THE KOREAN ECONOMIC REVIEW
Volume 16, Number 1, Summer 2000

A STUDY ON THE SECTORAL BUSINESS CYCLES IN KOREA AND TAIWAN USING THE MULTI-SECTOR MODEL

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This study examines the role of aggregate and disaggregate shocks in the Korean and Taiwanese economy. Variation in the growth rates of industrial output is decomposed into aggregate shock, industry group-specific shock, and sector-specific shocks. The results show that all types of shocks play a significant role in all levels of output but the role of shock differs at aggregate and sectoral output. In the case of Korean economy shocks in sectoral level are the driving forces of sectoral output fluctuations and have similar effects on aggregate output growth. Aggregate disturbances have similar effects across sectors and explain only 50 percent of total variance in aggregate output growth. The aggregate shock is a dominant source of aggregate output fluctuations in the Taiwanese economy. Aggregate disturbances have sharply differing effects across sectors and explain 82 percent of total variance in aggregate output growth. Shocks in sectoral level have sharply differing effects on aggregate output growth. And we can find some evidences that shocks could be transmitted across sectors in both countries.

JEL Classification: E32, O53
Keywords: Disaggregate Analysis, Role of Shocks

I. INTRODUCTION

Economists have long disagreed about the efficacy of discretionary fiscal and monetary policies to dampen business cycles. A fundamental empirical issue in this debate is to establish the underlying source of economic shocks. If shocks are national in scope and have common effects across sectors of the economy,

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Received for publication: Oct. 29, 1999. *Revision accepted:* Jan. 4, 2000.

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I want to thank two anonymous referees for their comments and suggestions, but the author is entirely responsible for all errors.

Financial support from Korea Research Foundation (1997) is gratefully acknowledged.

then a potential role for stabilization policy exists. However, if shocks are largely due to industry-specific factors, then it is less clear if aggregate policy instruments could be effective. Even if effective, the magnitude of the fiscal or monetary policy effect may depend on the industry or industries in which the shock originates, increasing the probability that the stabilization policy will have unintended consequences. Aggregate shocks can be defined as shocks that are common to all industries and can be due to nominal and/or real events. Examples of such shocks are monetary and fiscal policy as well as oil shocks. Disaggregate shocks can be defined as shocks that are specific to a sector. Examples of such shocks are taste changes, technological advancement, and productivity changes. It is possible that random fluctuations in the levels of sectoral shocks induce variation in aggregate output since the latter is a weighted sum of sectoral output. Altonji and Ham (1990) refer to this potential role for sectoral shocks as the "collective impact"[1]. Several studies have investigated the relative importance of aggregate and disaggregate shocks in industrialized economies. A common finding is that, while aggregate shocks are typically the predominant source of fluctuations in the aggregate economy, disaggregate shocks explain 20 to 40 percent of the fluctuations in aggregate output.

To date, all these studies have involved high income, industrialized economies with large domestic consumer demands. It is conceivable that industrial sectors in such large economies are relatively insulated from external shocks. For example, over the 1970-1995 period, imports represented 9.4 percent of U.S. Gross Domestic Product (GDP), 11.8 percent of Japan GDP, and 18 to 26 percent of GDP for Canada, France, Germany, Italy and the United Kingdom. In contrast, imports represented 30.9 and 34.4 percent of GDP in Korea and Taiwan respectively for the period of 1986-1997, suggesting that the Korean and Taiwanese firms are more exposed to fluctuations in international demand. Consequently, aggregate disturbances such as external shocks are likely to be a more important source of shocks in small open economies such as Korea and Taiwan than in large industrialized economies.

This study examines the relative importance of aggregate and disaggregate shocks in the Korean and Taiwanese economy. In the Korean economy we find that aggregate shocks are the source for 50 percent of changes in the aggregate economy, and another 50 percent of the changes in aggregate output are due to sectoral disturbances. On the other hand, aggregate disturbances can explain less than 50 percent of any single sector's output innovations. In the Taiwanese economy we find that aggregate shocks are the source for 82 percent of changes in the aggregate economy, but 18 percent of the changes in aggregate output are

[1] Long and Plosser (1983) demonstrated that aggregate output fluctuations could be due to disaggregate technology or taste shocks since real trade links among sectors can cause sector-specific shocks to be propagated across sectors in the economy. They showed that individual sectoral outputs may exhibit both serial and cross correlation even under the assumption that the productivity shocks are independent both across time and across sectors.

due to sectoral disturbances. Furthermore, aggregate disturbances can explain over 50 percent of any single sector's output innovations except Transportation. These results are comparable in the sense that sectoral shocks play an important role in the Korean economy while aggregate shocks play an important role in the Taiwanese economy.

The study begins with a review of what has been learned from previous studies of sectoral shocks. Next, an estimable form of Long and Plosser's (1983) general equilibrium multi-sector model is presented. Section 4 introduces the Korean and Taiwanese data and the decomposition of shocks into sectoral and aggregate components. Then the model is simulated to illustrate the propagation mechanisms for sectoral and aggregate shocks. Plausible sources of differences in propagation mechanisms are discussed.

Ⅱ. LITERATURE REVIEW

Several studies have investigated the relative importance of aggregate and disaggregate shocks in industrialized economies. While studies differ in methodology, countries covered, data frequency, and time period, a common finding has been that aggregate shocks cannot explain all of the variation in aggregate output. Such findings support the Long and Plosser's (1983) model of business cycles generated by sectoral disturbances which are propagated across industries.

