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A Reexamination of Korea's Trade Flows: What Has Changed and What Explains These Changes?

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**A Reexamination of Korea's Trade Flows:
What Has Changed and What Explains These Changes?**

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Abstract

This paper reexamines Korea's trade flows. Using the standard demand-based models, the paper finds that owing to the increasing share of electrical and electronic products (EEPs) in total exports, the income elasticity of the Korean export demand has fallen sharply while its price elasticity has risen dramatically. This is a curious result, which begs the question of why. Accordingly, an alternative supply-based model shows that the sharp increase in exports of EEPs is mainly due to Korea's remarkable ability to make technological improvements in their production. After reestimating the standard import equation, the paper finds estimates similar to those from previous studies. Since most of these imports are industrial inputs, they are jointly determined by consumption, fixed investment, and exports.

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I. INTRODUCTION

Despite the financial crisis in the late 1990s, Korea's economic development since the early 1960s remains a success story.[2] Arguably, this economic miracle hinges on Korea's openness to trade. During 1970–2001, Korea's real per capita GDP grew by five-fold, while its export volume grew by about 9,800 percent, with an increase in import volume of about 2,400 percent during the same period. In 2002, the share of Korean exports in total world exports was 2.5 percent, double the level in 1979, and the corresponding figure for imports was 2.4 percent, two and a half times the 1979 level.

Much like other those of Asian newly industrialized economies (NIEs), Korea's trade flows have been subject to extensive empirical research. For exports, many studies have found a high income elasticity of demand, with mixed results for the price elasticity. For example, Bayoumi (1996), using annual data for 1974–93, finds an income elasticity of 3.1 and a price elasticity of -0.7; and Giorgianni and Milesi-Ferretti (1997), using quarterly data for 1970–95, find an income elasticity of 3.2 and a price elasticity of -2.0. For imports, studies have found an income elasticity of around 1.5, with mixed results for the price elasticity.

These studies have focused primarily on a period when Korea, like most other Asian NIEs, was a developing economy with rapid economic growth and exports concentrated in labor-intensive products. Today, however, Korea has become a member country of the Organization for Economic Cooperation and Development (OECD), with a slower economic growth rate; moreover, the composition of exports has shifted toward capital-intensive goods, such as electrical and electronic products (EEPs).

Given all these changes, it is worthwhile reexamining the trade equations to see if Korea's exports and imports exhibit different income and price elasticities than those previously estimated using earlier data. The paper begins by reestimating the standard demand-based export and import equations using data for 1988–2001. Alternative models are then presented to explain the new findings and to deepen the analysis of exports and imports.

On the export side, the paper finds that the income elasticity of export demand has fallen considerably.[3] In addition, the paper finds that the price elasticity of Korea's export demand has also risen dramatically. Separate regressions on EEPs and non-EEPs show that the shift in export composition toward EEPs is the main factor behind the large decline in the income elasticity, and the large increase in the price–elasticity, of Korean exports. Specifically, the export demand for EEPs exhibits a low income elasticity and a high price elasticity. Non-

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[2] For a comprehensive review of Korea's experience of crisis and recovery in the late 1990s, see Coe and Kim, eds. (2002).

[3] Given that Korea's economic development has slowed, the decline in the income elasticity is consistent with the "45 degree rule" of Krugman (1989), which asserts that fast-growing countries face high income elasticities of demand for their exports, while the opposite is true for slow-growing countries.

EEPs, however, have a high income elasticity and a low price elasticity, —a result not too different from estimates of total export demand calculated using earlier data. This raises the question: why do EEPs have such a low income elasticity and a high price elasticity?

The steep decline in the price of EEP exports points, in the standard model, to a supply-side, rather than a demand-side, explanation. In particular, the production of EEPs may have benefited from significant technological improvement and may have experienced increasing returns to scale. Accordingly, the paper presents an alternative model based on a supply analysis. The result shows that exports of EEPs are strongly cointegrated with the total factor productivity (TFP) and the potential output of the economy. Moreover, evidence also points to the existence of increasing returns to scale. In contrast, estimates for non-EEPs show no strong link between exports of non-EEPs and TFP, and the production of non-EEPs shows no evidence of the existence of increasing returns to scale.

After reestimating the import equation, the paper obtains estimates similar to those from previous studies, although the income elasticity shows a slight upward trend. In addition, as an alternative to the standard import equation with one scale variable and one price variable, this paper estimates an import equation with multiple scale variables and multiple price variables. The results show that import demand is jointly correlated with consumption, fixed investment, and exports. Import prices, however, are not important determinants of imports.

This paper proceeds as follows: Section II describes the recent developments in Korean foreign trade and presents a graphical description of the key variables; Section III presents the econometric model used throughout the paper; Section IV discusses issues and results pertaining to exports, while those pertaining to imports are discussed in Section V; and Section VI concludes.

II. GRAPHICAL DESCRIPTION OF KOREAN FOREIGN TRADE

A. Overview

As shown in Figures 1–3, Korea is a highly open economy, with a rising trend in both export and import volumes; the share of Korean trade in total world trade has also been increasing.

However, as indicated in Table 1, the growth rates in both exports and imports have flattened, with the former showing a higher decline than the latter. The economic growth in Korea and the recipients of Korean exports have decelerated, with the former declining faster than the latter.[4]

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[4] The slow decline in the economies of Korea's trading partners is mainly due to the increasing share of exports to China, which have been growing rapidly in the 1990s. Other than China, Korea's main trading partners, particularly Japan, grew more slowly in the 1990s than before.

Figure 1. Export and Import Volume
(1995=100)

Sources: CEIC database; WEO; and IMF staff estimates.

Figure 2. Korea's Share of World Trade

Sources: CEIC database; WEO; and IMF staff estimates.

