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The relative importance of aggregate and disaggregate shocks in Korean business cycles

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Abstract

This study examines the role of aggregate and disaggregate shocks in a small open economy, Korea. Variation in the growth rates of industrial output is decomposed into portions attributable to aggregate, industry group, and sector-specific shocks. Although all types of shocks play a role, sectoral shocks are the dominant source of sectoral output fluctuations. While aggregate shocks are a significant source of sectoral and aggregate output fluctuations, they are no more important than in large industrialized economies that have been studied previously. Consequently, small open economies may not be any more susceptible to aggregate disturbances than are the G-7 countries.

JEL classification: E32; O53

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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, then a potential role for stabilization policy exists. However, if shocks are largely due to industry-specific factors, then it is less clear that aggregate policy instruments could be effective. In particular, if shocks are corrected by redistribution of capital and labor across sectors, macroeconomic stabilization policies may dampen the self-correcting mechanisms of a market economy and create a

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more severe recession than would have occurred without the policy.[1] 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.[2] 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 20–40% 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% of US gross domestic product (GDP), 11.8% of Japan GDP, and 18–26% of GDP for Canada, France, Germany, Italy and the United Kingdom. In contrast, imports represented 34.4% of GDP in Korea, suggesting that Korean firms are more exposed to fluctuations in international demand. Consequently, aggregate disturbances might be expected to be a more important source of shocks in small open economies such as Korea's than in large industrialized economies.

This study decomposes Korea's aggregate and sectoral output growth into components attributable to aggregate and sectoral shocks. We find that aggregate shocks are the source for 58% of changes in the aggregate economy, leaving 42% of the variation in aggregate growth to sectoral disturbances. Aggregate disturbances can explain at most 44% of any single sector's output innovations. These results are comparable to those reported by other authors for the G-7 countries, suggesting that sectoral shocks are as important for small open economies as for the largest industrialized economies. As a consequence, conditions for successful macroeconomic stabilization policies in Korea are similar to those in more developed industrialized economies.

The study utilizes an estimable form of Long and Plosser's (1983) general equilibrium multi-sector model. The model is simulated to illustrate the propagation mechanisms for sectoral and aggregate shocks. Differences in propagation mechanisms across sectors appear to be consistent with stylized facts on the relative importance of international trade to the sectors.

1. 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

[1] See Davis, Haltiwanger, and Schuh (1996, Chapter 7) for a discussion of stabilization policies in the face of sectoral shocks.

[2] 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.

shocks cannot explain all of the variation in aggregate output. Such findings support the Long and Plosser (1983) view that business cycles are generated by sectoral disturbances which are propagated across industries.

Long and Plosser (1987) concluded that common aggregate shocks could explain at most 40% of the variation in United States sectoral output. Norrbin and Schlagenhauf (1988, 1990, 1991) also examined US data, using a variety of specifications. Aggregate disturbances explained between 48 and 64% of the innovations in aggregate output, depending on the measure of output and methodology employed. 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 64–73% 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, disaggregate factors account for between 15% (Italy) and 66% (UK) of the innovations in quarterly output in Norrbin and Schlagenhauf's (1996) multicountry study. The presence of significant sectoral shocks supports the role of disaggregate shocks as a source of business cycles. Additionally, aggregate shocks explain some but not all of the variance in sectoral output. The transmission of aggregate disturbances is not uniform across industries, so common aggregate disturbance have uncommon sectoral consequences. To date, these methods have not been applied to small open economies, the focus of this study.

2. 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 extended 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 (1990) 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.

2.1. The restricted VAR model

Our multi-sector model is a restricted form of a VAR. The VAR 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 kth order VAR as

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

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

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

where $\pi^i_{j,k}$ is $[\pi^i_{1,k}, \pi^i_{2,k}, \ldots, \pi^i_{I,k}]$. 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 $I \times K$ parameters for each sectoral output equation. The empirical analysis below sets $I = 12$ and $K = 12$. This means that the unrestricted model involves estimating 144 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. Suppose that the I industries can be divided into G aggregate industries with $G < I$. Following Norrbin and Schlagenhauf (1990) let w^g_i be the fraction of output in industry i within its industry group,[3] and let w_i be the fraction of output in industry i within the whole economy.[4] 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:

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

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:

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

[3] We define an industry group to be an aggregation of similar industries. In the analysis below, our industry groups include mining, nondurable manufacturing, and durable manufacturing.

