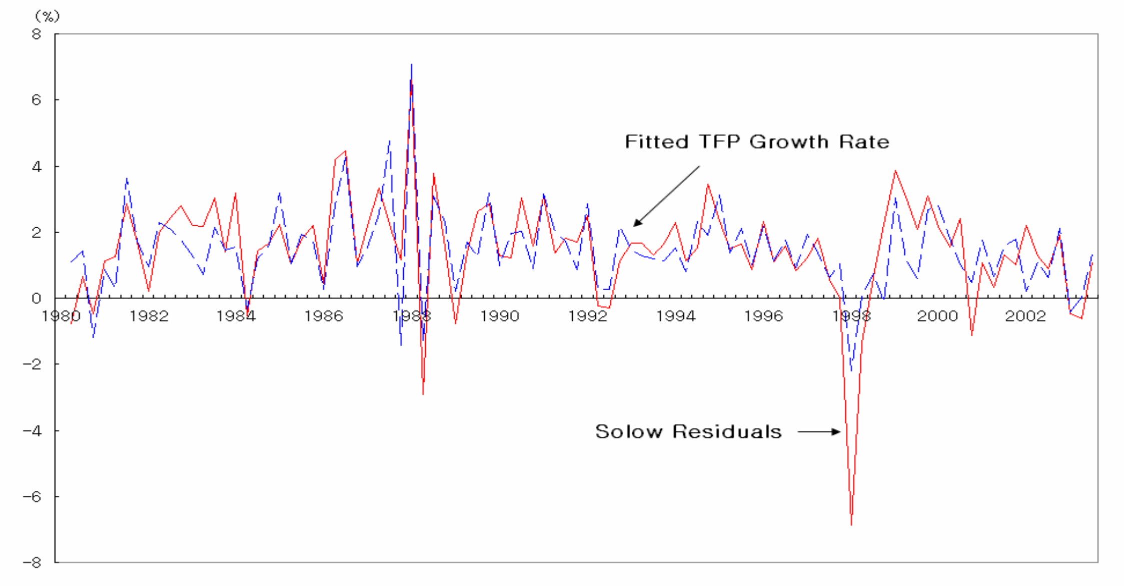
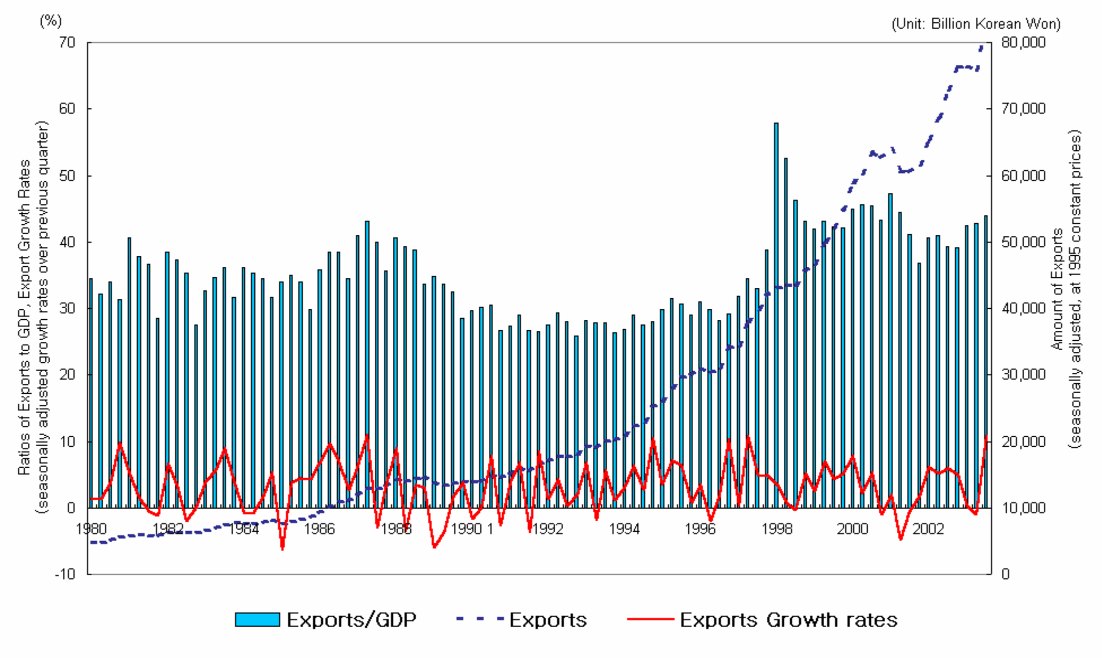


Figure 1. Growth of the Solow Residual and TFP with Cyclical Adjustment for the Korean Economy during 1980-2003

