# The Inventory Cycle and Asia's Rebound

Economics & Markets Research

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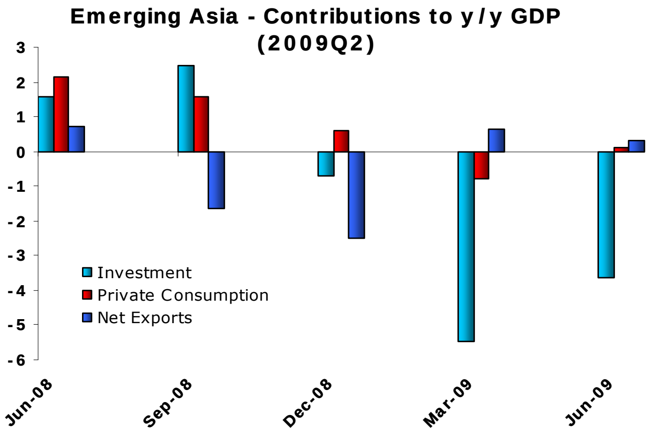
*The crisis that began in the United States first struck Asia through lower exports and then moved "on shore" via the interplay between the inventory-shipment ratio and industrial production (IP). In this paper we present our recent work in this area. We conclude that: (i) shipments are the main long-term driver of IP and (ii) IP tends to undershoot during downturns and overshoot during recoveries. Given the normalisation of inventory-shipment ratios and the ongoing weakness in foreign demand for Asia's exports, we see part of the recent boost in IP and its impact on growth as temporary. Absent any compensating factors, we therefore see downside pressure on IP, investment and GDP growth ahead.*


## Off-shore to On-shore: The Inventory Channel

**The initial shock to Asian growth from the financial crisis in the United States and much of Europe was sharply lower exports.** Through mid-2008, Asian economies remained largely unaffected by the financial crisis and the resulting recession in the United States. However, this changed dramatically with the intensification of the crisis following the collapse of Lehman Brothers in September 2008. As financial markets seized up and activity in the advanced markets began to fall sharply, demand for Asian exports fell rapidly. Indeed within a matter of months the year-on-year growth rate for exports across emerging Asia went from double-digit positive rates to double-digit negative rates. As we have noted elsewhere (see *The Anatomy of Emerging Asia's Export Slowdown*, December 2008), compared with the tech bust earlier this decade, the export downturn in the current crisis was quicker, deeper, and more broad-based. Northeast Asia's more export dependent economies (plus Singapore) were hit harder than those in Southeast Asia.




Sources: CEIC, ANZ Economics.

**However, the effects of the crisis subsequently broadened and investment has been the major contributor to Asian GDP growth in recent quarters.** It was originally thought that Asian economies would be able to at least partially decouple from the advanced countries. The reasoning was that domestic demand in this region was considered to have become more resilient owing to structural reforms, rising incomes and stronger exchange rates. However, this view was, with the wisdom of

