

Do Wild Fluctuations in Quarterly Inventory Investment Data Matter?:

A Study of Japanese GDP Statistics, 1994-2010 (2)

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[7]. Investigation of Corporate Inventory Investment Behavior, Focusing on the Lehman Shock Period: By Commodity

[7-1]. Introduction

In Sections [7]~[9], I investigate corporate inventory investment behavior, focusing on the consequences of an exogenous shock, realization of unexpected situation to most firms during the period called “the Lehman Shock” and its adjustment process.

As shown in previous sections, inventory investment estimates in the Japanese quarterly GDP statistics reveal wild and regular seasonal fluctuations. Keeping this observation in mind, in Sections [7]~[9] I use this quarterly GDP inventory investment statistics, which do not influence greatly the conclusions. For example, 2008Q4 expected to be the peak of the inventory accumulation process due to unexpected sales decrease after the Lehman Shock would be emphasized by it because it is the 4th quarter.

In this study I use the quarterly GDP inventory investment statistics both by inventory category and by commodity, and in the following sections I actively use the latter side. The conclusions drawn in previous sections basically hold when investigated by commodity, which I briefly mention below.

Inventory investment by industry

Recall the figures in [4-2] on the quarterly inventory investment of the all industries in 2003~2010 both on total inventory and inventory by category, and focus on the Lehman Shock period, particularly on 2008Q4 and 2009Q1. Also recall the corresponding figures in Section [5] shown by each quarter.

Note four points from figures in [4-2]. Particularly points (1) and (3) can be more clearly confirmed with figures in [5] by each quarter. I find either little accumulation of inventory stock expected as a consequence of unexpected exogenous shock or the subsequent inventory adjustment process.

- (1) The inventory investment in 2008Q4 recorded a large positive value, whose size however reached slightly more than that of previous 2nd or 4th quarters.
- (2) As viewed by category, goods-in-process- and product inventory investment in 2008Q4 were slightly smaller than the previous quarters. The distribution inventory investment notably increased in 2008Q4 than in the previous 4th quarters, which was the dominant factor of total inventory investment increase. The raw material inventory investment, almost always nearly 0, recorded a positive value, as well.
- (3) The volume of inventory investment in the following 2009Q1 recorded a huge negative value, which however was slightly below the level of previous 1st quarters. The absolute value of (the 2008Q4 inventory investment volume) – (its average in previous 4th quarter values) is smaller than the absolute value of (the 2008Q4 inventory investment volume) – (its average in previous 1st quarter values). This observation suggests that, if the former is the inventory accumulation as a consequence of unexpected shock, its resolution was completed within the next quarter.
- (4) The large negative value of goods-in-process inventory investment in the 2009Q1 overwhelmed the corresponding negative values of other categories, the absolute value of which did not exceed the average value of the previous 1st quarters. The same applies also to the distribution inventory investment. The product inventory investment recorded a slightly larger negative value, and the raw material inventory investment nearly 0.

Inventory investment by commodity: eight commodities

In this study I use quarterly GDP inventory investment estimates in four inventory categories and in ninety one commodities, which are obtained as intermediate products on the process of estimating the final aggregate data. The number of commodities whose inventory investment was not always 0 was fifty nine, and it is impractical to study inventory investment by commodity in all individual commodities.

In Sections [7] and [8], I focus on eight commodities: automobile, electric device and electric machine (hereafter, electric-machine), special-purpose machine (special machinery), general-purpose machine (general machinery), non-ferrous metal refining and manufacturing (non-ferrous metal product), steel product, petroleum product, apparels and personal belongings (apparel). I chose eight commodities from those with large weight in all industries total inventory investment, particularly with large

weight during the Lehman Shock period, with sufficient attention given to diversity and balance.

I place a special focus on 2008Q4 and 2009Q1. In the former all industries total inventory investment volume was slightly larger in absolute value than the 4th quarter average, and the latter than the 1st quarter average, too. From among commodities with large weight in all industries total inventory investment during these quarters, I choose four durables (automobile, electric-machine, special machinery, and general machinery, of which automobile is consumer durable, special and general machinery are industrial durable, and electric-machine includes both), three industrial materials and fuel (non-ferrous metal product, steel product, and petroleum product) and one non-durable (apparel), in total eight commodities.

Position of eight commodities and the structure by category of inventory investment

Table 6 exhibits the total inventory investment of individual commodities and all industries first in the values (unit: billion yen) and share by category to the total value, for 2008Q4 and 2009Q1 respectively. In several cases the share by category was negative.

For example, in special and general machinery which are industrial durables shares of goods-in-process inventory investment were high, and particularly in 2009Q1 when inventory investment drastically decreased its shares were overwhelming (72.2% and 98.2%). In contrast, in apparel (consumer non-durable) the share of distribution inventory investment was predominant (109.9% and 82.9%).

The next Table 7, for total-, goods-in-process-, and distribution inventory investment, exhibits the

Table 6 Position of eight commodities and the structure by category of inventory investment: 2008Q4 and 2009Q1
(unit: billion yen (value) and %)

	2008Q4					2009Q1				
	rtotal (value)	share to rttotal (%)				rtotal (value)	share to rttotal (%)			
		rfinal	rprocess	rdistribution	rrow		rfinal	rprocess	rdistribution	rrow
apparel	48.7	25.1	-5.3	109.9	-29.4	-213.5	7.8	5.2	82.9	4.1
petroleum	435.1	-26.7	-5.4	30.2	101.9	402.8	4.1	2.1	44.7	49.1
steel	54.0	-139.6	46.7	55.4	137.6	-221.6	62.5	16.3	8.0	13.2
non-ferrous metal	189.6	-5.1	21.7	25.3	58.2	74.6	23.7	-23.9	93.2	6.8
general machinery	94.5	41.8	48.9	9.2	0.0	-176.9	14.9	72.2	12.9	0.0
special machinery	207.8	35.9	51.7	12.4	0.0	-197.3	-16.4	98.2	18.2	0.0
electric-machine	555.9	12.7	26.1	61.2	0.0	-1292.8	18.6	50.6	30.7	0.0
automobile	553.2	2.3	32.4	65.2	0.0	-837.1	42.0	30.1	27.8	0.0
all inudstries	3,215.9	1.1	22.6	50.0	26.4	-4,278.1	23.4	55.6	22.6	-1.5

Table 7 Share of rprocess and rdistribution among eight commodities: 2008Q4 and 2009Q1

(unit: billion yen (value) and %)

		8 commodities' share in all industries	apparel	petroleum	steel	non-ferrous metal	general machinery	special machinery	electric machine	automobile	total
rtotal	2008Q4	100.0	1.5	13.5	1.7	5.9	2.9	6.5	17.3	17.2	66.5
	2009Q1	100.0	5.0	-9.4	5.2	-1.7	4.1	4.6	30.2	19.6	57.5
rprocess	2008Q4	22.6	-0.4	-3.3	3.5	5.7	6.4	14.8	20.0	24.7	71.4
	2009Q1	55.6	0.5	-0.4	1.5	0.7	5.4	8.1	27.5	10.6	54.0
rdistribution	2008Q4	50.0	3.3	8.2	1.9	3.0	0.5	1.6	21.2	22.5	62.1
	2009Q1	22.6	18.3	-18.6	1.8	-7.2	2.4	3.7	41.1	24.1	65.6

share (%) of each commodity and their sum total to the all industries inventory investment value in two focused quarters, respectively. In all cases, the sum total of eight commodity's shares exceeded 50%. The shares of electric-machine and automobile were remarkably high.

The 2nd and 3rd columns show the share of goods-in-process- and distribution inventory investment to the total inventory investment. The share of the former in 2008Q4 was 22.6%, and in 2009Q1 55.6%.

[7-2]. Automobile and Electric-machine

In sections [7-2]~[7-5] I study the inventory investment in eight commodities by commodity and by inventory category in the order corresponding to automobile and electronic-machine ([7-2]), special machinery and general machinery ([7-3]), non-ferrous metal-, steel-, and petroleum product ([7-4]), and apparel ([7-5]).

As shown below, both the composition ratio (shares) by category and fluctuation patterns of inventory investment varies a great deal depending on commodity. It is hard to select commodities that typically represent inventory investment composition and its fluctuation pattern, and my selection may not be exempt from blame that it is leading to an oversimplification. In any case, as a result both of the large shares in all industries inventory investment and of their wild fluctuations, four commodities I study in [7-2] and [7-3] represent and move in tandem with the all industries inventory investment behavior and fluctuation patterns we studied in previous sections.

[7-2-1]. Automobile

Quarterly inventory investment

Four figures exhibit the quarterly inventory investment in automobile (unit: billion yen), in total and by category, 2003~2010. The first figure exhibits the total and all four categories, then, three figures each for rfinal, rprocess, and rdistribution with rtotal, omitting rraw which is consistently 0.

All three categories move in tandem with the total inventory investment. Over the whole period, the influence of goods-in-process inventory was the largest, but for the period after the Lehman Shock that of distribution inventory became overwhelming. The distribution inventory investment consistently reported a positive value from 2007 to the 2008Q4, and then recorded a negative value for six quarters since 2009Q1 and a big positive value in 2010Q3.