Figure 3. Share of Trade in GDP
(in Real Terms)

Sources: CEIC database; WEO; and IMF staff estimates.
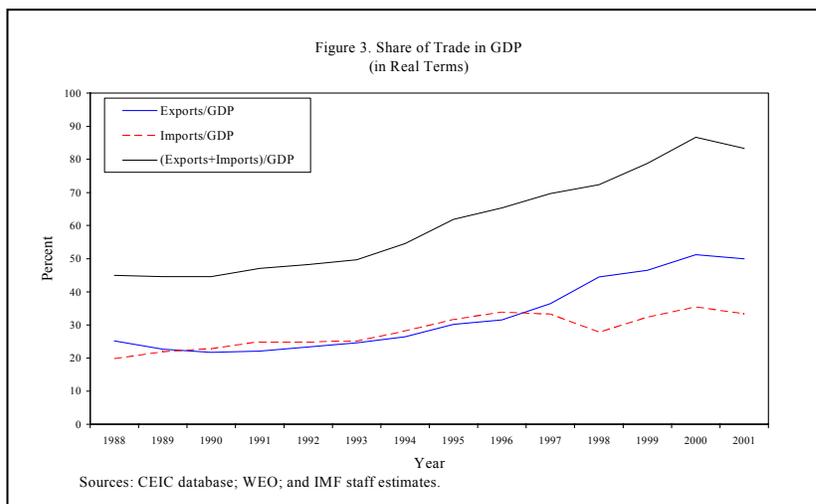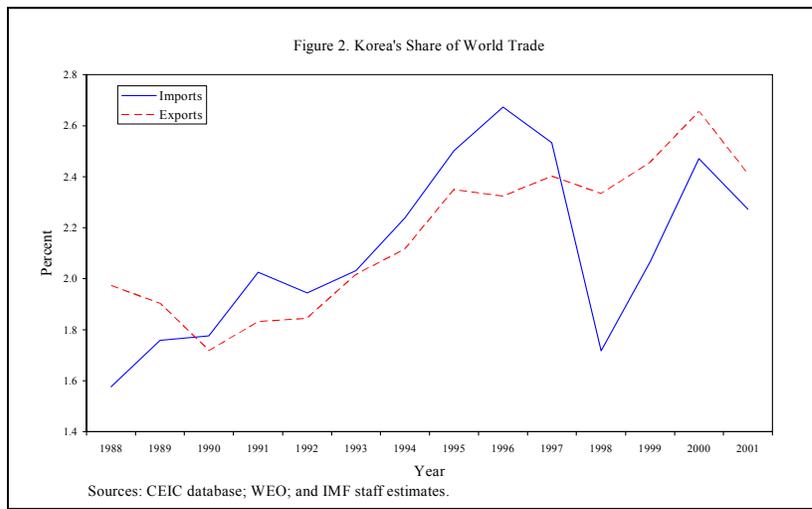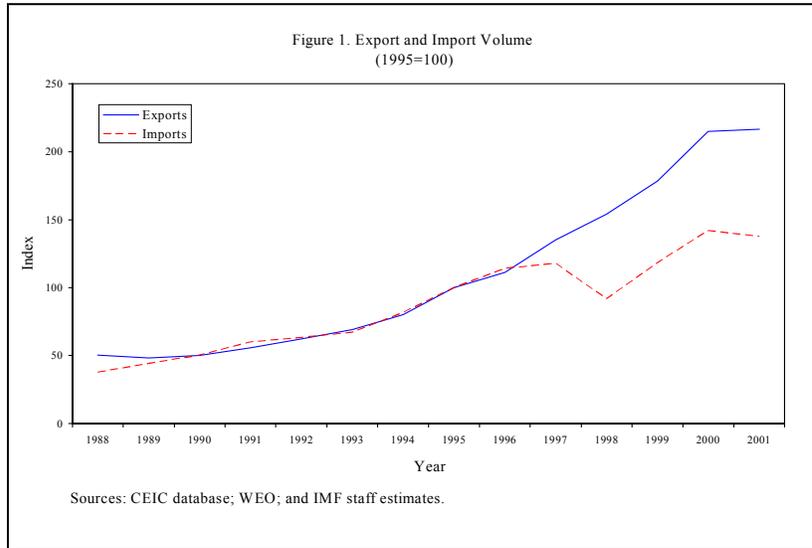
Table 1. Real Growth in Exports, Imports, and GDP, 1974–2001
(*average annual growth, in percent*)

	Exports	Imports	GDP	Export Recipients' GDP
1974–87	15.2	11.1	7.9	4.3
1988–2001	11.9	10.5	6.1	4.0
Difference	-3.3	-0.6	-1.8	-0.3

Sources: CEIC database; WEO; and IMF staff estimates

B. Exports

The composition of exports has changed radically over the past few decades. Korean exports, which consisted mostly of labor-intensive goods in the past, are now concentrated in capital-intensive goods, of which, electrical and electronic products (EEPs) constitute the bulk of exports.

Figure 4. Composition of Exports

Sources: CEIC database; and IMF staff estimates.
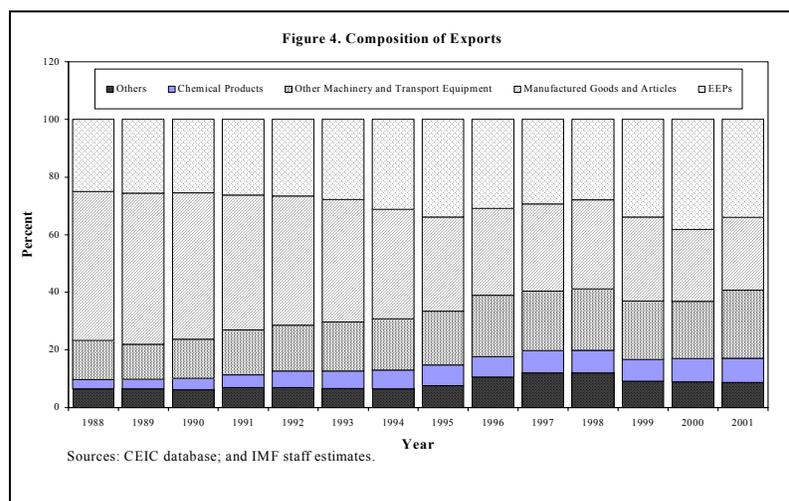
Figure 5 shows the export volume of EEPs and non-EEPs, indicating that the growth of the former is much faster than that of the latter.

As shown in Figure 6, the export unit values of the EEPs and non-EEPs have been falling, but the former exhibits a much steeper decline in prices. This suggests that the cost of production of the EEPs have fallen, which may be due to the presence of technological improvements and/or increasing returns to scale.

Figure 5. Export Volume: EEPs and Non-EEPs
(1995=100)

Sources: CEIC database; and IMF staff estimates.