[4] 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. Their quantitative results were not sensitive to the choice of identifying restrictions.

The data appendix contains a list of industry group and aggregate output weights for each industry. Using (3) and (4), we can specify the following restricted form of (2) for $y_{i,t}$:

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

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

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

$$\tilde{\pi}^i_{j,k} = \theta_{ik} + \delta_{ik} w_i^g + \tau_{ik} w_i, \quad \text{if } i = j, i \in g \quad (6)$$

$$\tilde{\pi}^i_{j,k} = \delta_{ik} w_i^g + \tau_{ik} w_i, \quad \text{if } i \neq j, i \in g \quad (7)$$

$$\tilde{\pi}^i_{j,k} = \tau_{ik} w_i, \quad \text{if } i \neq j, i \notin g \quad (8)$$

The term $\tau_{ik} y_{A,t-k}$ permits feedback from all of the industries in the economy, which contributes the coefficients $\tau_{ik} w_i$ 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 than from industries outside the group. 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 145 to 37 per equation.[5]

2.2. Error components

A distinct advantage of this restricted VAR formulation over previous specifications is that it allows considerable freedom in how shocks can be propagated through the economy. The VAR residuals represent the innovations to each sector's output growth. We assume that there are three types of shocks in the economy: an aggregate (or national) shock, industry group-specific shocks and sector-specific shocks. The disturbance for a given sector i in industry group g can be assumed to take the form,[6]

$$\varepsilon_{i,t} = f_i c_t + h_i r_{g,t} + e_{i,t}; \quad i = 1, 2, \ldots, 12, \quad g = 1, 2, 3; \quad (9)$$

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 12 equations for which we need estimates of response coefficients ($f_1, \ldots, f_{12}$, $h_1, \ldots, h_{12}$), and estimates of the variances of the aggregate shock (σ^2_{c}), industry group shocks ($\sigma^2_{\mathrm{G1}}, \ldots, \sigma^2_{\mathrm{G3}}$) and idiosyncratic shocks ($\sigma^2_{\mathrm{e1}}, \ldots, \sigma^2_{\mathrm{e12}}$). 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.

[5] In order to determine whether these restrictions are statistically significant we conducted modified likelihood ratio tests suggested by Sims (1980). A test statistic, 1313.62 with 1296 d.f. and 0.99 significance level, confirms these restrictions.

[6] The dimension of common shock will be determined later 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.

Given (9), the covariance matrix of ε_t, Σ, takes the form

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

$$\Sigma_{ij} = E(\varepsilon_{i,t}\varepsilon_{j,t}) = f_i f_j\sigma_{\mathrm{c}}^2 + h_i h_j\sigma_{\mathrm{G}g}^2, \quad \text{if } i \neq j, i \in g \tag{11}$$

$$\Sigma_{ij} = E(\varepsilon_{i,t}\varepsilon_{j,t}) = f_i f_j\sigma_{\mathrm{c}}^2, \quad \text{if } i \neq j, i \notin g \tag{12}$$

3. Data and estimation results

The data consists of monthly observations of seasonally adjusted industrial production indices for 12 sectors in Korea. The sample period is 1980:1–2000:9. 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.[7]

3.1. Estimating the restricted 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. 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. Use of output growth rates rather than levels was necessitated by the presence of unit roots in all industry output series. A lag length of 12 months was suggested by modified likelihood ratio tests. That lag length was sufficient to eliminate evidence of serial correlation in the residuals.