Figure 22a Inventory Investment: automobile rtotal and by category, 2003~2010, quarterly

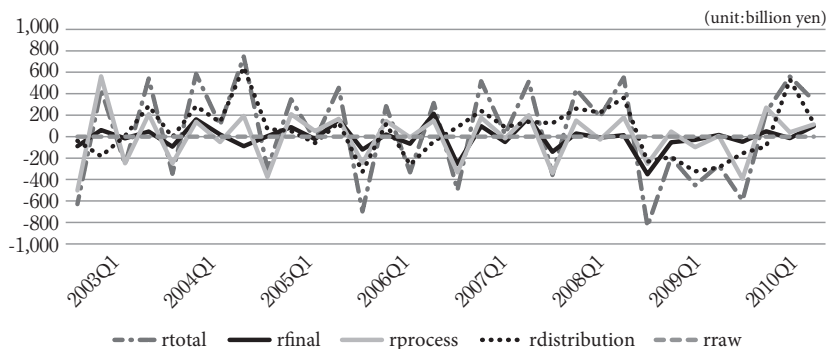
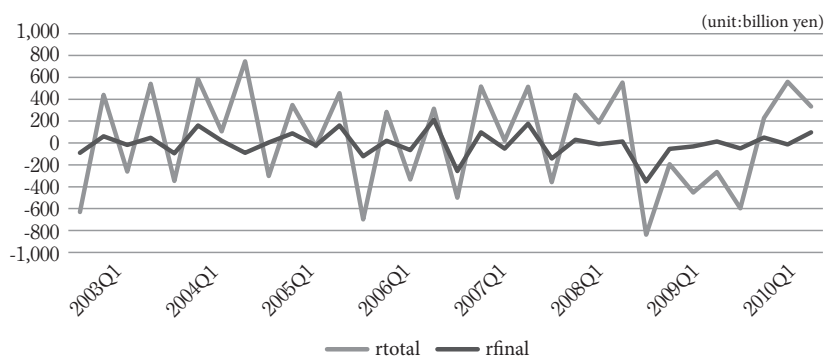
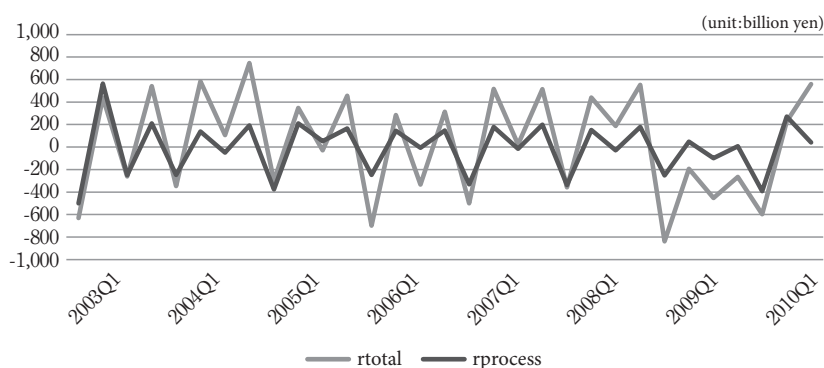
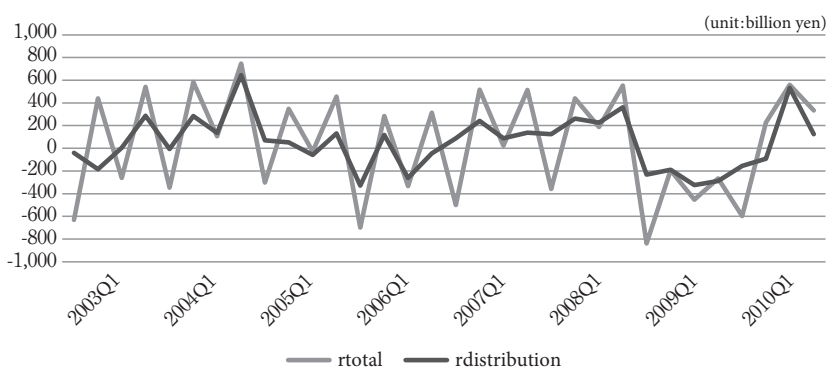
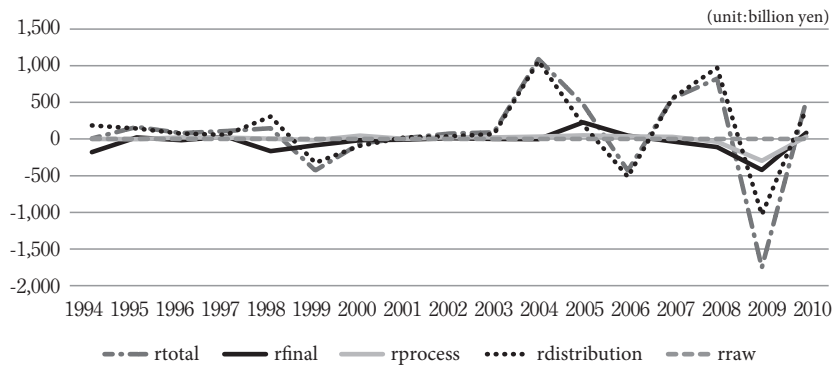
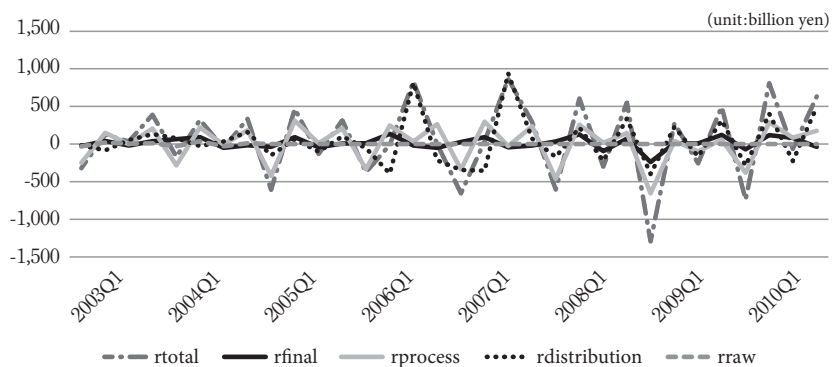
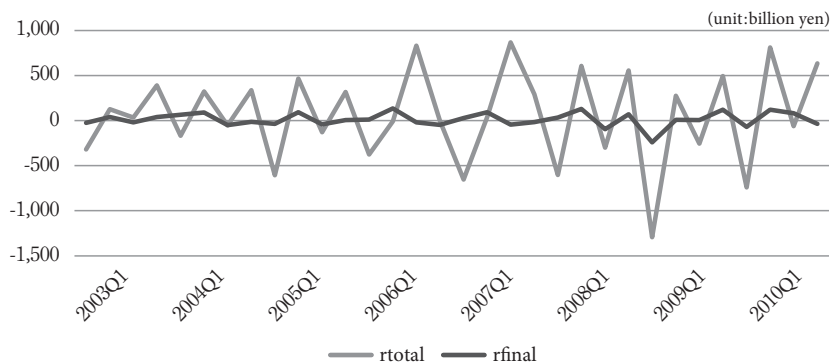


Figure 22b Inventory Investment: automobile rtotal vs. rfinal, 2003~2010, quarterly**Figure 22c** Inventory Investment: automobile rtotal vs. rprocess, 2003~2010, quarterly**Figure 22d** Inventory Investment: automobile rtotal vs. rdistribution, 2003~2010, quarterly

Annual inventory investment: 1994~2010

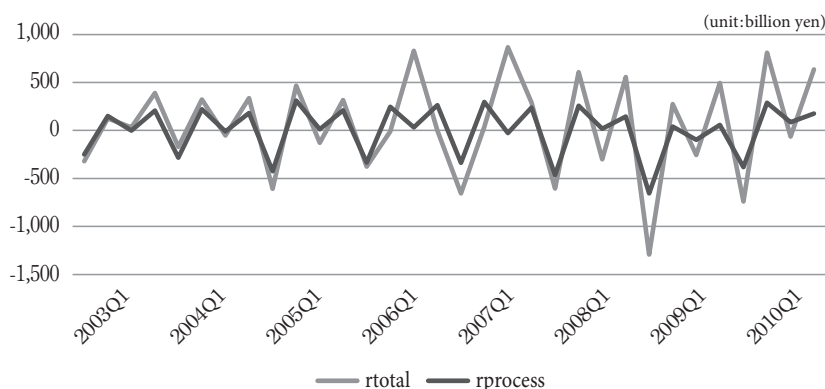
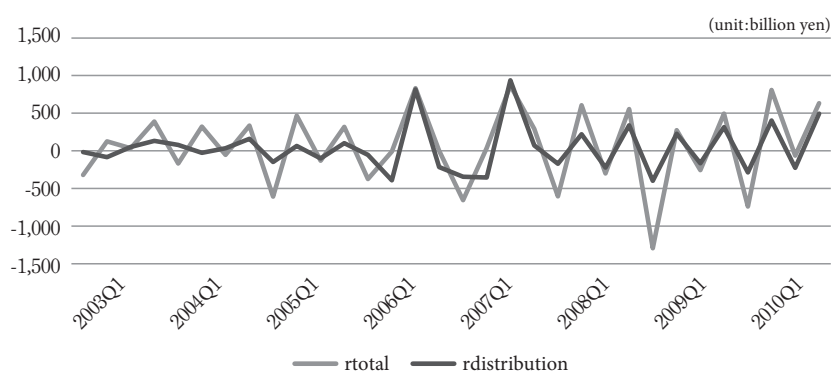
In annual automobile inventory investment estimates, 1994~2010, the influence of distribution inventory was overwhelming over the entire period. In contrast, that of the goods-in-process inventory, in quarterly estimates more than comparable to the distribution inventory, became dramatically small.