Long and Plosser (1987) concluded that common aggregate shocks could explain at most 40 percent of the variation in United States sectoral output. Norrbin and Schlagenhauf (1988, 1990, 1991) also examined U.S. data, using a variety of specifications. Aggregate disturbances explained between 48 and 64 percent of the innovations in aggregate output, depending on the measure of output and methodology. Stockman (1988) examined the source of shocks across seven European countries and the United States. International shocks, regional shocks, and common industrial shocks across nations can explain 64 to 73 percent of innovations in output growth. Norrbin and Schlagenhauf (1996) also conducted a cross country analysis, finding that national and international shocks accounted for less than half the innovations in quarterly national output in 7 of 10 countries, and less than half of the innovation in semi-annual output in 4 of 10 countries.

The general finding from these studies is that aggregate shocks explain a substantial proportion but not all of the innovations in national output. This leaves a significant share of output innovations that are attributable to idiosyncratic industry effects. For example, these disaggregate factors accounted for between 15 percent (Italy) and 66 percent (UK) of the innovations in quarterly output in Norrbin and Schlagenhauf's (1996) study. These studies have typically concluded that aggregate shocks explain some of the variance in sectoral output. Furthermore, the transmission of aggregate disturbances is not uniform across industries so that the common aggregate disturbance has uncommon sectoral consequences. The presence of significant sectoral shocks supports the role of disaggregate shocks as a source of business cycles.

Ⅲ. ECONOMETRIC MODEL

Long and Plosser (1983) first developed a multi-sector equilibrium business cycle model in which business cycles result from individual agent optimizing behavior in a competitive environment. Altonji and Ham (1990) used a similar empirical multi-sector model to investigate disaggregate and aggregate shocks to employment growth. Their model extends the Long and Plosser framework by allowing contemporaneous correlation in sectoral innovations, introducing the potential for common shocks across sectors. This section adapts Altonji and Ham's framework to a multi-sector time-series model of output growth. The model combines a vector autoregressive (VAR) structure with an error components representation of the output growth innovations. The VAR model is suitable for representing the propagation mechanism while the impulse mechanism is represented by the error components.

3.1. VAR model

The multi-sector model takes the form of a vector autoregression (VAR). The autoregressive coefficients capture the propagation of shocks among industries, while the error terms measure impulses which are uncorrelated with past information. To operationalize the model, let there be I industries and define $y_{i,t}$ to be output growth in industry i. We can write the k^{th} order VAR as

$$Y_t = \alpha + \sum_{K=1}^{K} \pi_k Y_{t-k} + \varepsilon_t \tag{1}$$

where Y_t is an Ix1 vector of observed setoral output growth, α is an Ixl vector of constants, π_k is an IxI matrix of regression coefficients corresponding to a vector of sectoral output growth dated k periods in the past, and ε_t is an $\mathrm{I}\times 1$ vector of error terms whose structure will be defined in the follwing section. Each row of(1) has the form

$$y_{i,t} = \alpha_i + \sum_{K=1}^{K} \sum_{j=1}^{I} \pi_{j,k}^{i} y_{j,t-k} + \varepsilon_{i,t} \tag{2}$$

where $\pi_{j,k}^{i}$ is $[\pi_{1,k}^{i}, \pi_{2,k}^{i}, \cdots, \pi_{I,k}^{i}]$. This implies that output changes in industry i depend on output changes in all of the other industries. The completely unrestricted multi-sector model is over-parameterized since the feedback matrix has IxK parameters for each sectoral output equation. The empirical analysis below sets $I=10$ and $K=12$. This means that the unrestricted model involves estimating 120 parameters plus a constant for each sector. While such a model could be estimated in principal, use of large parameterizations typically results in many imprecise coefficients even if the model is estimable. More parsimonious parameterizations typically yield lower forecast error variances. Therefore, some restrictions must be placed on the feedback coefficients of the multi-sector model. We imposed the following composite-variable restrictions[2]. Suppose that the I industries can be divided into G industry group with $G<I$. Following Norrbin and Schlagenhauf (1990) let w_i^g be the fraction of output in industry i within its industry group[3], and let w_i be the fraction of output in industr i within the whole economy. Then the log change in industry group output, $y_{g,t}$, is defined as a weighted average of output growth in each industry within its group

$$y_{g,t}=\sum_{i=1}^{n^g} w_i^g y_{i,t} \tag{3}$$

where n^g is the number of industries in a given industry group, g.

Similarly, the log change in aggregate output or national output, $y_{A,t}$, is defined as a weighted average of output in each industry within the whole economy

$$y_{A,t}=\sum_{i=1}^{I} w_i y_{i,t} \tag{4}$$

We then specify the following restricted form of (2) for $y_{i,t}$

$$y_{i,t}=\alpha_i+\sum_{k=1}^{K}(\theta_{ik}y_{i,t-k}+\delta_{ik}y_{g,t-k}+\tau_{ik}y_{A,t-k})+\varepsilon_{i,t}, \tag{5}$$

where the θ_{ik} is the sectoral output response to k^{th} lagged sectoral output growth, δ_{ik} is the sectoral response to k^{th} lagged industry group output growth, and τ_{ik} is the sector's response to k^{th} lagged changes in aggregate output.

The aggregation rules in (3) and (4) place the restrictions on $\pi_{j,k}^i$ in (2). At lag k, the restricted feedback coefficients, $\tilde{\pi}_{j,k}^i$, would be

[2] Norrbin and Schlagenhauf (1991) used two other restrictions to identify the system of equations. One is a principal component restriction which limits the cross-dependencies between output changes by reducing the dimension of the data matrix. The other is an input-output restriction which sets the feedback coefficients equal to the input requirements from other industries and the own industry. The quantitative results were similar across specifications.