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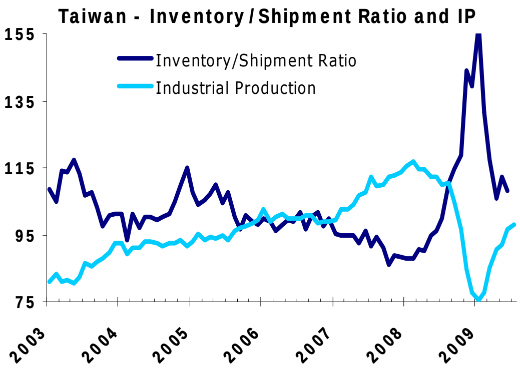
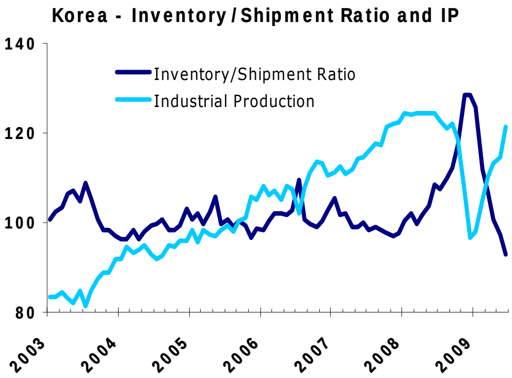
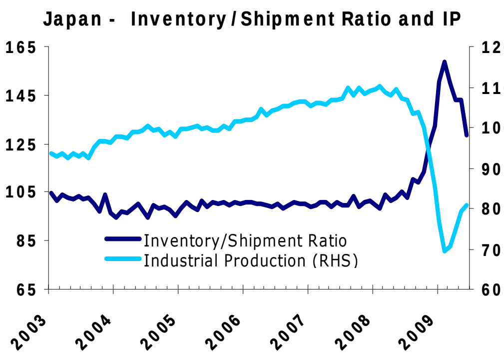
hindsight, too optimistic. Following the sharp decline in exports was a sizeable decline in investment (see chart), which has dominated growth in recent quarters.1 The effects of the crisis had therefore come "on shore."

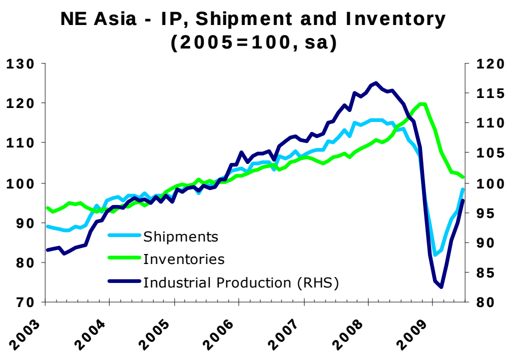
**A key driver of Asian investment has been the interplay between the inventory-shipment ratio and industrial production.** As demand for their products dried up in late 2008, Asian firms found themselves with too much inventory relative to shipments. Since holding inventory and producing goods are both costly, firms responded to the demand shock by slashing industrial production in order to rein in the surging inventory-shipment ratio. As a result, the levels for both of these indicators breached multi-year bands. Unfortunately, data to measure this process are not widely available across economies, so our sample size is limited to Japan, Korean and Taiwan. Despite the small sample size, the inventory-shipment management process is well established in these economies, which will allow us to measure and model the cycle.

**Industrial production growth has rebounded and inventory-shipment ratios across our sample have largely reverted to pre-crisis levels.** The data show that inventory-shipment ratios rose for several months following the onset of the crisis in Asia as shipments collapsed from both foreign and domestic sources.[2] However, the level shipments then bottomed and began rise off of a lower base at the same time that inventories were being run down. As a result, the inventory-shipment ratio began to decline. Industrial production then began to rise sharply in order to enable the return to an "equilibrium" inventory-shipment ratio. At the current juncture, this normalisation process appears largely complete in Korea and Taiwan, but is less advanced in Japan.




Sources: CEIC, ANZ Economics.

[1] These data exclude China, India and Vietnam, who do not publish national accounts on an expenditure based. China and Vietnam use a production basis; India uses factor costs.

[2] A breakdown between foreign and domestic shipments is only available in Korea, where the shares are roughly equal. We did not analyse this split in the current research project.

## Our Model: An Error Correction Framework

**In order to better understand this process, we specified an empirical model linking shipments, inventories and industrial production**. The dataset for each economy in our sample includes quarterly numbers for the indicators listed above, measured in log levels. The data span the period from the previous peak of the inventory-shipment ratio (reached earlier this decade) to the most recent peak in the latter part of 2008.[3] The analytical structure is an "error correction model" that seeks to estimate the long-run relationship between the variables in question as well as the short-run dynamics when the system is away from its equilibrium (long-run) values. Industrial production was the dependent variable (that is, the variable to be forecast) while inventories and shipments were the independent variables.