Figure 6. Export Unit Value: EEPs and Non-EEPs
(1995=100)

Sources: CEIC database; and IMF staff estimates.
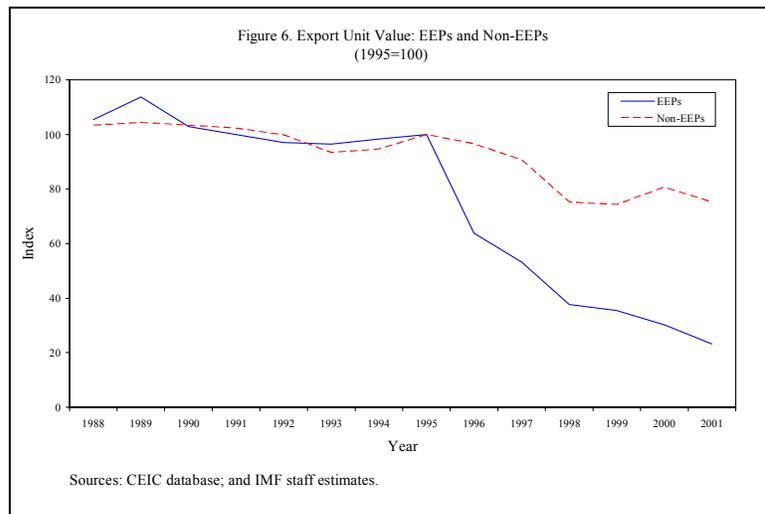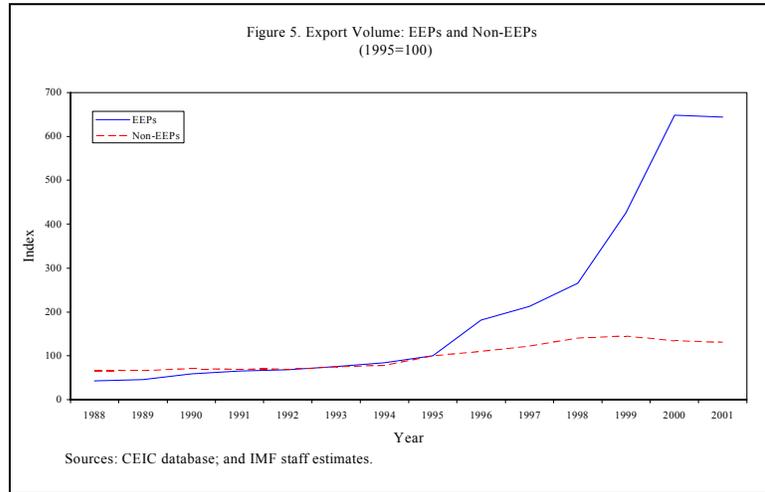
C. Imports

As shown in Figure 7, a high proportion of imports to Korea is for use in export production. Figure 8 suggests that a bulk of imports to Korea are capital or industrial raw materials, with consumer goods accounting for a small proportion

Figure 7. Imports Usage: for Domestic Use or Exports

Sources: CEIC database; and IMF staff estimates.
Note: Data for years not shown are not available.

Figure 8. Imports: Composition

Sources: CEIC database and IMF staff estimates.
Note: Data for years not shown are not available.
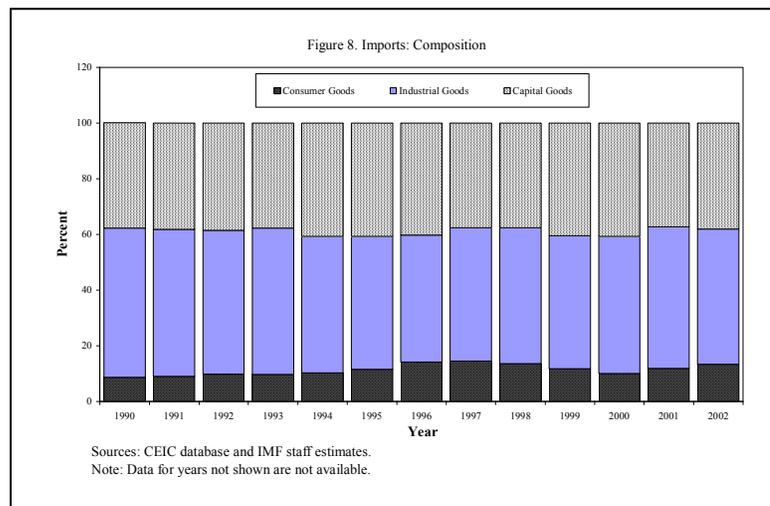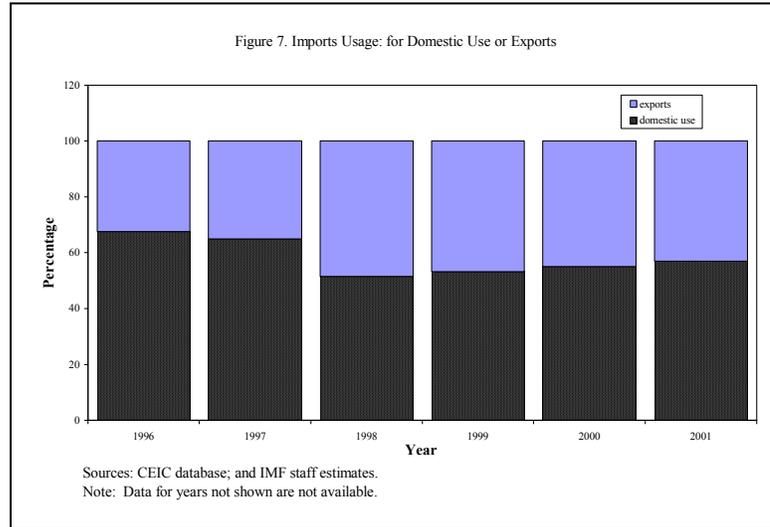
III. ECONOMETRIC SPECIFICATION

Throughout this paper, the econometric framework follows the standard procedure in studies in trade equations. The first step of the empirical analysis involves testing all variables for nonstationarity by the Dickey-Fuller tests. The results show that they largely appear to be I(1) processes.[5]

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[5] Results of these tests are available from the author on request.