[3] We define an industry group to be an aggregation of similar industries. In the analysis below, our industry groups include Nondurable Manufacturing and Durable Manufacturing.

$$\pi^{i}_{j,k} = \theta_{ik} + \delta_{ik} w_i^g + \tau_{ik} w_i \quad \text{if} \quad i=j,\ i\in g \tag{6}$$

$$= \delta_{ik} w_j^g + \tau_{ik} w_j \quad \text{if} \quad i\neq j,\ i\in g \tag{7}$$

$$= \tau_{ik} w_j \quad \text{if} \quad i\neq j,\ i\notin g \tag{8}$$

The term $\tau_{ik} y_{A,t-k}$ permits feedback from all of the industries in the economy and this term contributes the coefficients $\tau_{ik} w_j$ to the cross-industry feedback of $y_{j,t-k}$ to $y_{i,t}$. The term $\delta_{ik} y_{g,t-k}$ allows a stronger feedback from the same industry group to the sector than industries outside the group, and the term $\theta_{ik} y_{i,t-k}$ permits feedback from the sector's own past output growth. These restrictions reduce the number of parameters from 121 to 37 per equation.

3.2. Error components

One advantage of the VAR form is that it allows us to simulate how shocks are propagated through the economy. The VAR residuals can represent the innovations to each sector's output growth. Suppose that there are three types of shocks in the economy: an aggregate (or national) shock, industry group-specific shocks and sector-specific shocks. For our study, there are ten sectoral outputs which are further classified into two different industry groups in both countries. Then the disturbance for a given sector i in industry group g can be assumed to take the forms,[4]

$$\varepsilon_{i,t} = f_i c_t + h_i r_{g,t} + e_{i,t} \qquad (i=1,\ 2,\ \cdots,\ 10 \quad \text{and} \quad g=1,\ 2) \tag{9}$$

where c_t is an aggregate shock, $r_{g,t}$ is an industry group-specific shock, and $e_{i,t}$ is a sector-specific shock. These error components represent a system of ten equations for which we need estimates of response coefficients $(f_1, \cdots, f_{10}, h_1, \cdots, h_{10})$ and the variance of the aggregate shock (σ_c^2), industry group shocks $(\sigma_{G1}^2, \sigma_{G2}^2)$ and idiosyncratic shocks $(\sigma_{e1}^2, \cdots, \sigma_{e10}^2)$. These estimates will enable us to analyze the system's responses to sectoral and aggregate output growth innovations and to measure the relative importance of these shocks in explaining sectoral and aggregate output variation.

The model (9) predicts that Σ, the covariance matrix of ε_t, takes the form

$$\Sigma_{ij} = E(\varepsilon_{i,t}\varepsilon_{j,t}) = f_i^2\sigma_c^2 + h_i^2\sigma_{Gg}^2 + e_{ei}^2 \quad \text{if} \quad i=j,\ i\in g \tag{10}$$

$$= f_i f_j \sigma_c^2 + h_i h_j \sigma_{Gg}^2 \quad \text{if} \quad i\neq j,\ i\in g \tag{11}$$

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[4] The dimension of common shock can be determined statistically but assume one common factor (or aggregate shock) in the error process. This is consistent with the findings of Long and Plosser (1987) in their examination of the number of common shocks in the economy, using the monthly innovations from a restricted VAR model.

$$= f_i f_j \sigma_c^2 \qquad \text{if} \qquad i \neq j,\ i \notin g \tag{12}$$

IV. DATA AND ESTIMATION RESULTS

The data consists of monthly observations of seasonally adjusted industrial production indices for 10 sectors in Korea and Taiwan. The sample period is 1986:01-1997:12. Korean data were obtained from the National Statistical Office and Taiwanese data were obtained from the Department of Statistics at Ministry of Economic Affairs. The use of monthly data lessens the possibility that impulses will be confused with the propagation mechanism, as could occur in studies that employ longer time intervals. If shocks are propagated quickly through the economy, then annual data on sectoral output would almost certainly include both initial sectoral shocks and output responses in other sectors. Use of monthly data should allow us to distinguish more clearly between shocks and propagated responses.[5]

4.1. VAR model

The restricted VAR model in (5) can be estimated using ordinary least squares, but we can gain efficiency in estimation using seemingly unrelated regression (SUR). The growth rate of an individual sectoral output is regressed on the past history of its own growth rate, the growth rate of its industry group, and the growth rate of aggregate output.[6] A lag length of twelve months was suggested by modified likelihood ratio tests. That lag length was sufficient to eliminate evidence of serial correlation in the residuals. After getting SUR estimation results, we constructed the feedback coefficients of $\tilde{\pi}^{i}_{j,k}$ according to (6)-(8) even though they are not reported in this paper.

4.2. Error components model

The error components of disturbances in equation (9) were estimated by a maximum likelihood variant of method of moments estimation. The iterative numerical method selects a parameter vector, β, so as to minimize the difference between the covariance matrix ($\Sigma(\beta)$) and the sample covariance matrix (S). The maximum likelihood estimation chooses β to minimize.

$$L = Tr(S\Sigma(\beta)^{-1}) - I + \log(det(\Sigma(\beta))) - \log(det(S)) \tag{13}$$

[5] An example of this phenomenon can be found in Norrbin and Schlagenhauf (1996) who found that aggregate shocks were less important in quarterly data than in semi-annual data. Somewhat weaker evidence suggested greater importance for idiosyncratic sectoral shocks in the quarterly data.

[6] In estimation growth rates is used since all industrial output series have a unit root.

where I is the number of equations in the system, and β is composed of the parameters and variances in equation (10)-(12).[7]

We need to normalize some of the parameters in equations (10)-(12). In particular, the magnitude of the product terms $f_i f_i \sigma_c^2$ and $h_i h_j \sigma_{Gg}^2$ are identified, but the individual elements of the product terms are not identified. Following the strategy used by Altonji and Ham (1990), the variance of the aggregate shock and the industry group shocks were normalized to one. In addition, the response of each sectoral output to its own shock was normalized to one. Since we have ten sectors and three different types of shocks, this leaves 33 parameters to be estimated from 55 elements in the covariance matrix. The 33 parameters include 10 sectoral shock variances, two industry group shock variances, one aggregate shock variance, ten parameters representing sectoral responses to the industry group shocks, and ten parameters giving sectoral responses to the aggregate shock.