**Our "long-run" equation to measure the equilibrium of the system is the following** (details appear in the Appendix).

$$IP = constant + \beta_1 SHP + \beta_2 INV + error$$

where

IP = (logarithm of) industrial production

SHP = (logarithm of) shipments

INV = (logarithm of) inventories

$\beta_1$ and $\beta_2$ = coefficients to be estimated.

Namely, industrial production this period is a function of the observed level of shipments and the level of inventories. Our "prior" assumptions are that IP responds positively to increases in shipments (meaning that $\beta_1$ should be positive) and that it responds negatively to an increase in inventories (meaning that $\beta_2$ should be negative).

| Long-run coefficients | TWN | KOR | JPN |
|---|---|---|---|
| | | | |
| Shipments | 0.96 ** | 1.08 ** | 0.95 ** |
| Inventories | -0.17 | 0.00 | -0.11 |

** >95% significance level   * > 90% significance level

Sources: CEIC, ANZ Economics.

**Our long-run result is that changes in shipments, not inventories, are the main driver of IP levels**. Our regressions showed that the coefficient on the level of shipments is close to unity. This implies that, over the long run, any changes in shipments will drive a roughly equal change in industrial production. In contrast, the relation between the level of inventories and industrial production is much weaker. We found that for any given reduction (increase) in inventories, the long-run increase (decrease) in industrial production is much smaller. This result is intuitive since inventory levels are much smaller than shipments, and the ratio has declined owing to ongoing improvements in inventory management.

**We also (concurrently) estimated a short-run equation to measure the response of the system to shocks, which temporarily move the variables away from their long-run, equilibrium values.** Here, as opposed to the levels used in the long-run equation above, we look at the response of IP to changes in shipments, inventories and, for completeness, previous period's IP. Again, details appear in the Appendix.

[3] Various "information criteria" showed that regressions using this choice of this time period have the best fit with the least number of parameters.

| Short-run coefficients | TWN | KOR | JPN |
|---|---|---|---|
| | | | |
| Shipments | 0.55 ** | 1.19 ** | 1.00 ** |
| Inventories | -0.18 | 0.17 ** | 0.04 |

** >95% significance level   * > 90% significance level

Sources: CEIC, ANZ Economics.

**Our short-run result is that IP over-adjusts to temporary shocks by a factor as large as two**. In the present framework, a shock implies that shipments have been forecast incorrectly and are away from their equilibrium value given shipments and inventory. IP must therefore overcompensate for this "forecast error." Our coefficients on short-run industrial production's response to changes in shipments range from around ½ for Taiwan to greater than 1 for Korea and Japan (see table). When added to the fundamental or long-run coefficients, this implies that IP responds quite aggressively to out-of-equilibrium movements in shipments. In contrast, inventory coefficients are small and in two cases were statistically insignificant at the 90% level.

**Movements in IP affect investment and GDP growth**. As far as investment and growth are concerned, the implication is that the over-adjustment on the downside in IP in late 2008 and early 2009 exacerbated the slowdown in GDP, while the opposite has occurred in since. Thus, the over-adjustment of IP in recent quarters has contributed to the sharp recovery in GDP in many economies in the region.

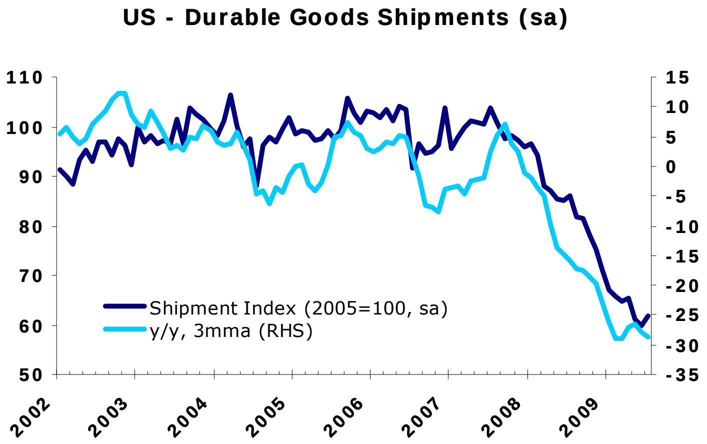
## Implications: IP burst and GDP growth to fade