Then, the long-run relationships (or cointegrating relationships) are estimated, followed by estimating the short-run relationships.[6] The Dynamic Ordinary Least Squares (DOLS) procedure of Stock and Watson (1993) is employed to estimate the long-run relationships between the dependent variables (exports or imports) and the independent variables (scale and price variables).[7] Specifically, the DOLS estimates the long-run relation between variables directly by OLS augmented by the first difference of the explanatory variables together with their lags and leads. Formally, DOLS amounts to running an OLS on the following specification:

$$\Phi_t = c + \theta' \Psi_t + \alpha' \Delta \Psi_t + \sum_{j=1} \beta_j ' \Delta \Psi_{t-j} + \sum_{j=1} \gamma_j ' \Delta \Psi_{t+j} + u_t,$$

where $[1, -\theta']'$ is the cointegrating vector for variables Φ (dependent variables such as exports and imports) and Ψ (the explanatory variables, such as income and prices).

After estimating the long-run relationships, short-run relationships are estimated using the error-correction approach. Specifically, the following regression is estimated:

$$\Delta \Phi_t = c + \delta' \Delta \Psi_t + \lambda ECM_{t-1} + \varepsilon_t,$$

where δ is a vector containing the short-run elasticities, and *ECM* is the error-correction term obtained from the long-term estimation, i.e., $ECM_t = \Phi_t - \theta' \Psi_t$.

IV. EXPORTS

This section investigates the determinants of Korea's exports. Subsection A focuses on the standard export equations, while subsection B presents an alternative model based on a supply analysis.

A. Standard Demand Model

Framework

The standard model used in most work on exports is a demand-based framework.[8] In this framework, supply is assumed to be perfectly elastic. Therefore, following the standard

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[6] Following the convention in the literature, this paper refers to the coefficients of the cointegrating variables in level as "long-run coefficients" and those from the regressions on the rate of change of the variables as "short-run coefficients."

[7] To ensure robustness, other methods are used to confirm the results. Estimates using other methods are available from the author.

[8] While some papers have estimated a simultaneous system of demand and supply equations for Korea, these papers yield estimates largely similar to those obtained from the single demand equation approach. Moreover, Giorgianni and Milesi-Ferretti (1997), using the

consumer's theory, Korea's real exports (X) should depend on the real income of the recipients of Korea's exports (Y^w), the price of Korea's exports (P^x), and the price of domestically-produced goods in Korea's trading partners (P^w):[9]

$$X = f(Y^w, P^r),$$

where $P^r \equiv \dfrac{P^x}{P^w}$.

Data

All data between 1988–2001 are official quarterly data from CEIC. Data prior to 1988 are from IMF's *International Financial Statistics* and *World Economic Outlook* databases.

P^x is the unit price of Korean exports expressed in dollars. The general price level in the economies of Korea's trading partners (P^w) is approximated by the trade-weighted average of CPIs in the twelve biggest importers of Korea's exports in the following way:

$$P^w = \exp[\sum_{i=1}^{12} \ln(W^i P^i * E^i)],$$

where W^i is the share of exports to country i, with $\sum_{i=1}^{12} W^i = 1$; P^i is the price level (CPI) in country i; and E^i is the exchange rate of local currency of country i vis-à-vis the dollar[10]. Y^w is the trade-weighted sum of the real GDP of Korea's main trading partners.

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system of equations approach, found a lack of strong simultaneity between export demand and supply shocks and that the estimated supply curve is almost perfectly elastic. In light of these, the "standard equation" refers to a single demand equation as used in most empirical work.

[9] Throughout this paper, uppercase letters denote level of variables whereas lowercase letters denote their logarithm.

[10] This formula follows the procedure used by the IMF Information Notice System to calculate the real effective exchange rates. An advantage of using this formula is that it greatly simplifies the calculation of P^w, which can be conveniently computed given Korea's real effective exchange rate, the Korean CPI, and the exchange rate of Korean won vis-à-vis the dollar.

Results

Long-run elasticities

Table 2 reports the econometric results for total exports. To depict the dynamic of the estimates and to provide a benchmark for comparison with other studies, estimation results are shown for 1988–2001, 1974–87, and the overall period.

Table 2. Long-Run Export Demand Equations

Period	y^w	p^r	R^2	AR(4)	White	ECM_{t-1}	Number of Observations
1974–87	3.07	-0.18	0.95	<0.01	0.13	-0.62	54
	(0.24)	(0.23)				(0.13)	
1988–2001	1.00	-1.46	0.99	<0.01	0.72	-0.19	52
	(0.70)	(0.37)				(0.05)	
1974–2001	2.59	-0.17	0.97	<0.01	0.05	-0.23	106
	(0.11)	(0.13)				(0.06)	

Notes: All regressions include a constant term. Quarterly data are used. The dependent variable is the export volume in logarithm *(x)*, and the independent variables, also expressed in logarithm, are defined in the text. The Dynamic Ordinary Least Squares procedure of Stock and Watson (1993) is used to estimate the long-run (or cointegrating) relationships between the dependent and independent variables. The values in the parenthesis undereath each estimated coefficient are the heteroscedasticity and autocorrelation consistent standard errors. *AR(4)* is the Lagrange-multiplier test for residual autocorrelation of the fourth order under the null of no autocorrelation, and the p-values for the *F* test are reported. The White test is a test for the presence of heteroscedasticity under the null of homoscedasticity, and the *p*-values for the *F* test are reported. ECM_{t-1} reports the coefficients on the lagged error-correction term in the estimation of the short-run relationships, and the values in the parenthesis underneath are the corresponding standard errors. Since all the variables appear to be I(1) in level, the significance of the lagged *ECM* term in the short-run regressions suggests that the errors in the long-run regressions are stationary, and therefore the variables in the long-run estimation are cointegrated. Results for other short-run relationships are available from the author.

Note that the estimates using data during 1974–88 essentially replicate those from previous studies.[11] The results indicate that the long-run income elasticity is declining while the long-run price elasticity is rising.

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[11] For example, Giorgianni and Milesi-Ferretti (1997) find a long-run income elasticity of 3.2 using data for 1970–99. Bayoumi (1996), using data for 1970–95, finds a long-run income elasticity of 3.1 and a long-run price elasticity of -0.5. For a comparison with estimates for other countries, see Table 7.