Both in quarterly- and annual estimates the influence of product inventory investment was extremely low-profile.

Figure 23 Inventory Investment: automobile rtotal and by category, 1994~2010, annual**Figure 24a** Inventory Investment: electric-machine rtotal and by category, 2003~2010, quarterly**Figure 24b** Inventory Investment: electric-machine rtotal vs. rfinal, 2003~2010, quarterly**[7-2-2]. Electric-machine**Quarterly inventory investment

Also in electric-machine rraw was almost always 0 (although before 2003 it was not exactly 0).

Both in quarterly- and annual estimates, the fluctuation pattern of electric-machine inventory investment in many aspects are similar to that of automobile. In quarterly estimates all three categories

Figure 24c Inventory Investment: electric-machine rtotal vs. rprocess, 2003~2010, quarterly**Figure 24d** Inventory Investment: electric-machine rtotal vs. rdistribution, 2003~2010, quarterly

move in tandem with the total inventory investment. Over the whole period, the influence of goods-in-process inventory was the largest, but after 2006, 2006~2007 in particular, that of the distribution inventory became overwhelming.

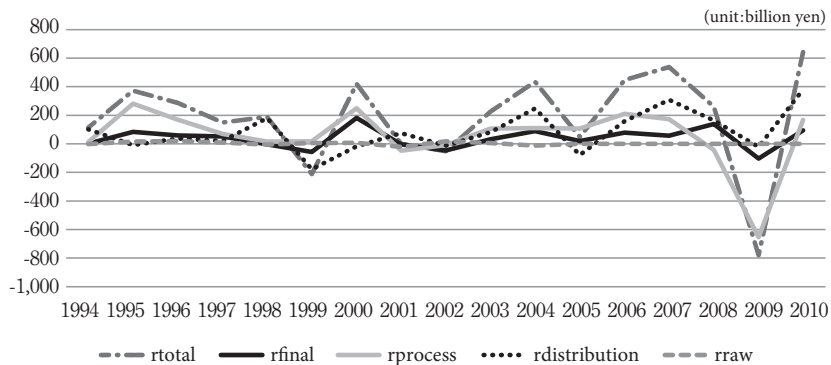
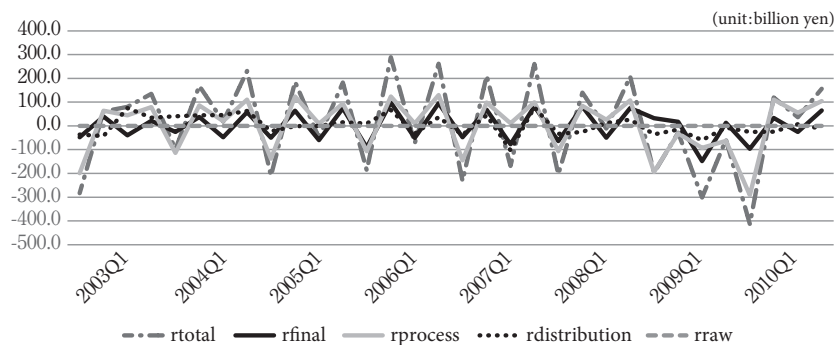
Unlike the case of automobile, nowhere we find the distribution inventory investment recorded either a positive or negative value continuously over a year. We find no noticeable change in its fluctuation pattern before and after the Lehman Shock.

Rfinal consistently fluctuated little.

Annual inventory investment: 1994~2010

The influence of rprocess on rtotal, which was big in quarterly estimates, was big also in annual electric-machine inventory investment estimates. The drastic decline in 2009 (big negative value) is particularly noteworthy. The influence of rdistribution, whose influence was as big as rprocess in quarterly estimates, was also big in annual estimates.

The content of “electric-machine” changes radically and rapidly. Partly for this reason, no clear explanation is available for the dramatic decline in electric-machine rprocess in 2009. My guess is that the contribution of the decrease in values due to fair value adjustments of goods-in-process inventory stock was dominant. As shown above, both rtotal and rprocess recorded a big negative value in 2009Q1.

Figure 25 Inventory Investment: electric-machine rtotal and by category, 1994~2010, annual**Figure 26a** Inventory Investment: special machinery rttotal and by category, 2003~2010, quarterly

[7-3]. Special machinery and general machinery

For two reasons, I include special machinery and general machinery, both for industrial equipment, in eight commodities. First, in all industries quarterly estimates the rprocess fluctuation dominates the rttotal fluctuation, but in annual estimates its influence almost disappears. For investigating the details of rprocess, I choose them as representatives of commodities with a big share in all industries rprocess. Second, during the dramatic collapse in overall economic activity after the Lehman Shock, deteriorating the economic prospect, the demand for equipment investment goods rapidly decreased. Supposing this influence most prominently, I choose them as representatives of equipment investment related commodities.

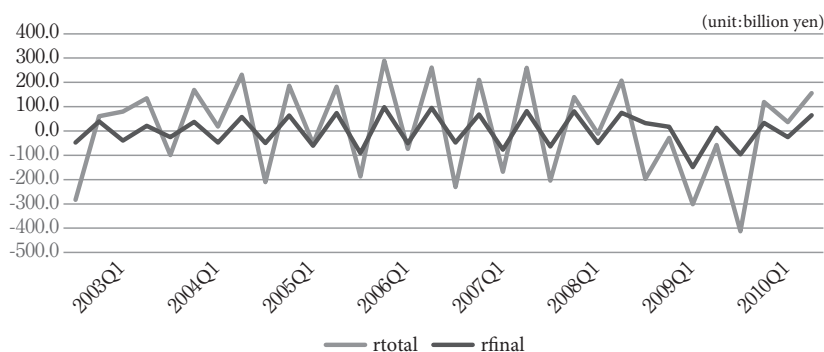
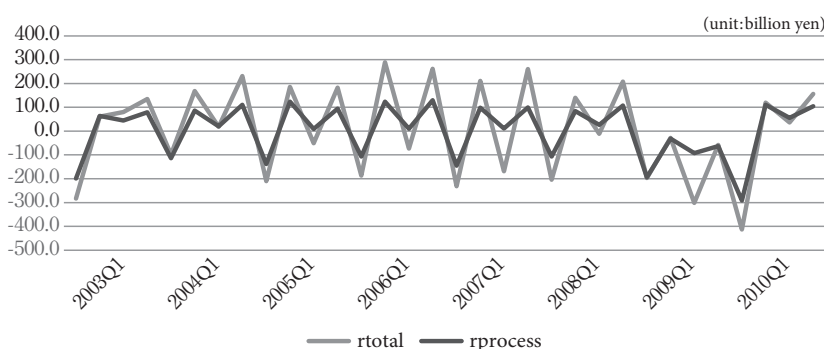
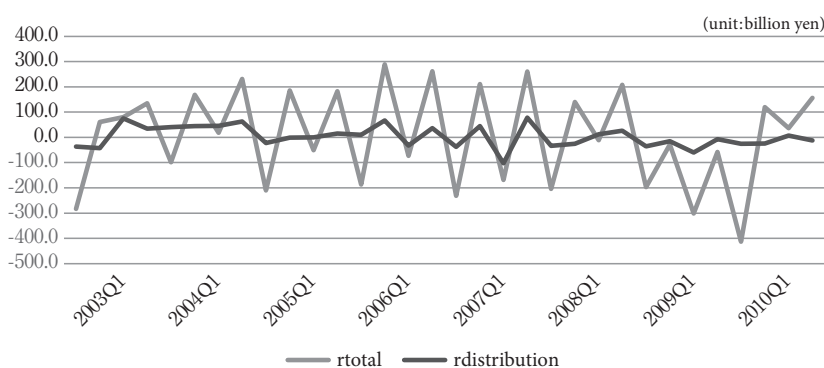
They share many characteristics each other. General machinery records a drastic decline in inventory investment around 2000, which is not found in special machinery, however.