**At present, with the short-run adjustment process (nearly) complete, industrial production and GDP growth should slow, all else constant**. Recent data suggest that the inventory-shipment ratio has returned to normal or equilibrium levels, meaning that the short-term adjustment process outlined above is largely complete. Absent other sources of new growth, this implies that the recent boost to activity from industrial production associated with the inventory-shipment management process will fade and that investment and GDP growth will fade as well. In our sample, this adjustment process seems complete in Taiwan and Korea (where there may have been some overshoot), although the adjustment in Japan still has some ways to go. Indeed, sequential IP growth in Korea and Taiwan has softened considerably of late. While other expenditure components such as consumption and domestic-led investment may pick up the slack, indicators remain mixed. Moreover, government spending plans with their heavy infrastructure components may underpin the slowdown in industrial production to the extent that these begin to roll off in the coming quarters.

**Going forward, a continued strong rise in IP growth will require an equally strong rise in shipments, which is not supported by the most recent indicators**. In terms of our model, the near-completion of the inventory-shipment adjustment means we are back in a long-run world. Therefore, industrial production, and hence investment and its contribution to GDP growth, will be driven largely by (expected) shipments. A key component to shipments—foreign demand—remains soft across much of Asia with both contemporaneous exports as well as export orders still weak. A good indicator of foreign demand facing Asia is durable consumption goods shipments in the United States. This indicator captures demand for the types of "discretionary" consumption goods that much of Northeast Asia produces and exports. The most recent data for US durable consumption goods shipments shows ongoing weakness into the second half of the year.[4] Durable goods consumption data found in the national accounts for Q2 (not shown) underscore this trend, albeit with a longer lag.[5]

[4] As to durable goods demand from domestic sources, the most recent consumer sentiment data for Korea show weak spending intentions for durable goods and tourism although overall consumer sentiment is relatively positive.

[5] Unfortunately for our analysis, the European Union does not produce comparable data on durable goods shipments and consumption. Our conjecture is that the story for consumption would be similar to what we see in the United States.




Sources: CEIC, ANZ Economics

**Overall, we continue to be wary of a V-shaped recovery in Asia**. Recent growth in emerging Asia has surprised on the upside, with a strong contribution from domestic demand, including industrial production and investment. Demand from outside the region has been weak and we expect it to remain so given the need for extensive household, bank and government balance sheet repair in the advanced countries. Our analysis has shown that part of the recent bounce in Asian economies relates to a short-term "over-adjustment" in industrial production related to managing the inventory-shipment ratio. Indeed, IP in the short-run may move by as much as twice the rate of the underlying movement in shipments. However, this adjustment process now appears largely complete, meaning that part of the recent impetus to growth from robust IP will fade going forward. Absent any offsetting new sources of growth in emerging Asia, IP, investment and GDP growth will be under downward pressure in the near term.

# Appendix

This Appendix provides a fuller explanation of the model presented in the main text; the actual regression results appear at the end.

## The Model

We begin with simple framework to model the long-run or equilibrium relationship between industrial output, shipment and inventory. We do this in terms of logarithms so that the coefficients have the usual interpretation of elasticities.

$$IP = constant + \beta_1\ SHP + \beta_2\ INV + error$$

where

IP = (logarithm of) industrial production

SHP = (logarithm of) shipments

INV = (logarithm of) inventories

$\beta_1$ and $\beta_2$ = coefficients to be estimated.