Initial estimation yielded two negative estimated variances for both countries even though sectors which yields negative variance are different.[8] The model was then reestimated, restricting responsive coefficients to industry group shock which yield negative variances to be zero. This restricted model yielded reasonable results in that all estimated variance were positive. Table 1 and Table 2 present the maximum likelihood estimates of the response coefficients and the variances of the shocks for the Korean and Taiwanese economy.

[Table 1] Maximum likelihood estimates: response coefficients and variance of various shocks (Korea)

Response coefficients[a]				Variance[b]	
Industry	Sector	Aggregate	Industry Group	Sector	Estimate
Non-durable	Food	0.0172(8.36)[c]	0.0125(29.04)	Food	0.000136(2.64)
	Textile	0.0118(8.25)	0.0[d]	Textile	0.000155(6.68)
	Paper	0.0096(5.52)	0.0	Paper	0.000291(7.58)
	Chemical	0.0140(8.19)	-0.0024(-1.07)	Chemcal	0.000198(5.35)
Durable	Basic	0.0122(8.31)	0.0	Basic	0.000163(6.65)
	Fabmetal	0.0216(7.35)	0.0193(5.07)	Fabmetal	0.000332(2.78)
	Electric	0.0133(3.97)	0.0114(2.83)	Electric	0.000988(7.42)
	Precision	0.0180(5.19)	0.0044(1.06)	Precision	0.001103(7.72)
	Transportation	0.0379(5.29)	0.0355(4.05)	Transportation	0.003535(5.94)
	Otherman	0.0141(6.10)	0.0090(3.33)	Otherman	0.000399(6.97)

[a] Response coefficients to sector-specific shocks are normalized to one.
[b] The variance of aggregate and industry group-specific shocks are normalized to one.
[c] Numbers in parentheses are t-value.
[d] Response coefficients are restricted to be zero.

[7] Bollen (1989, chapter 4) dicusses in detail the estimation method of covariance structure and derivation of maximum likelihood function.

[8] This can happen when data are highly correlated. Krieger (1989), Altonji and Ham (1990) also found negative variances for some shocks.

[Table 2] Maximum likelihood estimates: response coefficients and variance of various shocks (Taiwan)

Response coefficients[a]				Variance[b]	
Industry	Sector	Aggregate	Industry Group	Sector	Estimate
Non-durable	Food	0.0184(7.71)[c]	0.0[d]	Food	0.000472(7.38)
	Textile	0.0266(9.59)	0.0050(0.42)	Textile	0.000476(3.94)
	Paper	0.0352(11.84)	0.0021(0.37)	Paper	0.000376(6.11)
	Chemical	0.0198(9.81)	0.0111(0.45)	Chemical	0.000134(0.24)
Durable	Basic	0.0285(11.34)	0.0070(0.69)	Basic	0.000253(1.78)
	Fabmetal	0.0387(11.55)	0.0093(0.69)	Fabmetal	0.000425(1.71)
	Electric	0.0278(10.87)	0.0	Electric	0.000355(6.64)
	Precision	0.0401(9.72)	0.0	Precision	0.001126(7.01)
	Transportation	-0.0152(-2.86)	0.0051(0.44)	Transportation	0.002913(7.22)
	Otherman	0.0037(10.83)	0.0013(0.20)	Otherman	0.000735(6.51)

[a] Response coefficients to sector-specific shocks are normalized to one.
[b] The variance of aggregate and industry group-specific shocks are normalized to one.
[c] Numbers in parentheses are t-value.
[d] Response coefficients are restricted to be zero.

In the case of Korean economy all sectoral response coefficients to the aggregate shock are statistically significant. The uniformly positive coefficients imply that all sectors move procyclically with the aggregate shock. Transportation is the most responsive to the aggregate shock while Paper is the least responsive to the aggregate shock. In terms of industry group-specific shock Transportation is the most responsive to the durable industry group-specific shock. In the case of Taiwanese economy all sectoral response coefficients to the aggregate shock are statistically significant. The uniformly positive coefficients except Transportation imply that all sectors move procyclically with the aggregate shock. Precision is the most responsive to the aggregate shock while Other manufacturing is the least responsive to the aggregate shock. In terms of industry group-specific shock most responsive coefficients are statistically insignificant, but we decide to include these parameters in order to compare the results with those of Korea.

V. RELATIVE IMPORTANCE OF SHOCKS AND IMPULSE RESPONSES

The moving average representation of the multi-sector model generates a useful decomposition of instantaneous and steady-state output variance by source. This will enable us to establish the relative importance of aggregate and disaggregate shocks. In addition, we can simulate the system's responses to aggregate and disaggregate shocks, illustrating how shocks work their way through the economy. Using the error structure in (9), the restricted form of equation (1) is

$$Y_t = a + \sum_{k=1}^{12} \tilde{\pi}_k Y_{t-k} + Fc_t + Hr_{g,t} + e_t \tag{14}$$

where $\tilde{\pi}_k$ is the 10x10 matrix of restricted feedback coefficients at each lag, F is 10x1 vector with elements f_i and H is 10x2 matrix with elements h_i and $r_{g,t}$ is 2x1 vector of industry group shocks. Assuming that the process in (14) is stationary, the moving average representation is

$$Y_t - mean(Y_t) = \sum_{k=0}^{\infty} (\tilde{\pi}_k F) c_{t-k} + \sum_{k=0}^{\infty} (\tilde{\pi}_k H) r_{g,t-k} + \sum_{k=0}^{\infty} (\tilde{\pi}_k) e_{t-k} \tag{15}$$