To explain why the income elasticity of export demand has fallen sharply, with the opposite for the price elasticity, exports are broken down into exports of EEPs and those of non-EEPs. Table 3 shows the estimates for these items:

Table 3. Long-Run Export Demand Equations
for Electrical and Electronic Products (EEPs), Non-EEPs, and Total, 1988-2001

Type	y^w	p^r	R^2	AR(4)	White	ECM_{t-1}	Number of Observations
EEPs	0.51	-1.42	0.99	<0.01	0.19	-0.53	52
	(0.47)	(0.11)				(0.10)	
Non-EEPs	2.52	0.51	0.90	<0.01	0.47	-0.37	52
	(0.99)	(0.73)				(0.10)	
Total	1.00	-1.46	0.99	<0.01	0.72	-0.19	52
	(0.70)	(0.37)				(0.05)	

Notes: All regressions include a constant term. Quarterly data are used and data prior to 1988 are not available. The dependent variable is the export volume in logarithm (x), and the independent variables, also expressed in logarithm, are defined in the text. The Dynamic Ordinary Least Squares procedure of Stock and Watson (1993) is used to estimate the long-run (or cointegrating) relationships between the dependent and independent variables. The values in the parenthesis underneath each estimated coefficient are the heteroscedasticity and autocorrelation consistent standard errors. *AR(4)* is the Lagrange-multiplier test for residual autocorrelation of the fourth order under the null of no autocorrelation, and the p-values for the F test are reported. The White test is a test for the presence of heteroscedasticity under the null of homoscedasticity, and the p-values for the F test are reported. ECM_{t-1} reports the coefficients on the lagged error-correction term in the estimation of the short-run relationships, and the values in the parenthesis underneath are the corresponding standard errors. Since all the variables appear to be I(1) in level, the significance of the lagged *ECM* term in the short-run regressions suggests that the errors in the long-run regressions are stationary, and therefore the variables in the long-run estimation are cointegrated. Results for other short-run relationships are available from the author.

As shown in Table 3, the price elasticity of EEPs is high while the income elasticity of EEPs is low. On the contrary, conforming to the standard picture of a high income elasticity and a low price elasticity, the estimates for non-EEPs are not very different from those for total exports using 1974–87 data. Therefore, this implies that the recent changes in long-run elasticities of total export demand are mainly due to the increase in the share of EEPs in total exports.

This raises the question: why is the price elasticity of EEPs exports high and its income elasticity low? One may suggest that EEPs are a luxury good and is therefore more price-elastic. But this explanation cannot justify the low income elasticity: if EEPs are a luxury good, then the income elasticity should also be high. What makes EEPs so special that they exhibit elasticities different from other goods?

A plausible explanation is that instead of identifying the demand equation, the framework has identified a supply function. This can easily explain the insignificance of the foreign income variable, which is a factor of demand, but not a factor of supply. But if it is a supply curve, it is a negatively-sloped one. How can a supply curve slope downward? One plausible explanation is that the Korean production of EEPs have benefited from massive positive spillovers such as learning by doing and technological innovations, as well as increasing returns to scales at the industry level. Analysis along these lines will be elaborated in subsection B, which will also present a theoretical model proving the possibility of a negatively-sloped supply curve in the face of increasing returns to scale and other technological improvements.

B. An Alternative Supply Model

Much literature asserts that supply factors are important determinants of exports for high-growth country.[12] Massive technological progress and increasing returns to scale, for example, can best explain the dramatic surge in export volume of EEPs and the steep fall in the unit price of EEPs during the late 1990s. Consequently, in contrast to the demand-based approach, this subsection attempts explain Korea's exports, particularly the exports of EEPs, by a supply-based model.

Framework

Theoretical model

The standard approach, as presented in the previous subsection, estimates an export demand equation by assuming that export supply is perfectly elastic. On the contrary, this subsection assumes that export demand is perfectly elastic. This means that a Korean producer of EEPs, for example, is a price taker in the international EEPs market.[13]

In addition, suppose increasing returns to scale exist in the industry level, but is external to the representative firm.[14] Such situation can result from positive spillovers in production. For

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[12] An example is Krugman (1989). Numerous empirical papers have explained exports by export supply equations for other countries. See, for example, Halpern and Szekely (1992) and Diewert and Morrison(1986).

[13] This assumption is made mainly to enhance technical simplicity. In reality, each firm may have some market power so that it has an incentive to invest and innovate.

[14] The assumption of external increasing returns to scale is crucial to the assumption of the price taking behavior. If increasing return to scale is internal to a firm, then the firm has an incentive to expand until its production capacity reaches constant returns to scale or decreasing returns to scale, resulting in imperfect competition. One way in which increasing returns to scale and perfect competition can coexist is by assuming that the former is external to the firm. For more detail, see Marshall's classic, "Principles of Economics." Modern

example, there may be learning-by-doing, research, and innovation at the industry level. As a result, as aggregate production increases, the marginal cost of EEPs declines.
As discussed in the previous subsection, in the face of increasing returns to scale, the industry supply function can be downward sloping. To illustrate such a possibility and to substantiate other points discussed in this subsection, a simple model is constructed as follows:

Suppose there is a continuum of identical firms producing goods for export uniformly distributed on the interval of $[0, N]$. In other words, each of the infinitely many firms is indexed by j, where $j \in [0, N]$. Each identical firm j produces X_j and the aggregate production X is the sum of each firm's production:

$$X = \int_0^N X_j dj$$

To incorporate the external increasing returns to scale, each firm j faces a cost function depending on the aggregate output:

$$C(X, X_j) = \xi(X)\phi(X_j) \quad \xi(X) > 0, \ \phi(X_j) > 0 \ \xi'(X) < 0 \ , \phi'(X_j) > 0, \ \phi''(X_j) > 0$$

For simplicity, let $\xi(X) \equiv X^{-\varepsilon}$ and $\phi(X_j) \equiv X_j^{\alpha}$, where $\varepsilon > 0$ and $\alpha > 1$.[15]

In other words, as the aggregate production X increases, the marginal cost confronting each firm declines:

$$\frac{\partial^2 C}{\partial X_j \partial X} = -\varepsilon \alpha X^{-\varepsilon-1} X_j^{\alpha-1} < 0$$

However, since the increasing returns to scale depends on the aggregate production X, not the firm's own production X_j, each firm j has no incentive to expand its production to take advantage of the increasing returns to scale, therefore preserving the assumption of perfect

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economists Helpman and Krugman (1996) also have an excellent exposition on this point in Chapter 3 of their book.