Firms anticipating an increase in shipments would likely raise industrial production. Shipments and IP should be correlated in the long-run, with a coefficient close to one, and are likely to be co-integrated. If inventories are above target levels, firms are expected to correct the imbalance by lowering output to rundown inventories.

However, for the current study we are interested in the short-run response when key variables have been shocked and the resulting paths for these variables are out of equilibrium. We therefore need to introduce short-term dynamics, which is most naturally done using an error correction framework.

In the short-run, industrial production would adjust, through an error correction model, to fluctuations in shipment and inventory levels. We estimated a dynamic error correction model for industrial production, which incorporates the long-run relationship and short-run dynamics in a single equation.

$$\Delta IP_t = \lambda(IP_{t-1} - c - \alpha_1 SHP_{t-1} - \alpha_2 INV_{t-1}) + \beta_1 \Delta IP_{t-1} + \beta_2 \Delta SHP_t + \beta_3 \Delta INV_t + v_t$$

where Δ means the change from the previous period and v is an error term. The long-run, equilibrium equation is in parentheses and the short-run terms have the "deltas."

Rather than adopt a general form with an ex-ante unspecified number of lags for the short-term variables, we restrict the lags to one period. This: (i) reflects an assumption about the efficiency of the inventory management process in Northeast Asia; (ii) allows for easier interpretation of the regression results and (iii) preserves precious degrees of freedom since our data size is limited. On the last of these, data are quarterly and the sample period is chosen to include an entire cycle. The actual dates are 2001 Q4 to 2008 Q3 (for Japan the start date is 2003 Q3 owing to data availability).[6]

## Results

For clarity of exposition we will report the long-run and short-run results separately even though they were derived jointing when estimating the error correction equation above

[6] We experimented with several start and end dates for the sample, including peak to peak, trough to trough and excluding crisis periods. The final sample period was the one with the best ranking in terms of the standard "information criteria."

The long-run results conformed to our priors. For all three counties in our sample the coefficient on shipment was close to one (and correctly signed), meaning that in equilibrium changes in shipment translate nearly one-to-one into changes in industrial production. Moreover, the shipment variables were all highly significant. In contrast, the coefficients on inventory were not significant and several orders of magnitude smaller than shipments. Our interpretation, therefore, is that in the long-run or equilibrium, industrial production is almost exclusively driven by shipments.

| Long-run coefficients | TWN | KOR | JPN |
|---|---|---|---|
| | | | |
| Shipments | 0.96 ** | 1.08 ** | 0.95 ** |
| Inventories | -0.17 | 0.00 | -0.11 |

** >95% significance level * > 90% significance level

Sources: CEIC, ANZ Economics.

In the short run shipments again was the more important independent variable. For all three countries the coefficient on shipments was correctly signed and highly significant. For Taiwan the coefficient was just over one-half and for Japan and Korea it was greater than or equal to unity. The coefficients on inventories were again substantially lower than for shipments and in the cases of Taiwan and Japan inventories were statistically insignificant. For Korea, however, short run movements in inventories are significant (and positive), but in terms of size have one-seventh the effect of shipments.

| Short-run coefficients | TWN | KOR | JPN |
|---|---|---|---|
| | | | |
| Shipments | 0.55 ** | 1.19 ** | 1.00 ** |
| Inventories | -0.18 | 0.17 ** | 0.04 |

** >95% significance level * > 90% significance level

Sources: CEIC, ANZ Economics.

In terms of estimating activity, these short-run coefficients should be added to the long-run coefficient when the system is out of equilibrium. The implication is that, in response to a shock to shipment, IP will adjust by over 1½ times the initial shock in Taiwan and by at least twice the initial shock in Japan and Korea. This "over-adjustment" accords with the steep drop in IP in the crisis intensified in late 2008 and with the steep recovery in IP in recent quarters. It also implies that as the system moves back to equilibrium, the rate of IP growth should fall by up to one-half for any given level of shipments growth.