[7-3-1]. Special machinery

Quarterly inventory investment

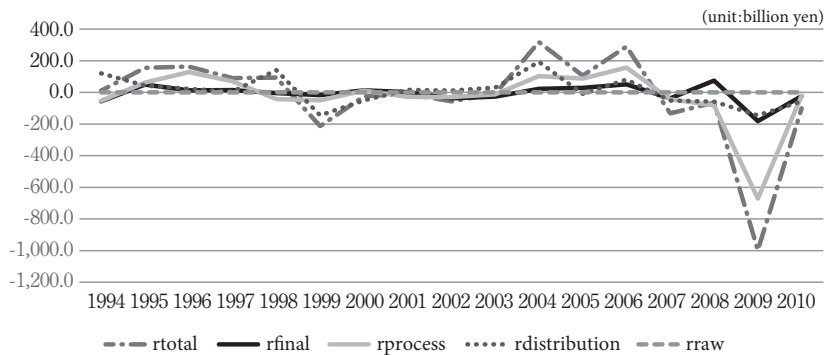
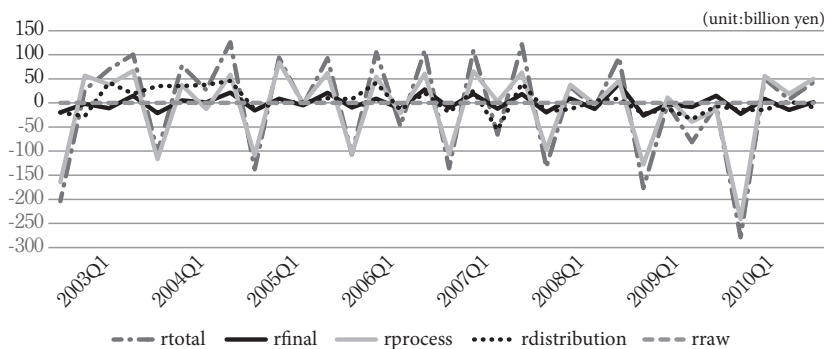
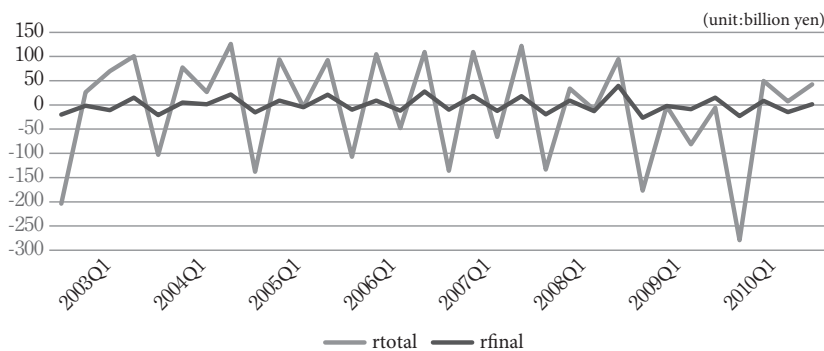
Quarterly rraw was consistently 0 also in special machinery.

The share of rprocess to rttotal was consistently overwhelming. Although the share was small, the rfinal moved in tandem with rttotal. For five quarters running since 2009Q1 rttotal and rprocess recorded big negative values. The share of rdistribution was consistently small.

Figure 26b Inventory Investment: special machinery rtotal vs. rfinal, 2003~2010, quarterly**Figure 26c** Inventory Investment: special machinery rtotal vs. rprocess, 2003~2010, quarterly**Figure 26d** Inventory Investment: special machinery rtotal vs. rdistribution, 2003~2010, quarterly

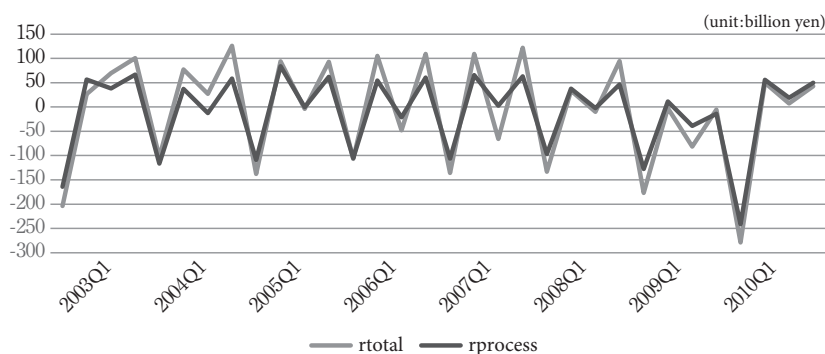
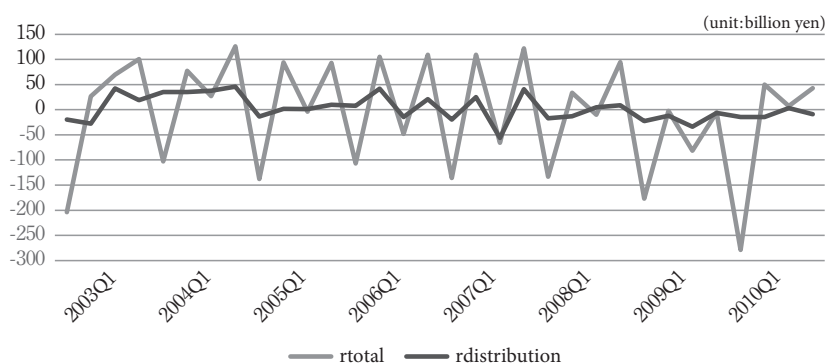
Annual inventory investment: 1994~2010

The influence of rprocess on rttotal, which was overwhelming in quarterly estimates, was remarkably smaller in annual special machinery inventory investment estimates. In contrast, rdistribution, whose share was extremely small in quarterly estimates, increased the share in annual estimates. Nonetheless, in dramatic rttotal decline in 2009, the share of rprocess was dominant.

Figure 27 Inventory Investment: special machinery rtotal and by category, 1994~2010, annual**Figure 28a** Inventory Investment: general machinery rtotal and by category, 2003~2010, quarterly**Figure 28b** Inventory Investment: general machinery rtotal vs. rfinal, 2003~2010, quarterly**[7-3-2]. General machinery**Quarterly inventory investment

As in special machinery, quarterly rraw was consistently 0 also in general machinery.

Also like special machinery, the share of rprocess to rtotal in general machinery was consistently overwhelming, and, although the share was small, the rfinal moved in tandem with rtotal. Also like special machinery, for five quarters running since 2009Q1 rtotal recorded big negative values, and rprocess moved similarly. The preceding 2008Q4 did not report a positive value larger than the average of previ-

Figure 28c Inventory Investment: general machinery rtotal vs. rprocess, 2003~2010, quarterly**Figure 28d** Inventory Investment: general machinery rtotal vs. rdistribution, 2003~2010, quarterly

ous 4th quarter values. Again like special machinery, the share of rdistribution was consistently small.

Here also we observe in rtotal and rprocess clearly regular seasonal fluctuations, particularly sharp decline in the 1st quarter. Though the size much smaller, we observe similar seasonal fluctuations in rfina.

Annual inventory investment: 1994~2010

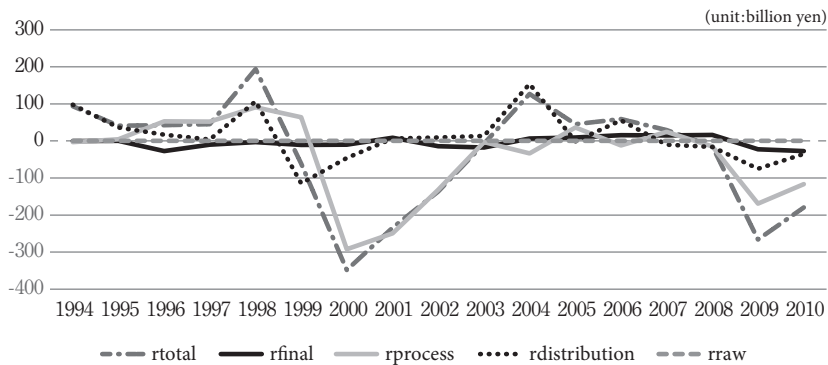
With the exception of years around 2000 and 2009, the influence of rprocess on rtotal, which was overwhelming in quarterly estimates, was remarkably small in annual general machinery inventory investment estimates. In contrast, rdistribution, whose share was extremely small in quarterly estimates, increased the share in annual estimates.

In years around 2000 and 2009 when rtotal recorded extremely big negative values, the share of rprocess was overwhelming. In 1998 and 2004 when rtotal increased (though not so remarkably), the share of rdistribution was dominant.

Four years' continued big negative values after the accumulation in 1998 are more striking than the decline after the Lehman Shock. As shown above, in special machinery we observe no such remarkable decline after 2008 like in general machinery.

[7-4]. Non-ferrous metal-, steel-, and petroleum product

Section [7-4] studies non-ferrous metal-, steel-, and petroleum product, which are raw materials, fuel or

Figure 29 Inventory Investment: general machinery rtotal and by category, 1994~2010, annual

intermediate products. In contrast with the four commodities studied in [7-2] and [7-3], both in quarterly- and annual estimates of those three, the share of rprocess was the smallest, rdistribution and rraw becoming much higher. This applies also to apparel studied in [7-5].

[7-4-1]. Non-ferrous metal product

Quarterly inventory investment

Together with petroleum product, non-ferrous metal product may be ideal in that the big rtotal increase in 2008Q4 after the Lehman Shock is consistent with the expectation and image of dramatic inventory accumulation as a consequence of unexpected demand collapse and the subsequent adjustment process. However, comparing with electric-machine and automobile, their rtotal's weights to the all industries rtotal were small. When the rtotal increased after the Lehman Shock, first rraw increased and then rdistribution followed. The same sequence applied to the start of adjustment process that followed. The same pattern is observed in petroleum product.

Over the whole period, the influence of rdistribution was dominant, and that of rraw followed. The period after the Lehman Shock was exceptional, when first rraw increased sharply and then rdistribution followed. This pattern applies also to petroleum product.

Annual inventory investment: 1994~2010

Here the influence of rdistribution is overwhelming, and next comes rraw by a large margin.