(A) Exports



(B) Imports

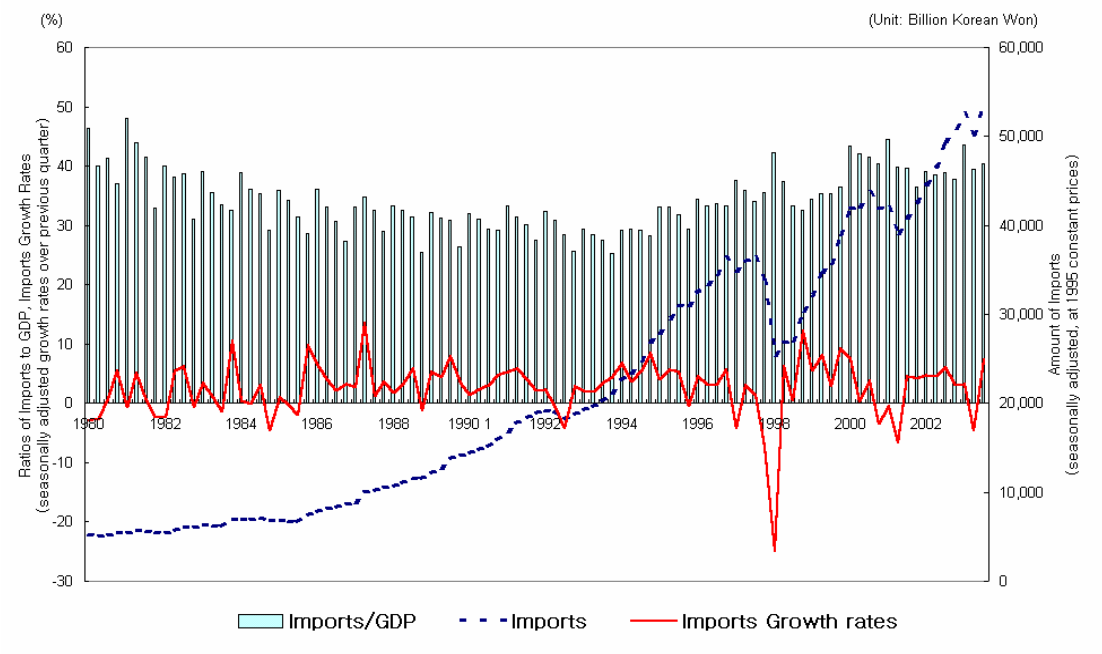


Figure 2. Evolution of Exports and Imports for Korea during 1980~2003

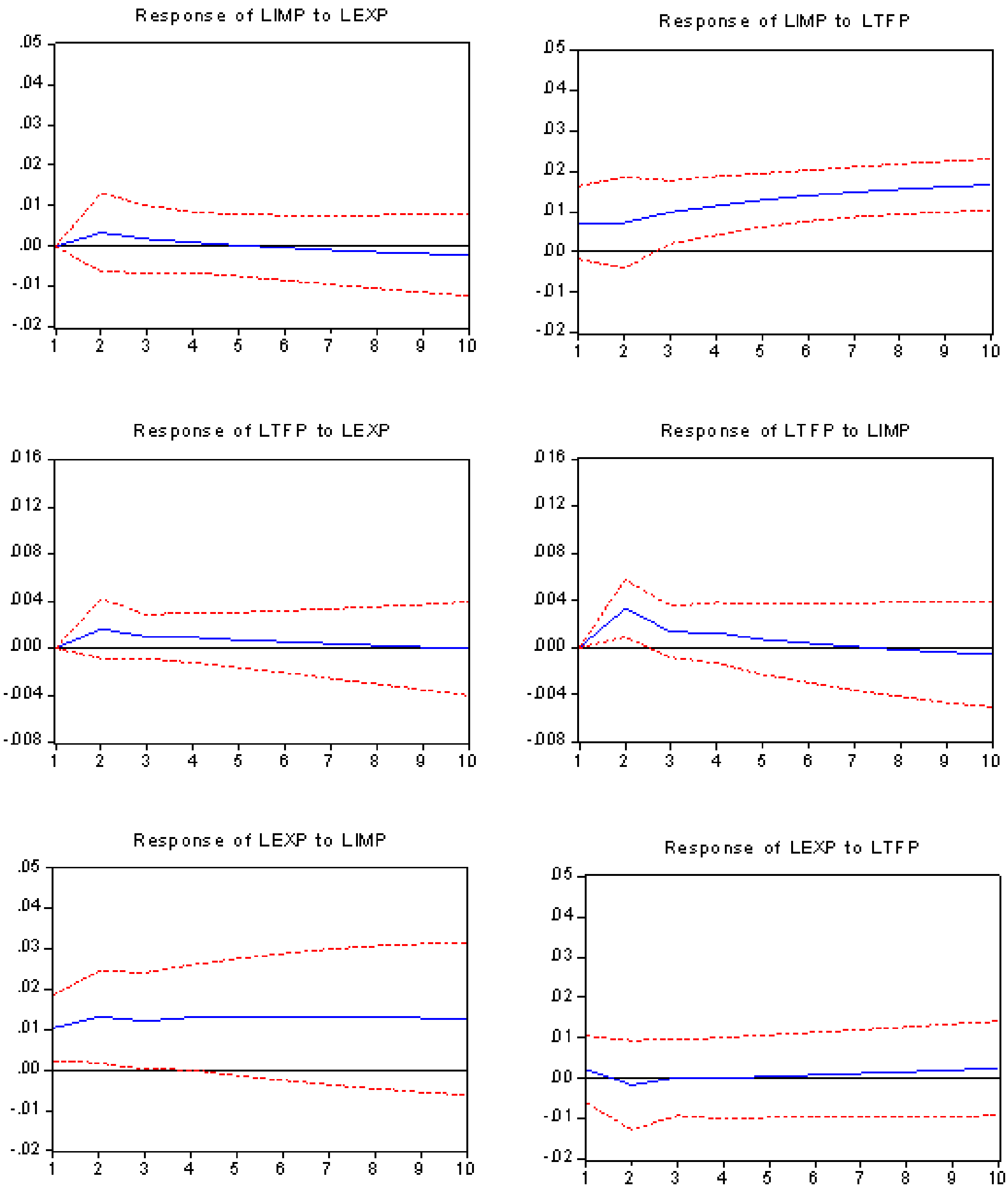


Figure 3. Impulse Response Functions in a VAR Model of Imports, Exports and TFP for Korea during 1980-2003

Table A1. Granger Causality Tests for the Relationship between Trade and GDP Growth for Korea (1980Q1~2003Q3)

Null Hypothesis (H_0)	Test statistics (χ^2)	Probability	Results
Bi-variate (VECM)			
$\Delta LIMP \not\rhd \Delta LGDP$	13.36*	0.001	Reject
$\Delta LGDP \not\rhd \Delta LIMP$	0.204	0.902	Do not reject
$\Delta LEXP \not\rhd \Delta LGDP$	0.224	0.893	Do not reject
$\Delta LGDP \not\rhd \Delta LEXP$	0.016	0.992	Do not reject
Tri-variate (VECM)			
$\Delta LIMP \not\rhd \Delta LGDP$	11.68*	0.002	Reject
$\Delta LEXP \not\rhd \Delta LGDP$	0.397	0.819	Do not reject
$\Delta LGDP \not\rhd \Delta LIMP$	1.179	0.554	Do not reject
$\Delta LEXP \not\rhd \Delta LIMP$	1.626	0.443	Do not reject
$\Delta LGDP \not\rhd \Delta LEXP$	0.866	0.648	Do not reject
$\Delta LIMP \not\rhd \Delta LEXP$	3.330	0.189	Do not reject
Tri-variate (VAR)			
$LIMP \not\rhd LGDP$	16.98*	0.000	Reject
$LEXP \not\rhd LGDP$	0.056	0.972	Do not reject
$LGDP \not\rhd LIMP$	7.611*	0.022	Reject
$LEXP \not\rhd LIMP$	0.787	0.674	Do not reject
$LGDP \not\rhd LEXP$	0.123	0.940	Do not reject
$LIMP \not\rhd LEXP$	0.865	0.648	Do not reject

Note: Test statistics are Wald statistics, and test results denote if the test rejects the null at the 5% significance level.

Notes

[1] For surveys of the debates on TFP growth and trade in East Asia, see Chen (1997) and Edwards (1993), respectively.

[2] For a literature survey, see Greenaway and Sapsford (1994)

[3] Hicks argued that severe market competition awakens firms from the laziness and comfort of a monopoly market and provides incentives for innovation.