The first step in the analysis was to establish the dimensionality of the common shocks. In principle, there may be many sources of common shocks, each requiring a separate estimated variance and vector of response coefficients. Factor analysis was used to decompose the residuals from the restricted VAR into one or more unobserved common factors and a set of unique disturbances.[8] Each common factor can be interpreted as an aggregate shock. There are several ways to determine the number of common factors. We employed the Chi-square goodness-of-fit test and Schwartz's Bayesian criterion to establish the dimensionality of the common factor. The tests are reported in Table 1. The Chi-square test suggests at least two common factors. However, the Chi-square test tends to overpredict the number of common factors. Schwartz's Bayesian criteria (SBC)

[7] 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. Use of monthly data appears to lower the estimated importance of aggregate disturbances somewhat relative to quarterly data, although the differences are small. Long and Plosser, using monthly US data, reported that aggregate disturbances accounted for 47% of the variance in aggregate growth, while the lower bound of Norrbin and Schlagenhauf's quarterly estimates was 48%. Of course, differences in methodology and data could also account for the discrepancy.

[8] Kim and Mueller (1978) can serve as a good introduction to factor analysis.

Table 1
χ^2 and Schwartz's Bayesian criteria (SBC) tests of the dimensionality of common aggregate factors

Factors	χ^2	d.f.	P-value	SBC
0	740.1	66	0.0001	
1	119.3	54	0.0001	−172.85
2	73.9	43	0.0023	−159.02
3	37.6	33	0.2656	−141.55

selects the number of common factors by the smallest value for the test statistic. The SBC indicates only one common factor. In the analysis that follows, we assume one common factor in the error decomposition.[9]

3.2. Estimating the error components model

The error components of disturbances in Eq. (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:

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

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

We need to normalize some of the parameters in Eqs. (10)–(12). In particular, the product terms $f_i f_j \sigma_c^2$ are identified, but the individual elements of the product terms are not identified. The response coefficient of coal industry to the aggregate shock was normalized to one. In addition, the response of each sectoral output to its own shock was normalized to one. Since we have 12 sectors and three different types of shocks, this leaves 40 parameters to be estimated from 78 elements in the covariance matrix. The 40 parameters include 12 sectoral shock variances, three industry group shock variances, one aggregate shock variance, 12 parameters representing sectoral responses to the industry group shocks, and 12 parameters giving sectoral responses to the aggregate shock.

Initial estimation yielded one negative estimated variance for an industry shock. This can happen when data are highly correlated.[11] The model was then reestimated with some insignificant response coefficients restricted to zero. This resolved the problem.

Table 2 presents the maximum likelihood estimates of the response coefficients and the variances of the shocks. All sectoral response coefficients to the aggregate shock are

[9] Long and Plosser (1987) reported only one common shock to growth rates of their thirteen industries. Our analysis did not appear overly sensitive to the specification of the number of aggregate shocks. We estimated the model allowing two common factors, but the model did not improve explanatory power, implying that a second factor is not necessary to parameterize the aggregate disturbances.

[10] Bollen (1989, Chapter 4) derives the maximum likelihood function and discusses in detail the estimation methods for the covariance structure.

[11] Krieger (1989) and Altonji and Ham (1990) also found negative variances for some shocks.

Table 2
Maximum likelihood estimates: response coefficients and variance of various shocks

Sector	Response coefficients			Variances	
	Sectoral shock	Aggregate shock	Industry group shock	Sector	Estimate
Mining					
Coal	1[a]	1[a]	−0.078 (7.96)	Coal	0.00149 (6.22)
Metal ore	1[a]	1.192 (4.47)[b]	0.071 (6.52)	Metal ore	0.00284 (8.61)
Nondurables					
Food	1[a]	0.816 (6.00)	0.155 (0.99)	Food	0.00039 (4.11)
Textiles	1[a]	0.646 (6.07)	0.088 (0.91)	Textiles	0.00024 (6.53)
Paper	1[a]	0.701 (3.90)	0.188 (1.48)	Paper	0.00200 (8.74)
Chemicals	1[a]	0.543 (5.44)	0[c]	Chemicals	0.00039 (10.05)
Durables					
Basic metals	1[a]	0.815 (6.22)	0[c]	Basic metals	0.00035 (8.81)
Fabricated metals	1[a]	1.119 (592)	0.064 (4.37)	Fabricated metals	0.00073 (6.88)
Electronics	1[a]	1.078 (4.35)	0.114 (4.78)	Electronics	0.00282 (7.60)
Precision instruments	1[a]	0.583 (3.61)	0.046 (2.70)	Precision instruments	0.00172 (10.05)
Transport equipment	1[a]	2.428 (5.53)	0.170 (7.75)	Transport equipment	0.00517 (6.98)
Other manufacturing	1[a]	1.116 (6.22)	0[c]	Other manufacturing	0.00066 (8.82)
				Aggregate	0.00039 (3.36)
				Mining	0.07450 (7.21)
				Nondurable	0.00214 (0.94)
				Durable	0.06329 (4.95)