Under the assumption that c_t, g_t and e_t are independently distributed, the innovation variance of Y_t in (14) can be written as

$$V(Y_t) = \sigma_c^2 FF' + H\Omega_r H' + \Omega_e \tag{16}$$

where Ω_r and Ω_e are the covariance matrices of $r_{g,t}$ and e_t respectively. The relative impotance of various shocks in the system can be calculated by the ratio of each shock's variance to the total innovation variance. Equation (16) enables us to assess the instantaneous decomposition of sectoral shocks by source. These shocks work their way though the economy over time. The steady-state variance of Y_t, $V^s(Y_t)$, can be written as (17).

$$V^s(Y_t) = \sigma_c^2 \sum_{k=0}^{\infty} \tilde{\pi}_k FF' \tilde{\pi}_k' + \sum_{k=0}^{\infty} \tilde{\pi}_k H\Omega_r H' \tilde{\pi}_k' + \sum_{k=0}^{\infty} \tilde{\pi}_k \Omega_e \tilde{\pi}_k' \tag{17}$$

Once again, the relative importance of the various shocks in steady-state can be calculated as the ratio of the shock's variance to the total steady-state variance. Table 3 and Table 4 report the contribution of various shocks to the total variance of the innovation in sectoral output growth rates through the economy for Korea and Taiwan. The numbers in parentheses give the corresponding steady-state variance decomposition by source. Comparing these two measures gives some insight on how shocks are transmitted across sectors. The aggregate shock is transmitted across all sectors instantaneously, industry group-specific shocks are also propagated across sectors within industry group immediately, but 'a priori' restrictions (equation (9)) impose a one month delay for disaggregate shocks to be transmitted across sectors.

In the case of Korean economy the aggregate shock accounts for 23 to 50 percent of the instantaneous variance in sectoral output growth rates in the nondurable industries. The nondurable industry group-specific shock explains another 0 to 27 percent of the instantaneous variance in these industries. The sector-specific shock explains the rest of the variance. The aggregate shock

[Table 3] Variance decompositions from a sectoral perspective (Korea)

Sector	Fraction of variance explained by				
	Aggregate	Nondurable	Durable	Sectoral: Own sector	Sectoral: All others
Non-durable					
Food	50.22(48.99)[a]	26.52(22.26)	0.0 (2.43)	23.24(19.66)	0.0 (6.66)
Textile	47.52(47.69)	0.0 (0.34)	0.0 (1.61)	52.47(44.78)	0.0 (5.58)
Paper	22.96(24.28)	0.0 (0.17)	0.0 (2.19)	76.03(68.30)	0.0 (5.06)
Chemical	48.93(44.31)	1.43(2.68)	0.0 (3.40)	49.63(39.93)	0.0 (9.68)
Durable					
Basic	47.60(28.37)	0.0 (1.94)	0.0 (3.54)	52.40(45.31)	0.0 (20.84)
Fabmetal	18.40(20.10)	0.0 (0.52)	43.18(36.72)	38.40(28.94)	0.0 (13.72)
Electric	13.68(15.00)	0.0 (0.31)	10.05(11.49)	76.26(57.04)	0.0 (16.16)
Precision	22.41(25.34)	0.0 (0.39)	1.33(4.78)	76.24(60.40)	0.0 (9.09)
Transportation	23.03(26.44)	0.0 (0.31)	20.20(19.28)	56.76(41.93)	0.0 (12.01)
Otherman	29.24(26.60)	0.0 (0.59)	11.91(13.21)	58.83(42.72)	0.0 (16.88)

[a] Numbers in parentheses refers to steady-state variance decompositions.

[Table 4] Variance decompositions from a sectoral perspective (Taiwan)

Sector	Fraction of variance explained by				
	Aggregate	Nondurable	Durable	Sectoral: Own sector	Sectoral: All others
Non-durable					
Food	41.82(52.75)[a]	0.0 (1.00)	0.0 (0.22)	58.17(42.01)	0.0 (4.02)
Textile	58.58(60.42)	2.06 (2.57)	0.0 (0.17)	39.34(31.93)	0.0 (4.91)
Paper	76.49(73.49)	0.27 (1.31)	0.0 (0.10)	23.23(21.00)	0.0 (4.10)
Chemical	60.33(63.15)	18.86 (13.34)	0.0 (0.32)	20.70(14.78)	0.0 (8.41)
Durable					
Basic	72.90(51.77)	0.0 (8.28)	4.39 (4.32)	22.69(19.02)	0.0 (16.61)
Fabmetal	74.56(64.33)	0.0 (3.82)	4.30 (3.56)	21.12(15.86)	0.0 (12.43)
Electric	68.61(51.55)	0.0 (3.69)	0.0 (2.20)	31.38(24.20)	0.0 (18.36)
Precision	58.75(53.39)	0.0 (2.15)	0.0 (0.73)	41.24(33.11)	0.0 (10.62)
Transportation	7.28(10.80)	0.0 (4.22)	0.81 (1.81)	91.89(67.19)	0.0 (15.98)
Otherman	68.81(62.72)	0.0 (2.68)	0.07 (0.48)	31.11(23.39)	0.0 (10.73)

[a] Numbers in parentheses refers to steady-state variance decompositions.

accounts for 14 to 48 percent of the instantaneous variance in sectoral output growth rates in the durable industries. The durable industry group-specific shock explains another 0 to 43 percent of the instantaneous variance in these industries. The sector-specific shock explains the rest of the variance. In the case of Taiwanese economy the aggregate shock accounts for 42 to 76 percent of the instantaneous variance in sectoral output growth rates in the nondurable industries. The nondurable industry group-specific shock explains another 0 to 19 percent of the instantaneous variance in these industries. The sector-specific shock explains the rest of the variance. The aggregate shock accounts for 7 to 75 percent of the instantaneous variance in sectoral output growth rates in the durable industries. The durable industry group-specific shock explains another 0 to 4 percent of the instantaneous variance in these industries. The sector-specific shock explains the rest of the variance. The aggregate shock plays more important role in generating fluctuations of sectoral output growth rates in the Taiwanese economy while disaggregate shocks such as sector-specific and industry group-specific shock play more important role in the Korean economy.