[15] The appendix will derive results for a general functional form.

competition. In fact, given the aggregate production X, each firm faces an increasing marginal cost function relative to its own production level X_j [16]:

$$\frac{\partial^2 C}{\partial X_j^{\,2}} = \alpha(\alpha-1)X^{-\varepsilon}X_j^{\,\alpha-2} > 0$$

So firm j's problem is to choose its X_j to maximize its profit:

$$PX_j - X^{-\varepsilon}X_j^{\,\alpha}$$

The first-order condition is:

$$P - \alpha X^{-\varepsilon}X_j^{\,\alpha-1} = 0 \;\blacktriangleright\; X_j = \left[\frac{P}{\alpha X^{-\varepsilon}}\right]^{\frac{1}{\alpha-1}}$$

The second-order condition is:

$$-\alpha(\alpha-1)X^{-\varepsilon}X_j^{\,\alpha-2} < 0 \;\blacktriangleright\; \alpha > 1, \text{ which is satisfied by assumption.}$$

Therefore the aggregate supply function of the industry is:

$$X = \int_0^N X_j\,dj = \int_0^N \left[\frac{P}{\alpha X^{-\varepsilon}}\right]^{\frac{1}{\alpha-1}} dj = N\left[\frac{P}{\alpha X^{-\varepsilon}}\right]^{\frac{1}{\alpha-1}} \tag{1}$$

Solving for the inverse supply function

$$P = \alpha X^{-\varepsilon}\left(\frac{X}{N}\right)^{\alpha-1}$$

The industry supply function may be downward sloping:

$$\frac{\partial P}{\partial X} = -\varepsilon\alpha X^{-\varepsilon-1}\left(\frac{X}{N}\right)^{\alpha-1} + \alpha(\alpha-1)X^{-\varepsilon}\frac{1}{N}\left(\frac{X}{N}\right)^{\alpha-2} < 0$$

$$\Updownarrow$$

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[16] The marginal cost confronting each firm j is $\dfrac{\partial C}{\partial X_j}$. Thus, the rate of change of the marginal cost with respect to an additional unit of output is $\dfrac{\partial^2 C}{\partial X_j^{\,2}}$.

$$\alpha(\alpha-1)X^{-\varepsilon}\frac{1}{N}\left(\frac{X}{N}\right)^{\alpha-2} < \varepsilon\alpha X^{-\varepsilon-1}\left(\frac{X}{N}\right)^{\alpha-1}$$

$$\updownarrow$$

$$\alpha-1 < \varepsilon$$

It can be shown that $\alpha-1$ is the elasticity of the marginal cost with respect to an additional unit of output, and ε measures the degree of positive external spillovers of an additional unit of output. Therefore, if the positive external effects of increasing returns to scale at the industry level outweigh the increasing marginal cost faced by each individual firm, a negatively sloped supply curve arises.

Empirical model

Equation (1) suggests that the supply of exports, X, is a function of the unit price of exports, as well as two parameters, α and ε. Since α measures the elasticity of the marginal cost with respect to an additional unit of output, it should be a function of factor prices. Likewise, since ε measures the economy-wide external effects of increasing returns to scale, it should be a function of technology and the scale of the economy. Accordingly, the export supply function may take the following form:

$$X = F(P, W, TFP, Y^p),$$

where P is the export unit price; W is factor prices, such as the real wage of labor; TFP, is the total factor productivity; and Y^p is the potential output of the economy, which is a proxy for all other "positive spillovers."[17]

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[17] As the positive spillovers may be intra-industrial or inter-industrial, the potential GDP is used. Since the total factor productivity and the potential output of the economy may be correlated, collinearity may arise; nevertheless, the estimates will still remain unbiased and consistent.

Data

Export prices P are the unit value of exports in terms of Korean won; W is the real wage index of Korean workers, expressed in won. Y^P; the potential output, is the GDP of Korea filtered by the Hodrick-Prescott method. Data for TFP are obtained from Zebregs (2003).

Results

Long-run elasticities

Table 6 displays the long run elasticities for total exports, EEPs and non-EEPs, based on the alternative model. The results show significant relations between EEPs exports and all the explanatory variables. In particular, EEP exports exhibit a strong and positive relation with both TFP and Korea's potential GDP. The results also indicate a strong and negative relation with the unit price of EEP exports. All of these constitute convincing evidence for the presence of increasing returns to scale, technological progress, and other positive spillovers, such as learning by doing at the industry level. On the contrary, non-EEPs do not exhibit similar patterns: TFP is not a significant variable for non-EEPs, and the price elasticity of non-EEPs exports is not significant.[18] Results for total exports are mixed.

Table 4. Long-Run Export Supply Equations for EEPs,
Non-EEPs, and Total, 1988-2001

Type	p	w	tfp	y^p	R^2	$AR(4)$	White	ECM_{t-1}	Number of observations
EEPs	-1.18	-1.26	1.49	2.74	0.99	0.36	0.40	-0.67	52
	(0.12)	(0.42)	(0.40)	(0.51)				(0.13)	
Non-EEPs	-0.79	-3.79	-0.69	5.28	0.92	<0.01	1.00	-0.23	52
	(1.09)	(2.00)	(0.65)	(2.52)				(0.11)	
Total	-0.28	-1.93	1.17	3.59	0.99	<0.01	0.53	-0.18	52
	(0.53)	(0.85)	(0.47)	(1.22)				(0.06)	

Notes: All regressions include a constant term. Quarterly data are used and data prior to 1988 are not available. The dependent variable is the export volume in logarithm *(x)*, and the independent variables, also expressed in logarithm, are defined in the text. The Dynamic Ordinary Least Squares procedure of Stock and Watson (1993) is used to estimate the long-run (or cointegrating) relationships between the dependent and independent variables. The values in the parenthesis undereath each estimated coefficient are the heteroscedasticity and autocorrelation consistent standard errors. *AR(4)* is the Lagrange-multiplier test for residual autocorrelation of the fourth order under the null of no autocorrelation, and the p-values for the *F* test are reported. The White test is a test for the presence of heteroscedasticity under the null of homoscedasticity, and the *p* -values for the *F* test are reported. ECM_{t-1} reports the coefficients on the lagged error-correction term in the estimation of the short-run relationships, and the values in the parenthesis underneath are the corresponding standard errors. Since all the variables appear to be I(1) in level, the significance of the lagged *ECM* term in the short-run regressions suggests that the errors in the long-run regressions are stationary, and therefore the variables in the long-run estimation are cointegrated. Results for other short-run relationships are available from the author.