[a] Response coefficients of the coal industry to the aggregate shock and all response coefficients to sector-specific shocks are normalized to one.
[b] Numbers in parentheses are t-values.
[c] Restricted to zero.

statistically significant. The uniformly positive coefficients imply that all sectors move procyclically with the aggregate shock. However, we will need to simulate the model to illustrate how the coefficients propagate shocks through the economy.

4. 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 variances 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 Eq. (1) is

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

where $\tilde{\pi}_k$ is the 12×12 matrix of restricted feedback coefficients at each lag, F is 12×1 vector with elements f_i, H is 12×3 matrix with elements h_i, and $r_{g,t}$ is 3×1 vector of industry group shocks. Assuming that the process in (14) is stationary, the moving average representation of the vector of sectoral output growth is

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

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

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

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

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

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 reports the contribution of the aggregate, industry group and sectoral shocks to the variance of sectoral output growth rates. The contemporaneous decompositions are presented first. The corresponding steady-state variance decompositions are reported in parentheses. Compar-

Table 3
Variance decompositions from a sectoral perspective

Sector	Fraction of variance explained by					
	Aggregate	Industry group			Sectoral	
		Mining	Nondurable	Durable	Own sector	All others
Mining						
Coal	20.60[a] (20.64)[b]	18.60 (15.99)	0.0 (0.11)	0.0 (1.37)	60.76 (48.70)	0.0 (13.19)
Metal ore	18.25 (16.35)	9.53 (9.93)	0.0 (0.08)	0.0 (1.31)	72.21 (65.99)	0.0 (6.34)
Nondurables						
Food	42.84 (43.91)	0.0 (0.03)	6.54 (6.06)	0.0 (0.37)	50.60 (45.83)	0.0 (3.80)
Textiles	45.08 (42.55)	0.0 (0.05)	3.52 (3.62)	0.0 (0.90)	51.39 (48.18)	0.0 (4.70)
Paper	10.68 (10.20)	0.0 (0.16)	3.25 (3.03)	0.0 (2.97)	86.06 (76.52)	0.0 (7.12)
Chemicals	27.45 (27.76)	0.0 (0.05)	0.0 (1.23)	0.0 (0.56)	72.54 (63.05)	0.0 (7.40)
Durables						
Basic metals	49.10 (44.08)	0.0 (0.07)	0.0 (0.43)	0.0 (0.69)	50.89 (48.41)	0.0 (6.32)
Fabricated metals	39.10 (35.44)	0.0 (0.23)	0.0 (0.64)	16.00 (15.35)	44.88 (38.08)	0.0 (10.26)
Electronics	13.88 (12.82)	0.0 (0.17)	0.0 (0.34)	19.44 (17.98)	66.66 (61.70)	0.0 (6.99)
Precision instruments	8.47 (13.18)	0.0 (4.19)	0.0 (0.12)	6.55 (5.59)	84.96 (52.66)	0.0 (24.26)
Transport equipment	29.84 (28.81)	0.0 (1.22)	0.0 (0.03)	18.38 (16.76)	51.77 (46.24)	0.0 (6.94)
Other manufacturing	48.94 (34.92)	0.0 (5.40)	0.0 (0.16)	0.0 (2.00)	51.50 (25.72)	0.0 (31.80)

[a] Instantaneous variance decompositions.
[b] Numbers in parentheses are steady-state variance decompositions.

ing these two measures gives some insight on how shocks are transmitted across sectors. The aggregate shock is transmitted across all sectors instantaneously. Own industry group-specific shocks are also propagated instantaneously to sectors within the group, but cross-sector and cross-group effects are transmitted with a one month lag.