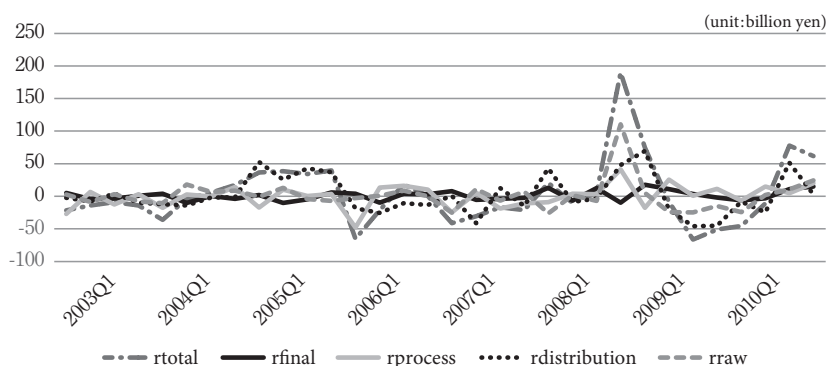
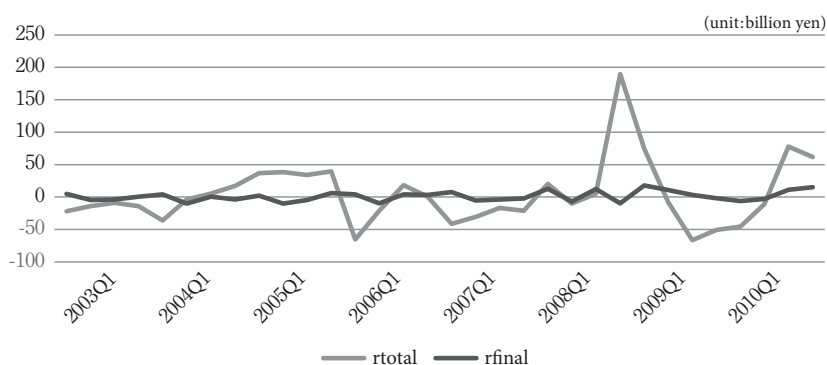
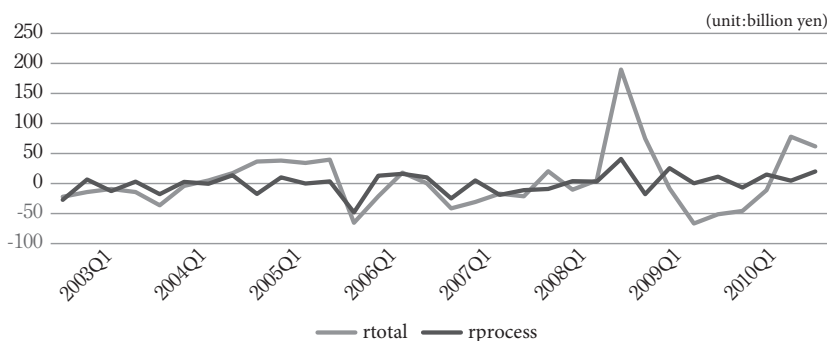
[7-4-2]. Steel product

Quarterly inventory investment

Like non-ferrous metal- and petroleum product, steel product is for industrial material and intermediate product. Here we do not find two observations commonly found in four commodities including automobile studied in [7-2] and [7-3]: (1) the influence of rprocess was overwhelming; (2) rraw was consistently 0.

Quarterly inventory investment of steel product is different from that of non-ferrous metal- and petroleum product in that all four inventory category had fairly big share, respectively.

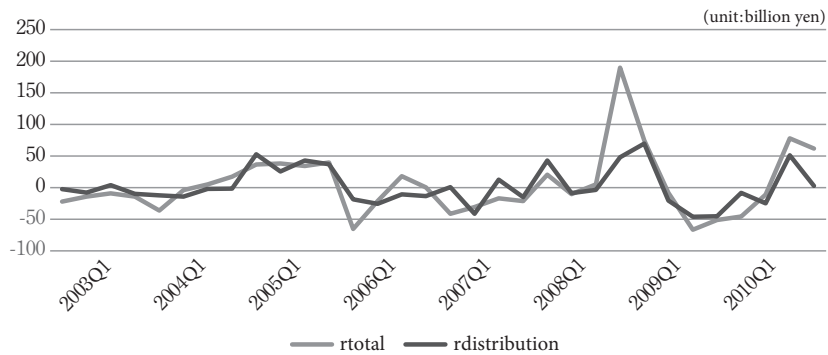
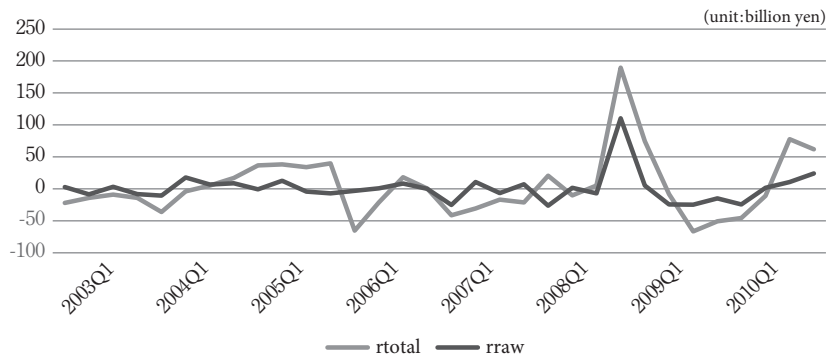
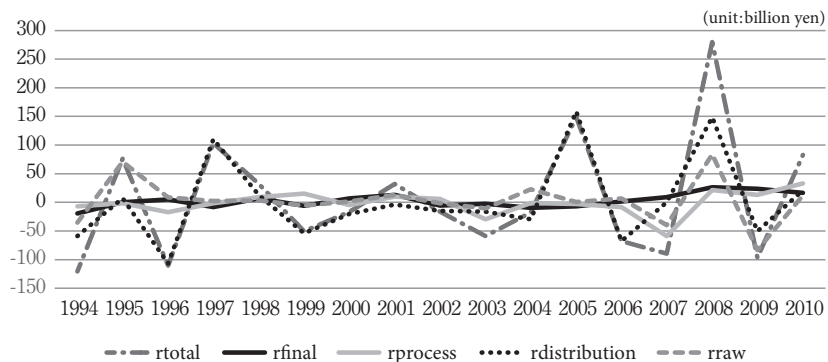
Both in all industries and in many commodities we commonly observe that rtotal radically decline

Figure 30a Inventory Investment: non-ferrous metal rtotal and by category, 2003~2010, quarterly**Figure 30b** Inventory Investment: non-ferrous metal rtotal vs. rfinal, 2003~2010, quarterly**Figure 30c** Inventory Investment: non-ferrous metal rtotal vs. rprocess, 2003~2010, quarterly

in the 1st quarters, where most inventory categories, particularly rprocess, move in tandem with rtotal. This applies also to steel product.

The size of fluctuations in rprocess obviously decreased since 2006, in contrast that of rraw and rdistribution increased.

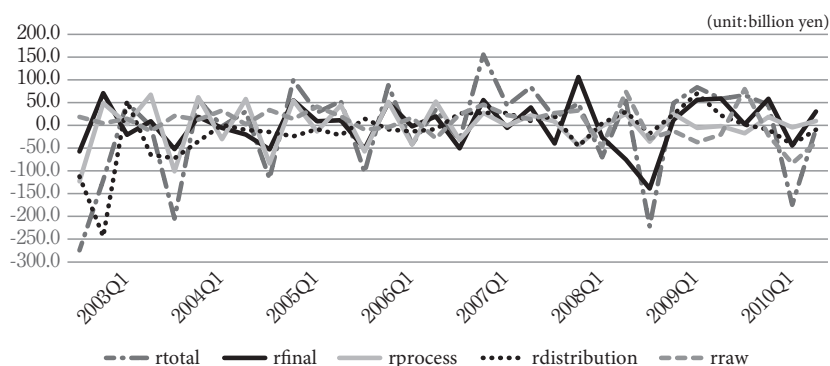
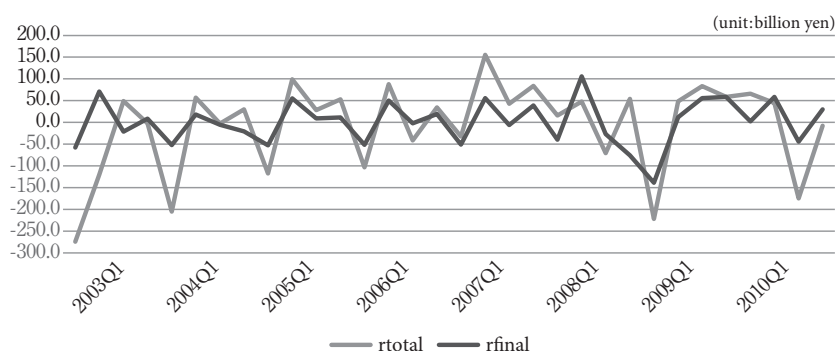
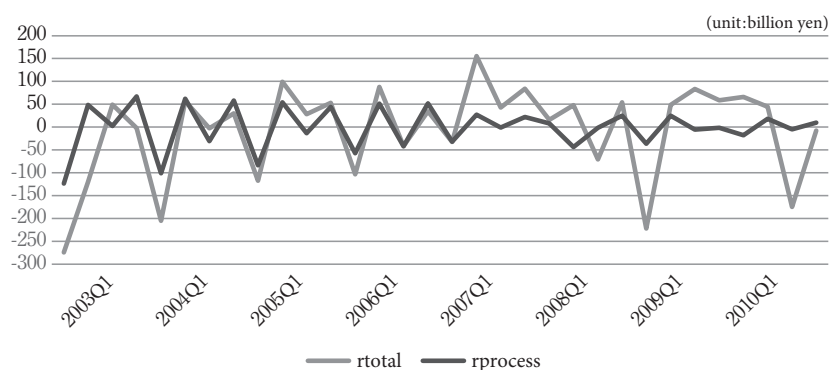
In four commodities including automobile studied in [7-2] and [7-3] rtotal recorded big negative values for several quarters running since 2009Q1. However, in steel product, as before, rtotal recorded a

Figure 30d Inventory Investment: non-ferrous metal rtotal vs. rdistribution, 2003~2010, quarterly**Figure 30e** Inventory Investment: non-ferrous metal rtotal vs. rraw, 2003~2010, quarterly**Figure 31** Inventory Investment: non-ferrous metal rtotal and by category, 1994~2010, annual

big negative value in 2009Q1 and positive value in the next quarter. In that sense, the Lehman Shock period was not special for steel product. Neither is the preceding 2008Q4 when rtotal increased.