[4] Schumpeter, however, suggested that a certain level of monopoly in the market provides firms with excess profit for R&D investments, thus promoting their productivity.

[5] For capital, the perpetual inventory method was used to expand the capital estimated by Pyo (2003).

[6] The result that labor productivity is not affected by the capital utilization rate is fairly general in real business cycle theory. Other proxies, such as military spending, oil shocks, and a political dummy, have been suggested to represent cyclical movements in correcting productivity measures. Complete treatment, however, is beyond the scope of this paper, and simple correction using the capital utilization rate is sufficient for the purpose.

[7] Productivity can also affect business cycles, just as business cycles affect productivity. To eliminate this endogeneity problem, only lagged values of the capital utilization rate are included as explanatory variables in the regression.

[8] The adjustment of TFP is to eliminate any error that may exist in the Solow residual as a productivity measure; that is to extract the part of the Solow residual that represents pure productivity. Cyclical movement of the adjusted TFP is still at a smaller scale than the residual; however, the adjustment is not intended to delete the correlation between TFP and business cycles entirely. The causality of TFP in business cycles is well established in

real business cycle theory, while the reverse effect from business cycles to productivity should be eliminated to avoid a spurious relationship. Thus, a high correlation after adjustment is very natural.

[9] For a discussion, see Sims (1980).

[10] The coefficient estimates are not reported here to save space but can be obtained from the authors upon request.

[11] Nevertheless, their sign remained unchanged, reserving the qualitative results.