The aggregate shock accounts for 18–21% of the instantaneous variance in sectoral output growth rates in the mining industries. The mining industry group-specific shock explains another 10–19% of the instantaneous variance in these industries. This leaves most of the instantaneous sector-specific variances in the mining group (61–72%) attributable to own sector shocks.

For nondurables, the aggregate shock accounts for 11–43% of the instantaneous variance of sectoral output growth rates. Sector-specific shocks account for 51–86% of the sectoral variance. The nondurable industry group shocks are not important. Qualitatively similar outcomes are found for durable manufacturing sectors. Aggregate shocks explain up to 49% of the contemporaneous variance in sectoral growth, but in all cases, the sector specific shock is more important than the aggregate shock. Consequently, own sector-specific shocks are the dominant source of innovations in contemporaneous sectoral growth rates.

When shocks are allowed to propagate across sectors and time, sector-specific shocks continue to play the dominant role in generating fluctuations in sectoral growth rates. Adding the own sector and other sector effects, sectoral disturbances account for at least 48% of steady-state variance in sectoral growth rates. In contrast, aggregate shocks explain at most 44% of the variance of sectoral growth. Aggregate shocks are not the dominant source of fluctuations in any sector of the Korean economy. In fact it is less important in the Korean economy than in most more developed economies. This result is surprising, given the presumption that small open economies would be more prone to aggregate shocks.

We can also assess the relative importance of shocks for industry groups and for the aggregate economy. To do this, we need to aggregate the sectoral growth rates to their industry group or aggregate economy levels. We approximate the aggregate growth rate as the weighted sum of sector growth rates, where the weights are the sector share of aggregate output. For example, let the period t growth rate of the mining industry group be designated $Y_{mt} = w_m Y_t$, where $w_m = [w_1^1, w_2^1, \ldots, 0]$ is 1×12 vector of industry share weights in the mining industry group. The share weights are reported in Appendix A. The innovation variance of Y_{mt}, $V(Y_{mt})$, can be decomposed according to

$$V(Y_{mt}) = w_m V(Y_t) w_m' \quad = \sigma_c^2 w_m F F' w_m' + w_m H \Omega_r H' w_m' + w_m \Omega_e w_m' \tag{18}$$

Similarly, we can compute innovation variances for nondurables, and durables and for the aggregate economy. The results are reported in Table 4.

Aggregate shocks are more important in explaining innovations in aggregated industries than in individual industries. Aggregate shocks account for 20% of the variation in output growth rates in the mining industry group, 54% in the nondurable manufacturing industry group, and 45% in the durable manufacturing industry group. The durable manufacturing group shock is relatively important, explaining 19% of the variance in durable growth rates. The rest of the industry groups are small. Sectoral shocks are quite important, particularly in mining where they represent nearly 71% of the total variance. Sectoral disturbances explain 41% of the nondurable manufacturing growth rate variance and 34% of the durable variance.

Table 4
Steady-state variance decompositions from industry groups and aggregate perspectives

	Fraction of variance explained by					
	Aggregate	Mining	Nondurables	Durables	Own sector	All others
Industry group						
Mining	19.66	7.27	0.08	1.43	68.96	2.60
Nondurables	54.43	0.04	3.91	0.73	39.69	1.20
Durables	45.30	1.88	0.18	18.67	22.85	11.12
Aggregate	57.91	1.33	0.54	12.76	27.46	

When we aggregate across all sectoral growth rates, aggregate shocks increase in relative importance. The aggregate shock accounts for 58% of the variance in aggregate growth rates. Industry group-specific shocks explain 15%, while sector-specific shocks account for 27% of the variance of aggregate output growth rates. This finding is qualitatively consistent with previous studies on more developed economies, again suggesting that aggregate shocks are no more important in Korea than in the largest economies.