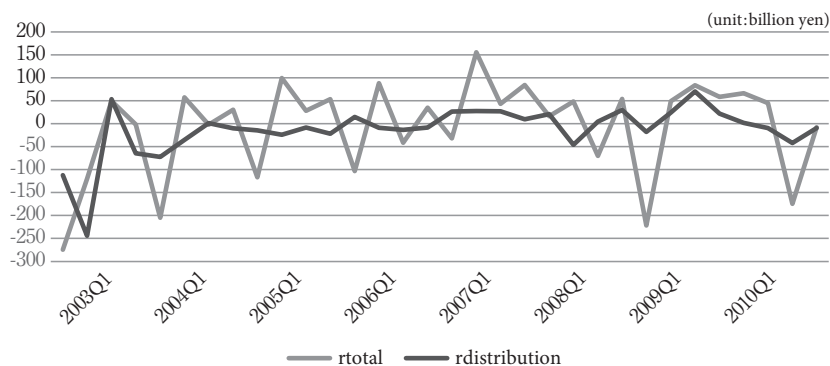
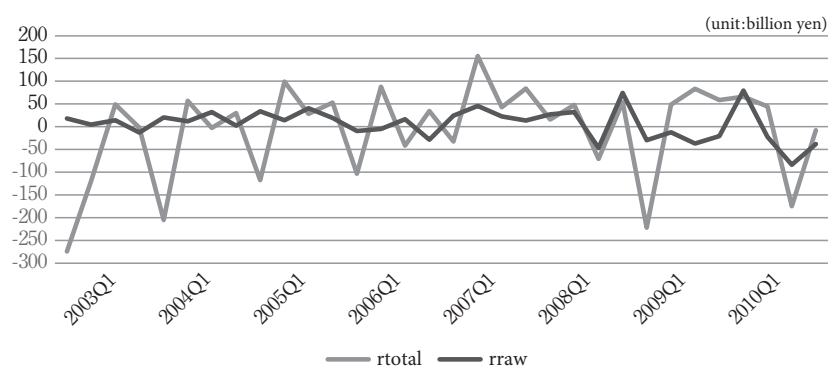
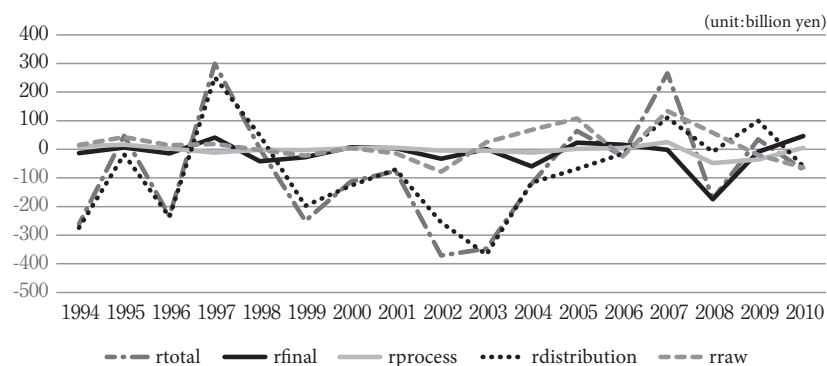
Annual inventory investment: 1994~2010

Also in steel product, annual inventory investment is significantly different from quarterly inventory investment.

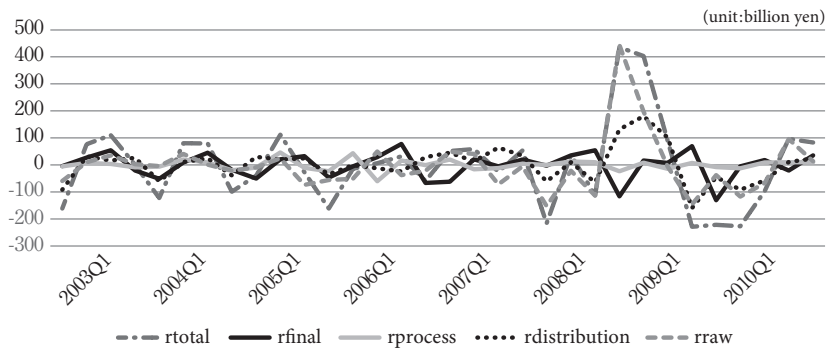
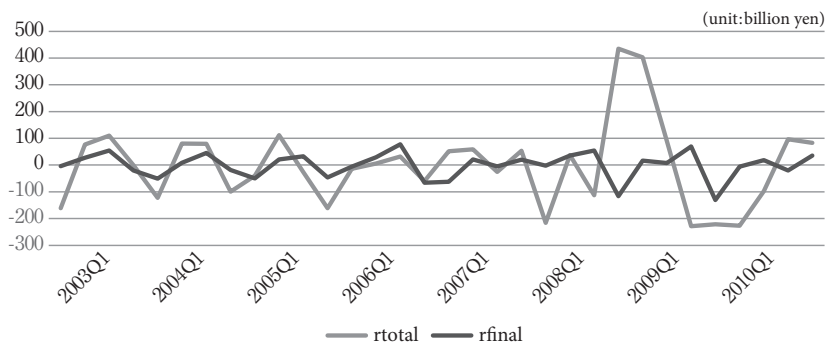
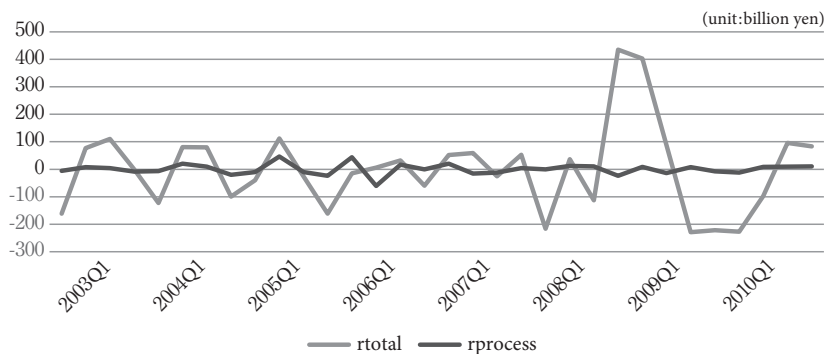
Figure 32a Inventory Investment: steel rtotal and by category, 2003~2010, quarterly**Figure 32b** Inventory Investment: steel rtotal vs. rfinal, 2003~2010, quarterly**Figure 32c** Inventory Investment: steel rtotal vs. rprocess, 2003~2010, quarterly

Before around 2004, the influence of annual rdistribution overwhelmed the annual rtotal. Since then, rraw also increased the share. Rprocess whose share is large in quarterly estimates is small in annual estimates, and rdistribution whose share is small in quarterly estimates increases in annual estimates.

It was in 2007 (not in 2008) when rtotal increased, where rdistribution and rraw increased.