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[18] This implies that the production of non-EEPs may exhibit constant returns to scale. Therefore, the assumption of a perfectly elastic supply curve in the standard model may be appropriate.

V. IMPORTS

A. Standard Model

Framework

Like the standard export equation, the standard import equation, based on the demand theory, depends on the domestic income level (Y), the unit price of Korean imports (P^m), and the general price level in Korea (P):

$$M = f(Y, P^r),$$

where $P^r \equiv \dfrac{P^m}{P}$.

Data

The Korean consumers' income is measured by Korea's seasonally-adjusted GDP. The general price level is measured by the CPI.

Results

Long-run elasticities

Table 5 reports long-run elasticities for Korean imports. The results show that the income elasticity of import demand has risen slightly. But, overall, the estimates are stable across time and are broadly consistent with those from previous studies.[19]

B. Alternative Model

Framework

The standard model includes only one scale variable and one price variable. As discussed in Section II, the bulk of Korean imports consist of industrial raw materials and capital goods used for investment or for re-export, while others are used for consumption. Therefore, Korea's imports should be a sum of imported consumer goods (M^c) and imported capital goods (M^k). The former depends on the price of imported consumer goods (P^{mc}), the price

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[19] For example, Giorgianni and Milesi-Ferretti (1997), using earlier data obtain an income elasticity of 1.2 and a price elasticity of -1.1. Also, Bayoumi (1996), using earlier data, obtains an income elasticity of 1.4 and a price elasticity of 0.6. For a comparison with estimates for other countries, see Table 7.

Table 5. Long-Run Import Demand Equations

Type	y	p^r	R^2	AR(4)	White	ECM_{t-1}	Number of Observations
1974–87	1.22	-0.65	0.97	<0.01	0.78	-0.43	54
	(0.05)	(0.16)				(0.09)	
1988–2001	1.60	-0.19	0.98	<0.01	0.77	-0.26	55
	(0.06)	(0.14)				(0.10)	
1974–2001	1.31	-0.49	0.99	<0.01	0.96	-0.29	109
	(0.04)	(0.16)				(0.06)	

Notes: All regressions include a constant term. Quarterly data are used and data prior to 1988 are not available. The dependent variable is the import volume in logarithm (m), and the independent variables, also expressed in logarithm, are defined in the text. The Dynamic Ordinary Least Squares procedure of Stock and Watson (1993) is used to estimate the long-run (or cointegrating) relationships between the dependent and independent variables. The values in the parenthesis undereath each estimated coefficient are the heteroscedasticity and autocorrelation consistent standard errors. *AR(4)* is the Lagrange-multiplier test for residual autocorrelation of the fourth order under the null of no autocorrelation, and the p-values for the F test are reported. The White test is a test for the presence of heteroscedasticity under the null of homoscedasticity, and the p-values for the F test are reported. ECM_{t-1} reports the coefficients on the lagged error-correction term in the estimation of the short-run relationships, and the values in the parenthesis underneath are the corresponding standard errors. Since all the variables appear to be I(1) in level, the significance of the lagged ECM term in the short-run regressions suggests that the errors in the long-run regressions are stationary, and therefore the variables in the long-run estimation are cointegrated. Results for other short-run relationships are available from the author.

of domestically-produced consumer goods (P^c), and the permanent income of the Korean consumers, which can be approximated by the aggregate consumption (C). The latter, based on the standard theory of production, depends on the factor price of imported capital goods (P^{mk}), the factor price of domestically-produced capital goods (P^k) and a targeted production level.[20] Since the capital goods can be used to produce consumer goods, capital (investment) goods, or goods for export, the targeted production level should depend on consumption, investment (I) and exports (X). Consequently, Korea's import function can be expressed as:

$$M = M^c(P^{mc}, P^c, C) + M^k(M^{mk}, P^k, C, I, X) = M(P^{mc}, P^c, P^{mk}, P^k, C, I, X).$$

Since only relative prices matter, the import demand function can be rewritten as:

$$M = M(P^{mc}/P^c, P^{mk}/P^k, C, I, X)^{21}$$

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[20] Formally, the demand function for capital goods is derived by solving the producer's cost minimization problem subject to a production target.

[21] A distinguishing feature of this model is that different scale variables and different price variables are incorporated in the equation simultaneously. In most empirical models on import equations, only one scale variable and one price variable are included. For example,

(continued)

Data

The price of imported consumer goods and the price of imported capital goods are obtained from the Korea Customs Service. The price of domestically-produced consumer goods and the price of domestically-produced capital goods are approximated by the CPI and the Producers' Price Index (PPI) respectively. Investment is limited to gross fixed capital formation.[22] All scale variables are real quantities.

Results

Long-run elasticities

Table 6 presents the long-run results, indicating that consumption, fixed investment, and exports are jointly significant determinants of imports. On the contrary, prices appear to be less important in determining imports.

Table 6. Long-Run Import Demand Equations with Multiple Scale
and Price Variables, 1988-2001

c	i	x	p^{mcr}	p^{mkr}	R^2	$AR(4)$	$White$	ECM_{t-1}	Number of Observations
0.47	0.40	0.35	-0.22	-0.30	1.00	0.38	0.62	-0.76	56
(0.19)	(0.05)	(0.06)	(0.16)	(0.16)				(0.14)	

 Notes: All regressions include a constant term. Quarterly data are used and data prior to 1988 are not available. The dependent variable is the import volume in logarithm (m), and the independent variables, also expressed in logarithm, are defined in the text. The Dynamic Ordinary Least Squares procedure of Stock and Watson (1993) is used to estimate the long-run (or cointegrating) relationships between the dependent and independent variables. The values in the parenthesis undereath each estimated coefficient are the heteroscedasticity and autocorrelation consistent standard errors. *AR(4)* is the Lagrange-multiplier test for residual autocorrelation of the fourth order under the null of no autocorrelation, and the p-values for the *F* test are reported. The White test is a test for the presence of heteroscedasticity under the null of homoscedasticity, and the p-values for the *F* test are reported. ECM_{t-1} reports the coefficients on the lagged error-correction term in the estimation of the short-run relationships, and the values in the parenthesis underneath are the corresponding standard errors. Since all the variables appear to be I(1) in level, the significance of the lagged *ECM* term in the short-run regressions suggests that the errors in the long-run regressions are stationary, and therefore the variables in the long-run estimation are cointegrated. Results for other short-run relationships are available from the author.