Equally important are the findings in Tables 3 and 4 that aggregate disturbances have nonneutral effects on individual industries and industry groups. Aggregate shocks explain as little as one-tenth of the innovations in paper, but as much as 44% in food and basic metals. Consequently, national policies aimed at smoothing the business cycle would have nonneutral effects across sectors.

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 sectoral output are shown in Fig. 1. The graphs show percentage deviation in sectoral output from the baseline output level in absence of any shocks. Sectors respond quite rapidly to the aggregate disturbances—most of response is completed within 12 months. Mining industries are relatively sensitive to the aggregate shock, with both coal output and metal ore output rising around 3% over their base levels. In contrast, nondurable manufacturing sectors are hardly affected by the aggregate shock except for the textile industry where output rises a bit over 2%. Transportation equipment is by far the most sensitive sector to aggregate disturbances with output rising 6% over the base. Two other durable goods industries, electronics and other manufacturing, rose over 2%. The other durable sectors grew at or just below 2% after 24 months.

Data on trade by sector does not match up too closely to the data on sectoral output. Nevertheless, there does appear to be a relationship between international trade and exposure to aggregate shocks. Several of the sectors that are most sensitive to aggregate disturbances are also heavily engaged in international trade. Textiles, transportation equipment, electronics and other manufacturing all have ratios of exports relative to total production between 0.2 and 0.5. In contrast, paper, food, and chemicals had export to output ratios ranging from 0.04 to 0.13. Therefore, it may be that sectors which rely on domestic demand for their output are relatively insulated from aggregate disturbances. Lest we make too large a case for this, only 3% of mining output is exported but that mining lagged only transportation, electronics and other manufacturing in responsive to aggregate disturbances.

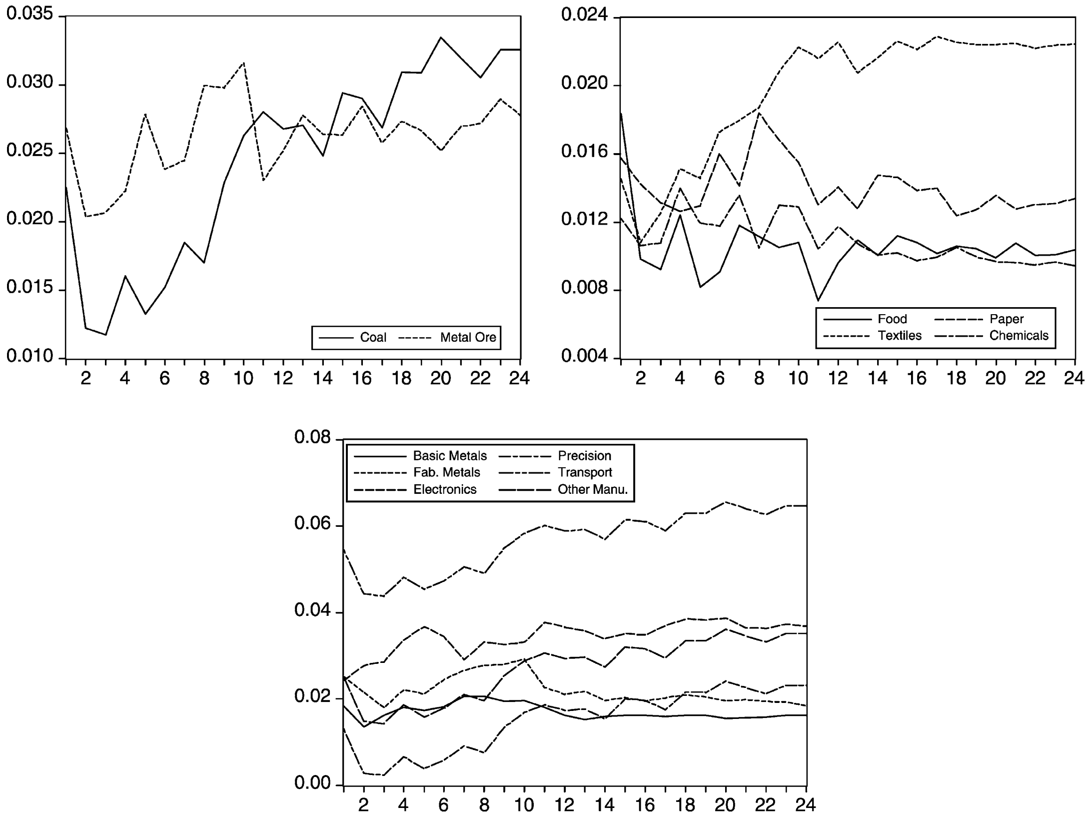

Fig. 1. Response of the logarithm of sectoral output to a one standard deviation innovation in aggregate output.