When shocks are allowed to be propagated across sectors and time, sector-specific shocks continue to play the dominant role in generating the fluctuations of sectoral output growth rates in the Korean economy while aggregate shock continues to play the dominant role in the Taiwanese economy.[9] While sector-specific shocks explain a smaller share of the own sector steady-state output growth variance than the instantaneous variance, this is attributable to the propagation of sectoral disturbances to other sectors. In the Korean economy sectoral shocks explain 5 to 21 percent of the steady-state variance of output in other sectors while sectoral shocks explain 4 to 18 percent of the steady-state variance of output in other sectors in the Taiwanese economy. This is a limited evidence of Long and Plosser (1983)'s claim that sector-specific shocks could be propagated across sectors in the economy due to real trade linkage among sectors. In the case of Korea sector-specific shock in Chemical and Transportation have a strong evidence of being propagated across sectors while sector-specific shock in Chemical and Electric have a strong evidence of being propagated across sectors in the Taiwanese economy.[10] Even though the importance of aggregate and disaggregate shocks in the steady-state change a little, but qualitatively similar outcomes are found. The stylized fact that aggregate shock is important but not a dominant source of fluctuations in the Korean economy is inconsistent with the findings of other studies. But this finding is consistent with the view that sectoral shocks would be more important in a small and relatively closed economy. The finding that aggregate shock plays a more important role in generating sectoral business cycles in the Taiwan

[9] The size of importance of sectoral shocks in this model is the upper bound since there is one aggregate shock. This implies that we may introduce an additional observed aggregate shock such as oil shock in the model so that stylized facts of this study to be robust.

[10] The numbers of last column in Table 3 and Table 4 are the sum of all sectoral shocks except own sectoral shock in the economy. Shocks in Chemical and Transportation in the Korean economy have larger contributions in this number. We can interpret these contributions as the evidence of propagation mechanism of shocks. The existence of propagation mechanism of shocks in Chemical and Transportation in the Korean economy may be due to a strong forward and/or backward linkage effect of those industries. This interpretation could be applied to the Taiwanese economy.

economy than in the Korean economy is due to more openness of the Taiwanese economy.

We can also assess the relative importance of shocks for industry group and for the aggregate economy. To do this, we exploit the fact that the output growth rate of an aggregated group of industries is approximately equal to the weighted sum of the individual sectoral growth rates. For example, let the growth rate of the nondurable industry group output be Y_{nt}. Then the innovation variance of Y_{nt}, $V(Y_{nt})$, can be decomposed according to

$$V(Y_{nt}) = w_n V(Y_t) w_n' \\ = \sigma_c^2 w_n FF' w_n + w_n H \Omega_r H' w_n' + w_n \Omega_e w_n' \quad (18)$$

where $w_n = [w_1^1, w_2^1, w_3^1, w_4^1, 0 \cdots\cdots 0]$ is 1×10 weighting vector of nondurable industry group. Similarly, we can compute innovation variances for durable industry group and for the aggregate economy. The results for Korea and Taiwan are reported in Table 5 and Table 6.

[Table 5] Steady-state variance decompositions from industry and aggregate perspective (Korea)

	Fraction of variance explained by				
Sector	Aggregate	Nondurable	Durable	Own sector	All other sectors
Industry perspective					
Nondurable	66.49	1.99	2.83	25.13	3.56
Durable	37.47	0.57	22.51	31.20	13.25
Aggregate perspective					
Aggregate	50.14	0.76	16.72	32.38[a]	

[a] Each industry's contributions are as follows: Transportation (14.23), Precision (5.47), Chemical (5.41) etc.

[Table 6] Steady-state variance decompositions from industry and aggregate perspective (Taiwan)

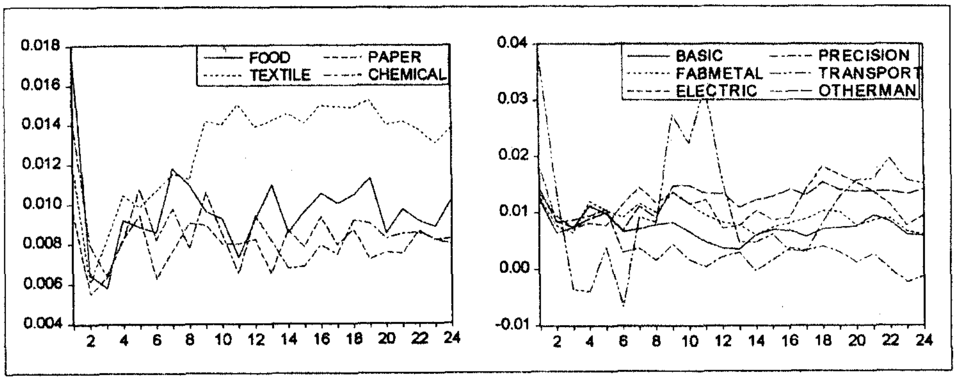
	Fraction of variance explained by				
Sector	Aggregate	Nondurable	Durable	Own sector	All other sectors
Industry perspective					
Nondurable	77.94	6.16	0.19	14.13	2.12
Durable	75.62	2.53	1.61	14.62	5.62
Aggregate perspective					
Aggregate	82.25	2.60	0.80	14.35[a]	

[a] Each industry's contributions are as follows: Electric (3.67), Textile (2.32), Transportation (2.17) etc.