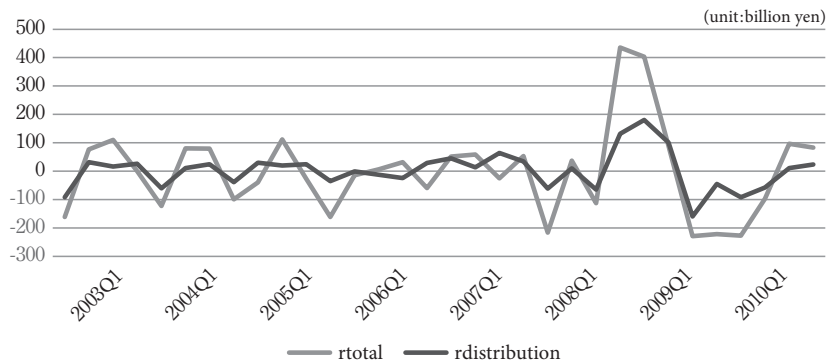
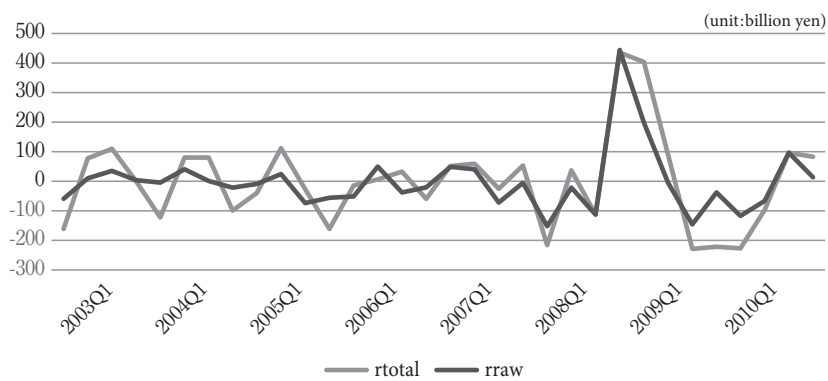
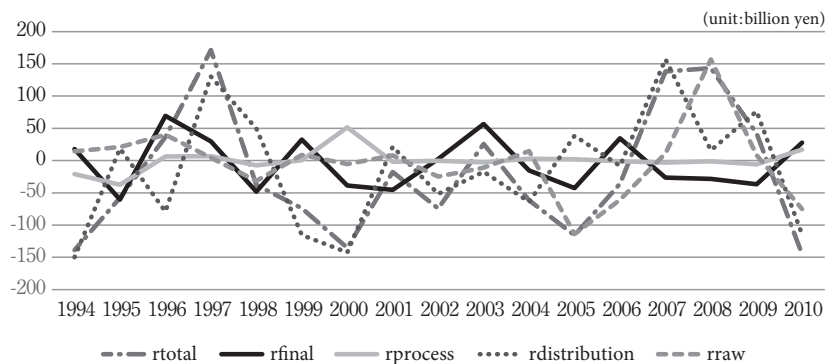
Figure 32d Inventory Investment: steel rtotal vs. rdistribution, 2003~2010, quarterly**Figure 32e** Inventory Investment: steel rtotal vs. rraw, 2003~2010, quarterly**Figure 33** Inventory Investment: steel rtotal and by category, 1994~2010, annual**[7-4-3]. Petroleum product****Quarterly inventory investment**

Like non-ferrous metal- and steel product, petroleum product is for industrial material, fuel and intermediate product. Here we do not find observations commonly found in four commodities including automobile studied in [7-2] and [7-3], either.

Figure 34a Inventory Investment: petroleum rtotal and by category, 2003~2010, quarterly**Figure 34b** Inventory Investment: petroleum rtotal vs. rfinal, 2003~2010, quarterly**Figure 34c** Inventory Investment: petroleum rtotal vs. rprocess, 2003~2010, quarterly

Both in all industries and in many commodities we commonly observe that rtotal radically decline in the 1st quarters, where most inventory categories, particularly rprocess, move in tandem with rttotal. This does not apply to petroleum product.

What is conspicuous in rttotal in petroleum product is a dramatic increase both in 2008Q4 and 2009Q1, and remarkable negative values for three quarters running since 2009Q3. Both primarily reflected the fluctuations of rdistribution and rraw, although their shares changed radically across quar-

Figure 34d Inventory Investment: petroleum rtotal vs. rdistribution, 2003~2010, quarterly**Figure 34e** Inventory Investment: petroleum rtotal vs. rraw, 2003~2010, quarterly**Figure 35** Inventory Investment: petroleum rtotal and by category, 1994~2010, annual

ters. The influence of rprocess during this period was the smallest.

Annual inventory investment: 1994~2010

In petroleum product, annual inventory investment is not significantly different from quarterly inventory investment.

Either in increase or decrease, the fluctuation in redistribution decisively influenced rtotal. During the period after 2007, redistribution increased first and rraw followed. In 2008 redistribution decreased, but rraw increased, leaving rtotal at a high level. In 2009, both rraw and rttotal decreased dramatically, and redistribution increased a little.

[7-5]. Apparel

Section [7-5] studies apparel as a representative of non-durable consumer product.

Quarterly inventory investment

Also in apparel we find the observation common to many commodities that rttotal sharply declines in the 1st quarters. In the 1st quarters all the four inventory categories report negative values in chorus, of which the influence of redistribution is overwhelming. As in many commodities, they record big positive values both in the 2nd and 4th quarters, and intermediate values in the 3rd quarters.

Presumably reflecting an obvious downward trend in nominal sales consistently observed during the period under study, we observe a consistent downward trend in rttotal, which is more clearly found in annual inventory investment.

Figure 36a Inventory Investment: apparel rttotal and by category, 2003~2010, quarterly

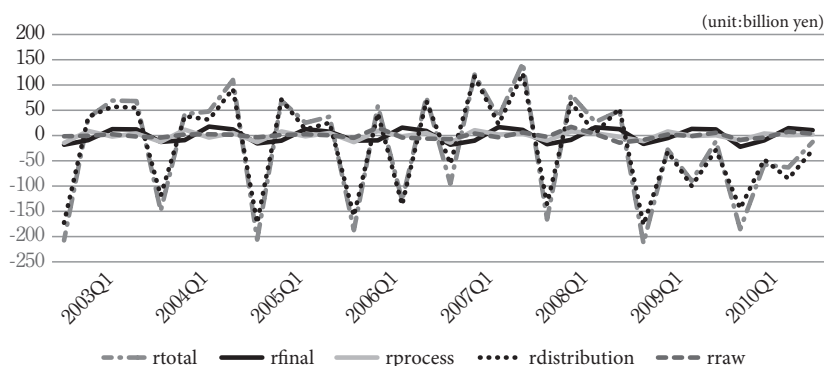


Figure 36b Inventory Investment: apparel rttotal vs. rfinal, 2003~2010, quarterly

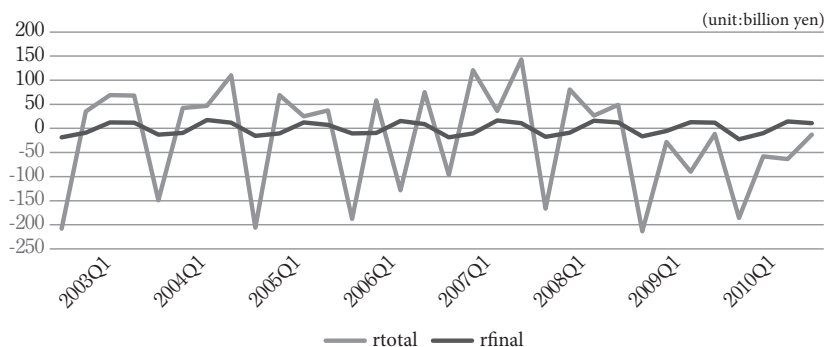
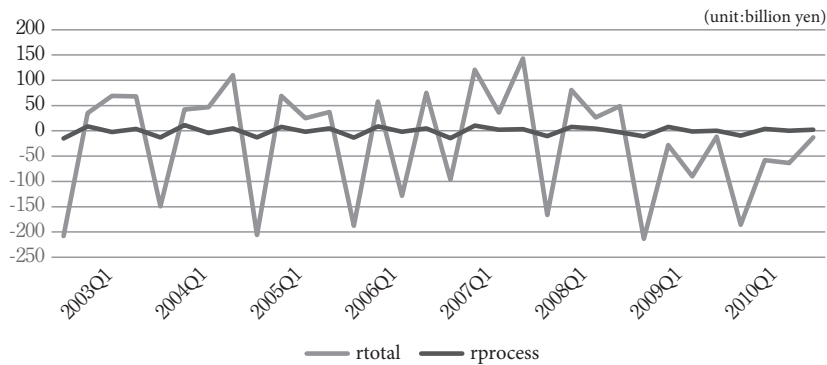
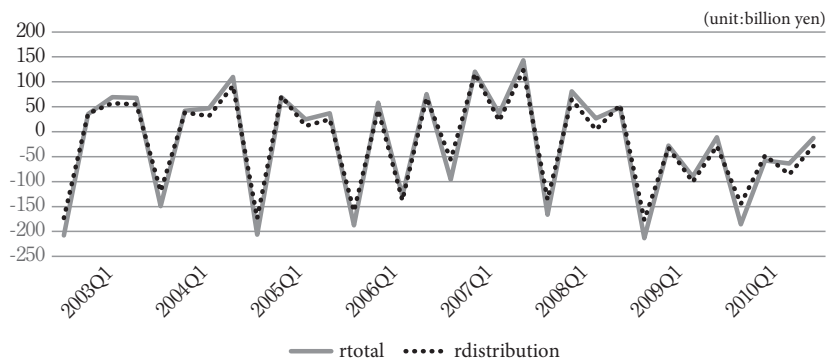
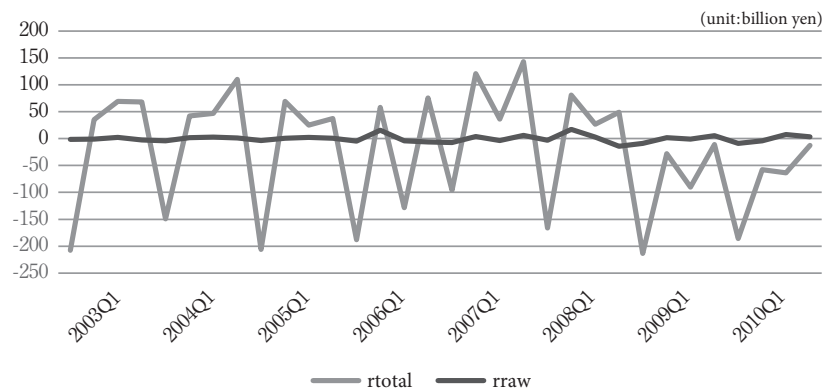
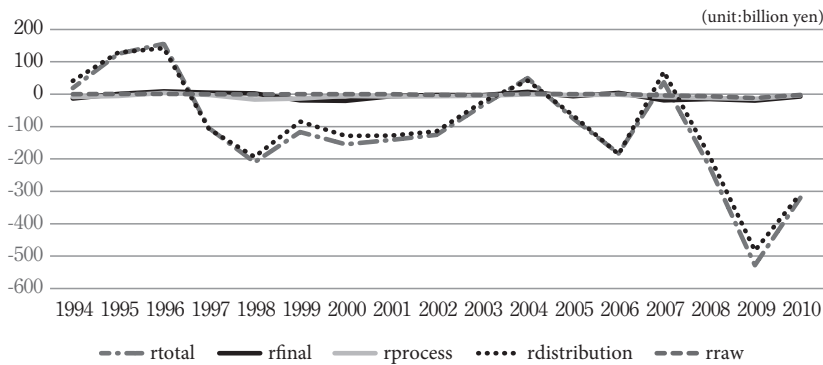