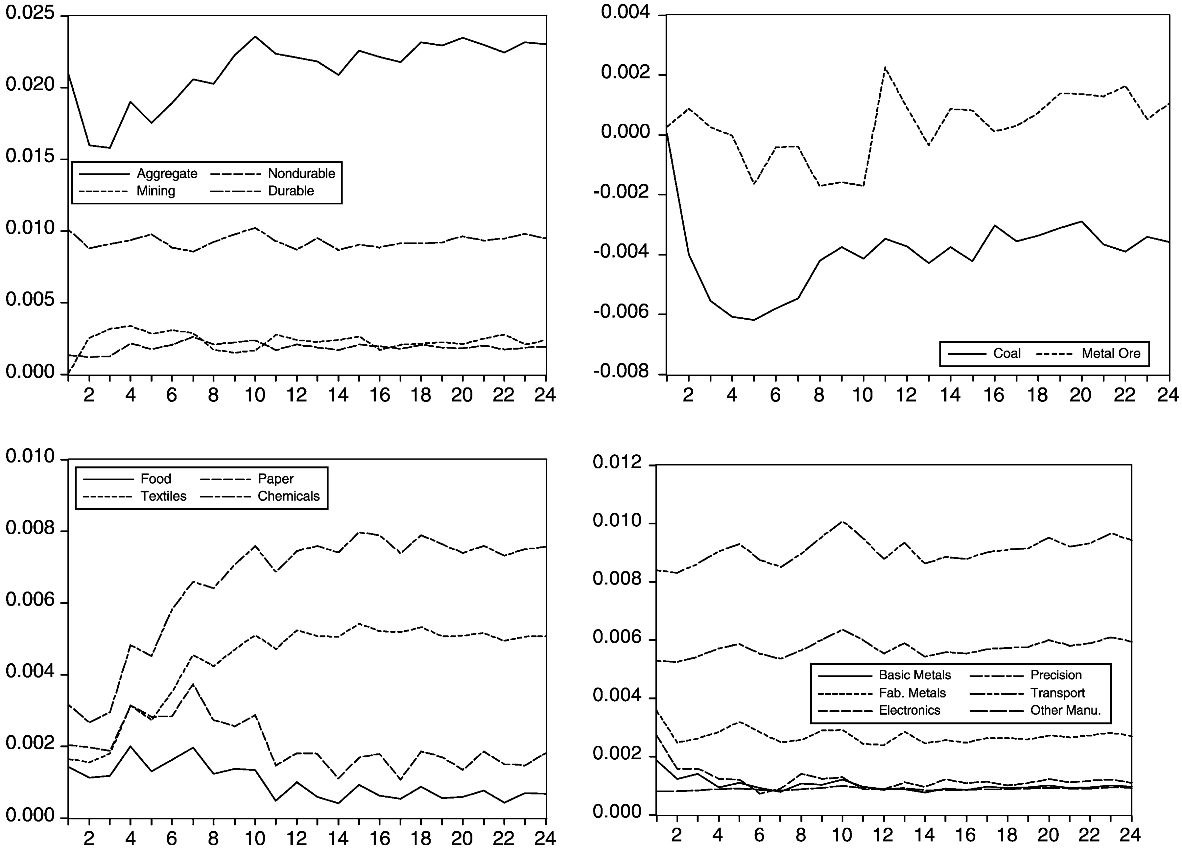

Fig. 2. Response of the logarithm of aggregate output to one standard deviation shocks to aggregate, industry group, and sectoral output.