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although Giorgianni and Milesi-Ferretti (1997) experiment the use of different scale and price variables in the import equation, they do not include all of them simultaneously.

[22] Total capital formation does not perform well in the estimation.

Table 7. Trade Elasticities for Other Countries[1]

	Exports		Imports	
	Income elasticities	Price elasticities	Income elasticities	Price elasticities
Australia	1.33	-0.19	1.85	0.45
Canada	2.06	0.00	2.01	0.49
Chile	2.87	0.10	1.70	0.23
Hong Kong	4.11	-0.07	1.92	1.01
Indonesia	1.27	-0.32	1.66	0.68
Japan	2.10	-0.69	0.79	0.55
Korea	3.12	-0.52	1.36	0.61
Mexico	1.55	-0.77	1.60	1.43
Malaysia	1.86	-0.53	1.47	0.01
New Zealand	0.98	-0.51	1.70	0.68
Philippines	1.34	0.10	1.65	-0.75
Singapore	1.77	-0.21	1.05	0.00
Taiwan Province of China	3.28	-0.70	1.23	0.66
Thailand	2.73	-0.99	1.03	0.75
United States	1.47	-0.85	2.46	0.26
Panel of all countries	1.96	-0.80	1.46	0.28

1/ This table is reproduced from Bayoumi (1996) based on annual data for 1974–93.

VI. CONCLUSION

This paper reexamines Korean trade flows, with the primary focus placed on the period between 1988 and 2001. It started by reestimating Korea's export and import equations using the standard demand-based model. In addition, it presents alternative models to deepen the explanations for these findings.

After reestimating the standard export equations, the paper finds that the income elasticity of Korean export demand has fallen sharply, with the opposite true for the price elasticity. Separate econometric analyses on EEPs and non-EEPs reveal that such changes are largely due to the increasing share of EEPs in total exports, with export demand (for EEPs) exhibiting a low income obtained elasticity and a high price elasticity. The estimates for non-EEPs are similar to those for total exports using earlier data. To explain such findings for EEPs, the paper presents an alternative export model based on a supply analysis and finds that the surge in EEP export volume can be explained by the presence of increasing returns to scale and technological improvement in the production of EEPs.

Results on imports using the standard model show values similar to those found by previous studies, except that the income elasticity of import demand shows a slight increase. An alternative model that incorporates multiple scale and price variables demonstrates that consumption, fixed investment and exports are important determinants of imports.

Like those of Korea, many of the studies on the trade flows of other Asian NIEs using earlier data have found a high income elasticity and a low price elasticity of export demand. An area of fruitful research would be to reexamine these using recent data. In particular, a supply-based export analysis may be useful in explaining exports of EEPs from other Asian NIEs.

APPENDIX

I.   Mathematical Background on Supply-Based Model

This appendix derives conditions for the existence of a negatively-sloped supply curve using a general functional form. Following the setup of Section IV, each firm j faces a cost function depending on the aggregate output:

$$C(X, X_j) = \xi(X)\phi(X_j),$$

where, $\xi(X) > 0$, $\phi(X) > 0$, $\xi'(X) < 0$, $\phi'(X_j) > 0$, $\phi''(X_j) > 0$.

In other words, as the aggregate production X increases, the marginal cost confronting each firm declines:

$$\frac{\partial^2 C}{\partial X_j \partial X} = \xi'(X)\phi'(X_j) < 0$$

However, given the aggregate production X, each firm faces an increasing marginal cost function relative to its own production level X_j :

$$\frac{\partial^2 C}{\partial y_j^2} = \xi(X)\phi''(X_j) > 0$$

So firm j 's problem is to choose its X_j to maximize its profit:

$$PX_j - \xi(X)\phi(X_j)$$

The first-order condition is:

$$P - \xi(X)\phi'(X_j) = 0 \quad \blacktriangleright \quad \frac{P}{\xi(X)} = \phi'(X_j)$$

Let $g(\cdot)$ be the inverse function of $\phi'(\cdot)$, i.e., $g(\phi'(Z)) = Z$ for all Z.

Thus the supply function for each firm j is:

$$X_j = g\left(\frac{P}{\xi(X)}\right)$$

The second-order condition is:

$-\xi(X)\phi''(X_j) < 0$ ➜ $\phi''(X_j) > 0$ and $\xi(X) > 0$, which are satisfied by assumption.

Therefore the aggregate supply function of the industry is:

$$X = \int_0^N X_j \, dj = \int_0^N g\left[\frac{P}{\xi(X)}\right] dj = Ng\left[\frac{P}{\xi(X)}\right]$$

Since $\phi'(\cdot)$ is the inverse function of $g(\cdot)$, we can solve for the inverse supply function

$$P = \xi(X)\phi'(\frac{X}{N})$$

The industry supply function may be downward sloping if:

$$\frac{\partial P}{\partial X} = \xi'(X)\phi'\left(\frac{X}{N}\right) + \frac{1}{N}\xi(X)\phi''\left(\frac{X}{N}\right) < 0$$

$$\Updownarrow$$

$$\frac{\xi'(X)}{\xi(X)} < -\frac{\phi''(X/N)}{\phi'(X/N)}\frac{1}{N}$$

Since both sides are negative, multiplying both side by X, we have:

$$X\left|\frac{\xi'(X)}{\xi(X)}\right| > \frac{X}{N}\left|\frac{\phi''(X/N)}{\phi'(X/N)}\right|$$

The left-hand side is the elasticity of the function $\xi(X)$ with respect to an additional output of X, in absolute term; the right-hand side is the elasticity of the marginal cost with respect to an additional output by an *average* firm, given the aggregate output, in absolute term.[23] Since the function $\xi(X)$ controls the degree of increasing returns to scale, in other words, if the positive external effects of increasing returns to scale at the industry level outweigh the increasing marginal cost faced by each individual firm, a negatively sloped supply curve arises.

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[23] Given the aggregate output, X, the marginal cost confronting firm j, $MC(X_j)$, is equal to $\xi(X)\phi'(X_j)$. The elasticity of the marginal cost with respect to an additional output of X_j, $\frac{MC'(X_j)}{MC(X_j)}X_j$, is therefore equal to $\frac{\phi''(X_j)}{\phi'(X_j)}X_j$. Since X/N is the average output, $\frac{X}{N}\frac{\phi''(X/N)}{\phi'(X/N)}$ is the elasticity of the marginal cost with respect to an additional output by an average firm.

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