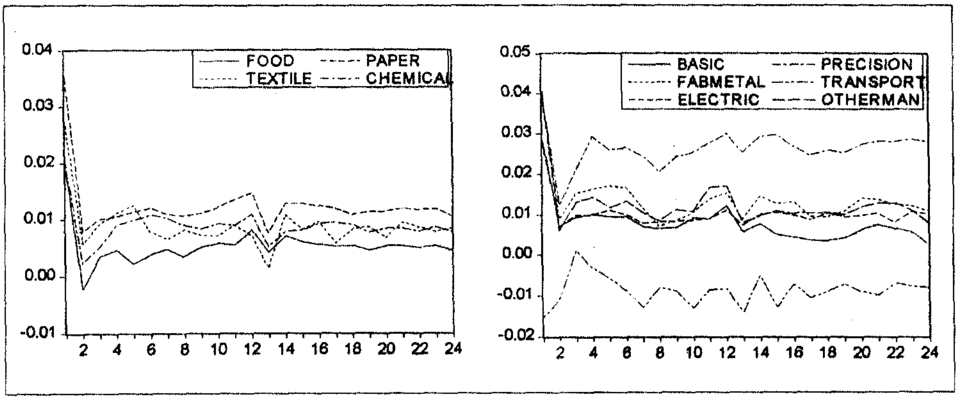
In Korea aggregate shocks are more important in explaining innovations in aggregated industries than in individual industries. Aggregate shocks account for 66 percent of output growth rates in the nondurable industry group and 37 percent of output growth rates in the durable manufacturing industry group. As before, the aggregate shock plays a more important role in nondurable manufacturing than in durable industry group. The industry group shocks are relatively unimportant, explaining only 1 to 23 percent of industry group output innovations. Sectoral shocks account for 25 to 31 percent of the variation in own-industry group output growth rates, and 4 to 13 percent of other industry group output growth rates. In Taiwan aggregate shocks are also more important in explaining innovations in aggregated industries than in individual industries. Aggregate shocks account for 78 percent of output growth rates in nondurable industry group and 76 percent of output growth rates in durable industry group. The industry group shocks are relatively unimportant, explaining only 0.2 to 6 percent of industry group output innovations. Sectoral shocks account for 14 to 15 percent of the variation in own-industry group output growth rates, and 2 to 6 percent of other industry group output growth rates.

Aggregate shocks continue to increase in relative importance as we aggregate to the level of the economy as a whole. The aggregate shock accounts for 50 percent and 82 percent of the variance in aggregate growth rates of Korea and Taiwan respectively. Industry group-specific shocks altogether explain only 17 percent (which is equal to 0.76 percent plus 16.72 percent) and 3 percent (which is equal to 2.6 percent plus 0.8 percent), while sector-specific shocks account for 32 percent and 14 percent of the variance of aggregate output growth rates of Korea and Taiwan respectively. This finding is qualitatively consistent with previous studies on more developed countries. Perhaps equally important is the finding that aggregate disturbances have nonneutral effects on individual industries, implying that aggregate stabilization policies will have nonneutral benefits across sectors.

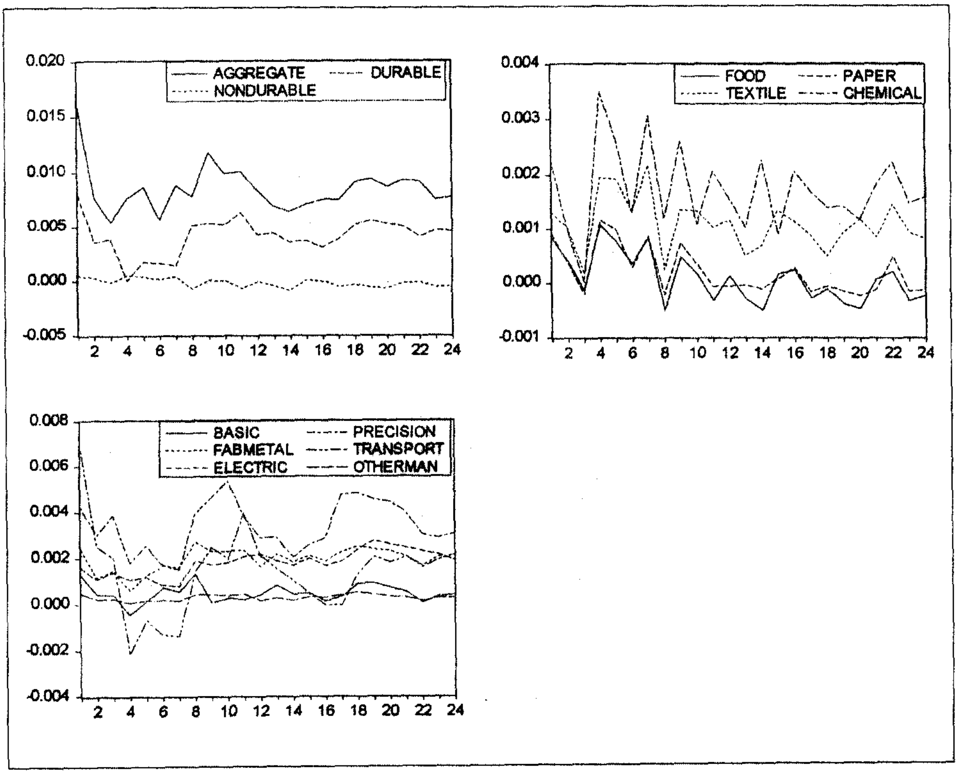
[Figure 1] Response of the logarithm of sectoral output to a one standard deviation innovation in aggregate output (Korea)