One other finding from the impulse responses in Fig. 1 is worth emphasizing—the sectoral responses to an aggregate disturbance are completed within 12 months. In fact, the foreign currency crisis of 1997–1998 resulted in a recession that lasted four quarters. Such a rapid response to the large external fiscal crisis can be explained by the variance decompositions in Table 3—most of the sectoral growth rate is attributed to factors that are purely domestic—originating in the own sector or in other sectors of the economy. This relative importance of sectoral shocks, or alternatively, the relative unimportance of aggregate shocks, implies that the source of shocks is itself a stabilizing force in the Korean economy.[12]

Aggregate output is also not equally sensitive to all shocks. In Fig. 2, we find that group shocks in mining and nondurable manufacturing have virtually no impact on aggregate output. Looking at the individual sectors in mining and nondurable manufacturing, one standard deviation shocks to chemicals and textiles raise aggregate output by 0.5–0.7%. Aggregate output is more sensitive to shocks in durable goods. Transportation equipment has the biggest effect—nearly a 1% increase in aggregate output from a one standard deviation innovation in that sector. Precision instruments also has an impact of about 0.6%.

One might suspect that the relative importance of sectoral disturbances for aggregate output would be simply a matter of size. Indeed, chemicals, textiles, transportation equipment and precision instruments all have shares over 10%. However, basic metal and fabricated metal manufacturing have comparable shares but their shocks have very little effect on aggregate output.

5. Conclusions

One might have anticipated that a small open economy such as Korea would be more highly susceptible to aggregate disturbances than would be larger and more developed economies. However, the results reported herein suggest that aggregate disturbances explain only 58% 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. Consequently, Korea is no more prone to aggregate shocks than are the G-7 countries which have been studied previously.

The relative importance of sectoral shocks suggest that diversified small open economies such as those of South and East Asia can be self-stabilizing. To the extent that sectoral shocks are independent of one another, bad shocks in one part of the economy may be partially or fully offset by good draws elsewhere. Indeed, the very rapid response of the Korean economy to the foreign currency crisis of 1997–1998 would appear to be consistent with our finding that sectoral shocks have such a large role in the Korean economy.

We also find that aggregate disturbances have sharply differing effects across sectors. The nonneutral effects of aggregate disturbances across sectors would complicate national policies to smooth aggregate shocks. Of course, the very rapid sectoral output response to aggregate disturbances illustrated in Fig. 1 suggest that the economy may fully respond to the shock before a discretionary stabilizing policy can be implemented.

[12] Our finding of rapid response to aggregate disturbances was not driven by the foreign currency crisis. Virtually identical conclusions were derived when the time series was cut off before 1997.

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Appendix A. Data descriptions and sector weights

There are 12 monthly industrial production series from 1980:1 to 2000:9 which can be classified into three industry groups. There are two types of weights. One is the share of output in industry i within its industry group, w_i^g. The other is the share of aggregate output produced by industry I, w_i. Industry group weights sum to one within the group. Aggregate output weights sum to 0.950 across all sectors because the utilities sector is excluded from the analysis.

Sector	Description	w_i	w_i^g
Mining			
Coal	Coal mining	0.001	0.140
Metal ore	Other mining	0.005	0.860
			1.000
Nondurables			
Food	Food, beverages and tobacco	0.072	0.188
Textiles	Textiles, apparel and leather	0.106	0.278
Paper	Paper and paper products, printing and publishing	0.045	0.118
Chemicals	Chemicals and petroleum, rubber and plastic products	0.159	0.416
			1.000
Durables			
Basic metals	Primary metal and nonferrous	0.101	0.180
Fabricated metals	Fabricated metal products, machinery and equipment	1.33	0.236
Electronics	Semiconductors and electronic components	0.052	0.292
Precision instruments	Medical and telecommunication instruments	0.128	0.227
Transport equipment	Automobiles and trucks	0.117	0.208
Other manufacturing	Manufacturing not elsewhere classified	0.032	0.057
		0.950[a]	1.000

[a] Sector weights sum to 0.950 because of the exclusion of utilities from the analysis.

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