**Taiwan**
Dependent Variable: DLOG(IP)
Sample: 2001Q4 2008Q3

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.737 | 0.287 | 2.569 | 0.018 |
| LOG(IP(-1)) | -0.772 | 0.205 | -3.770 | 0.001 |
| LOG(SHP(-1)) | 0.743 | 0.194 | 3.820 | 0.001 |
| LOG(INV(-1)) | -0.129 | 0.083 | -1.553 | 0.136 |
| DLOG(IP(-1)) | 0.159 | 0.140 | 1.134 | 0.270 |
| DLOG(SHP) | 0.548 | 0.102 | 5.350 | 0.000 |
| DLOG(INV) | -0.180 | 0.109 | -1.661 | 0.112 |

| | | | |
|---|---|---|---|
| R-squared | 0.774 | Mean dependent var | 0.015 |
| Adjusted R-squared | 0.709 | S.D. dependent var | 0.023 |
| S.E. of regression | 0.013 | Akaike info criterion | -5.706 |
| Sum squared resid | 0.003 | Schwarz criterion | -5.373 |
| Log likelihood | 86.885 | Hannan-Quinn criter. | -5.604 |
| F-statistic | 11.968 | Durbin-Watson stat | 1.968 |
| Prob(F-statistic) | 0.000 | | |

**Korea**
Dependent Variable: DLOG(IP)
Sample: 2001Q4 2008Q3

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | -0.304 | 0.078 | -3.901 | 0.001 |
| LOG(IP(-1)) | -0.825 | 0.174 | -4.744 | 0.000 |
| LOG(SHP(-1)) | 0.890 | 0.185 | 4.813 | 0.000 |
| LOG(INV(-1)) | -0.002 | 0.035 | -0.047 | 0.963 |
| DLOG(IP(-1)) | 0.044 | 0.050 | 0.883 | 0.387 |
| DLOG(SHP) | 1.187 | 0.055 | 21.676 | 0.000 |
| DLOG(INV) | 0.173 | 0.064 | 2.701 | 0.013 |

| | | | |
|---|---|---|---|
| R-squared | 0.969 | Mean dependent var | 0.017 |
| Adjusted R-squared | 0.960 | S.D. dependent var | 0.020 |
| S.E. of regression | 0.004 | Akaike info criterion | -8.020 |
| Sum squared resid | 0.000 | Schwarz criterion | -7.687 |
| Log likelihood | 119.279 | Hannan-Quinn criter. | -7.918 |
| F-statistic | 109.931 | Durbin-Watson stat | 2.061 |
| Prob(F-statistic) | 0.000 | | |

**Japan**
Dependent Variable: DLOG(IP)
Sample (adjusted): 2003Q3 2008Q3

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 0.629 | 0.278 | 2.264 | 0.040 |
| LOG(IP(-1)) | -0.848 | 0.234 | -3.620 | 0.003 |
| LOG(SHP(-1)) | 0.808 | 0.225 | 3.600 | 0.003 |
| LOG(INV(-1)) | -0.096 | 0.063 | -1.540 | 0.146 |
| DLOG(IP(-1)) | -0.054 | 0.115 | -0.469 | 0.646 |
| DLOG(SHP) | 0.996 | 0.087 | 11.409 | 0.000 |
| DLOG(INV) | 0.043 | 0.091 | 0.474 | 0.643 |

| | | | |
|---|---|---|---|
| R-squared | 0.949 | Mean dependent var | 0.006 |
| Adjusted R-squared | 0.927 | S.D. dependent var | 0.014 |
| S.E. of regression | 0.004 | Akaike info criterion | -8.097 |
| Sum squared resid | 0.000 | Schwarz criterion | -7.749 |
| Log likelihood | 92.020 | Hannan-Quinn criter. | -8.022 |
| F-statistic | 43.101 | Durbin-Watson stat | 1.978 |
| Prob(F-statistic) | 0.000 | | |

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