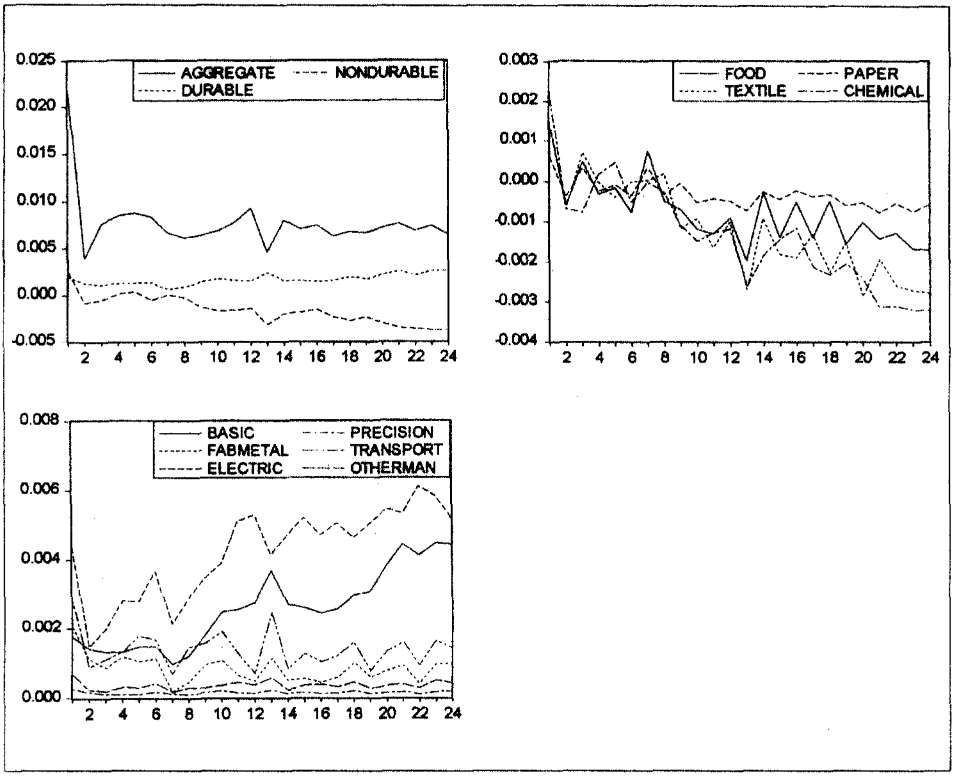
[Figure 2] Response of the logarithm of sectoral output to a one standard deviation innovation in aggregate output (Taiwan)



[Figure 3] Response of the logarithm of aggregate output to a one standard deviation shock to aggregate, industry group, and sectoral output (Korea)



[Figure 4] Response of the logarithm of aggregate output to a one standard deviation shock to aggregate, industry group, and sectoral output (Taiwan)



The diversity of sectoral responses to aggregate shocks can also be observed in sectoral responses to a one standard deviation aggregate shock. The effects of such a one-time shock on the log-level of sectoral output are shown in Figure 1 and Figure 2 for Korea and Taiwan.

The graphs show the percentage deviation in sectoral output from the baseline output level in the absence of any shocks. In Korea most industries have almost the same degree of sensitiveness to the aggregate shock, and Transportation has the largest fluctuations to the aggregate shock. In Taiwan durable industries are more sensitive to the aggregate shock than nondurable industries, and Transportation's output is growing below one percent over the baseline level after 24 months.

Aggregate output is also not equally sensitive to all shocks. In Figure 3 and Figure 4, we find that sectoral shocks in nondurable, whether individually or as a group, have less impact on aggregate output than sectoral shocks in durable in both countries. It does not appear that individual sectoral shocks have sufficiently large or persistent effects to explain aggregate business cycle fluctuations in the

Korean and Taiwanese economy.

It is important to establish underlying causes of diverse responses to aggregate and sectoral shocks. While a formal test of hypothesis is outside the scope of this paper, the pattern of sectoral and aggregate responses to shocks suggests several interesting hypotheses. For example, durable industries are particularly sensitive to aggregate shocks, especially in the Taiwanese economy. The positive correlation between aggregate and sectoral output disturbances lend themselves to both demand-side and supply-side (technology shock) explanations. First, durable industries are more sensitive to output shocks in other sectors than nondurable industries in both countries. This suggests that durable output growth is driven by domestic sectoral demands to a less extent than nondurable output growth, an interpretation that corresponds to durable's status as a producer of final rather than intermediate goods. Second, sectoral output growths in the Taiwanese economy are more sensitive to aggregate shocks than those in the Korean economy may imply that the Taiwanese economy is more open to the world economy and thus more sensitive to world demand or supply shock. The fact that sectoral output growths in the Korean economy are more sensitive to sector-specific shocks may imply that the technology shock could be the source of sectoral business cycles in the Korean economy. Further research will be required to establish this explanation.

VI. CONCLUSIONS

One might have anticipated that small open economies such as Korea and Taiwan would be much more subject to aggregate disturbances than larger and more developed economies. However, the results reported herein suggest that aggregate disturbances explain only 50 percent of total variance in Korean output growth, a proportion roughly at the midpoint of the range of results reported by Norrbin and Schlagenhauf for the United States economy. In contrast, aggregate disturbances explain 82 percent of total variance in Taiwanese output growth, a proportion higher than the range of results reported by Norrbin and Schlagenhauf. We also find aggregate disturbances have similar effects across sectors in the Korean economy while they have sharply differing effects across sectors in the Taiwanese economy. Similarly, the sectoral disturbances have similar effects on aggregate output growth in the Korean economy while they have sharply differing effects on aggregate output growth in the Taiwanese economy. The importance of sectoral disturbances in causing Korean business cycles and the nonneutral effects of aggregate disturbances across sectors complicate national policies to smooth aggregate shocks. Our results suggest that such policies are as prone to unforeseen or negative consequenses on a small open economy as in the larger economies which have been studied previously.

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