Figure 36c Inventory Investment: apparel rtotal vs. rprocess, 2003~2010, quarterly**Figure 36d** Inventory Investment: apparel rtotal vs. rdistribution, 2003~2010, quarterly**Figure 36e** Inventory Investment: apparel rtotal vs. rraw, 2003~2010, quarterly

Annual inventory investment: 1994~2010

In apparel, annual inventory investment is not significantly different from quarterly inventory investment. Reflecting an obvious consistent downward trend in nominal sales, both rttotal and inventory investment by category almost always recorded negative values, where the influence of rdistribution was overwhelming.

Figure 37 Inventory Investment: apparel rtotal and by category, 1994~2010, annual

[8]. “Inventory Stock Adjustment” Process

[8-1]. Introduction, and All Industries Inventory Investment

Section [8] investigates the “inventory stock adjustment” processes, shifting the focus of the study from individual quarters and years to their sequences for “stock adjustment”. The focus of the investigations are the details of inventory accumulation due to the dramatic demand decline after the Lehman Shock and the subsequent stock adjustment process, that is the fluctuations in inventory by category and the time course of adjustment process including the length of adjustment time.

Inventory investment in each time unit (for example, quarter) is the difference in value of inventory stock at the end of period and that at its beginning, that is, the net increase in inventory stock value. The accumulation of inventory stock and its subsequent adjustment process is the variation in inventory stock value. For the whole picture of inventory investment and its fluctuations, studying inventory investment in individual quarters is insufficient, and it is essential to focus on “accumulation process” over sequence of time units (quarters or years). In accordance with the result of the study in previous sections, Section [8] focus on the accumulation- and adjustment processes.

Either with quarterly- or annual estimates, previous sections studied the inventory investment focusing on individual unit periods. However, whether or not depending on a long-term program, it is not unusual to accumulate or reduce inventory stock continuously over several unit periods, as the conventional wisdom argues. It is implausible to assume that $rtotal$ or inventory investment by category at quarter t is independent of the ones at quarter $t-1$ or $t+1$ (and more distant quarters).

This study investigates the inventory investment fluctuations that occurred as a consequence of an exogenous shock (an unexpected event) and its subsequent adjustment process, focusing on the period around Lehman Shock, for which it is more appropriate to take sequences of unit periods as a basic examination object. The conventional wisdom argues that during the period around Lehman Shock, the Japanese economy suffered from an unexpected severe economic downturn with dramatic demand collapse over several quarters. Upon this, many business people and researchers with longstanding interest in inventory fluctuations should have thought and expected that in various areas of the economy inventory stock had accumulated in an enormous scale over several quarters and then its adjustment process had followed for another several quarters. For examining the accuracy and validity of this expectation

along the conventional wisdom, as part of detailed study of inventory fluctuations, we have to take sequences of adjustment period as basic examination unit.

Section [8] investigates the accumulation and its subsequent adjustment process in all industries and eight commodities studied in [7], focusing on the period around Lehman Shock. In addition, for comparison, on the subset of those commodities I carry the same study over the period of “Financial Crisis”⁴¹⁾ after the fall of 1997, on which I confirm that the conclusion drawn from the study of the Lehman Shock period is neither special nor idiosyncratic.

Previous discussions up to [7] show that, with the exception of petroleum- and non-ferrous metal product, even during the period after Lehman Shock in most commodities no notable increase in inventory investment was observed. This holds also in all industries inventory investment. The implication of this observation that rarely remarkable inventory stock accumulation was observed even as a consequence of an unexpected dramatic demand decline is important. In most commodities we observe remarkable decline in $rtotal$ in 2009Q1 and after, and many commodities recorded negative $rtotal$ value for several quarters running.⁴²⁾

It was $rdistribution$ and $rrow$ that increased $rtotal$ in an exceptional move in petroleum- and non-ferrous metal product during the period after Lehman Shock. In all industries $rprocess$ overwhelmed the fluctuations of $rtotal$, whereas in these two commodities the share of $rprocess$ was small and their fluctuations low-profile. In special- and general machinery where the share of $rprocess$ was dominant and in automobile and electric-machine whose weights in all industries $rprocess$ were high, rarely do we find notable increase in $rtotal$ after the Lehman Shock, and we find notable decrease in $rprocess$ in the following quarters.

Note that 2008Q4 when $rtotal$ increased remarkably in some commodities is the 4th quarter when $rtotal$ remarkably increases as part of regular seasonal fluctuations, and that 2009Q1 when $rtotal$ recorded a dramatic decline in almost all commodities is the 1st quarter when $rtotal$ drastically decreases, reporting a large negative value.

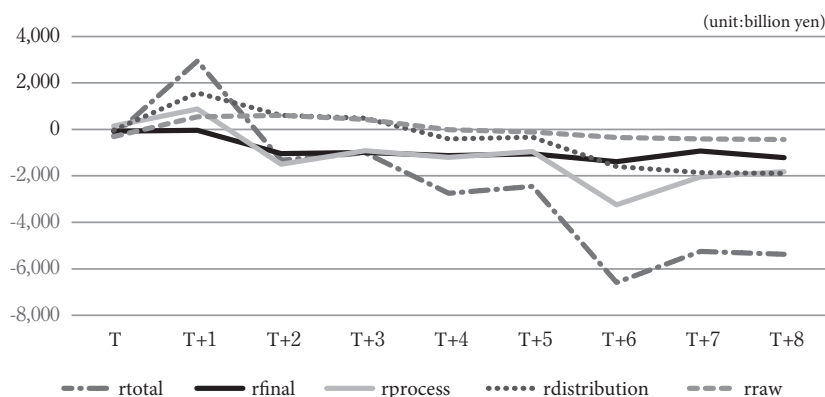
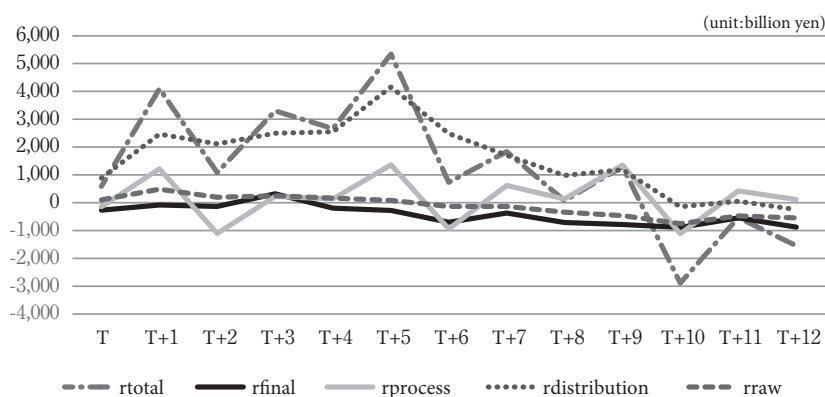
All industries accumulated inventory investment values

Before the study by commodity in [8-2], I show below two figures on all industries accumulated inventory investment values, taking 2008Q3 and 1997Q3 as the starting point T . For the details of those figures, including the choice of T , see the discussion on the petroleum product accumulated inventory investment values in [8-2].

As shown in detail in [8-3] concerning automobile, the fluctuation patterns observed in automobile accumulated inventory investment values are basically common to such commodities as electric-machine, special- and general machinery, and also all industries. For example, I find neither notable accumulation in inventory stock after the Lehman Shock nor its ex-post adjustment process. In quarterly estimates the influence of $rprocess$ is dominant in $rtotal$ fluctuations, but in the trend and long-run fluctuations in $rtotal$ $rdistribution$ becomes important.

Period around the Lehman Shock

The increase in inventory stock in 2008Q4 ($T+1$), just after the Lehman Shock, was rather small, and most accumulated inventory stock values turn to be negative in 2009Q1 ($T+2$) and recording larger

Figure 38a Accumulated Inventory Stock Value: all industries, T=2008Q3**Figure 38b** Accumulated Inventory Stock Value: all industries, T=1997Q3

negative values in the following quarters. No inventory stock reduction to be regarded as an adjustment process for the accumulated inventory stock due to the Shock.

Period around the “Financial Crisis”

During the period around the “Financial Crisis” the peak of all industries accumulated inventory stock, primarily due to rdistribution, was 1998Q4 (T+5), where the difference of its value from that at T=0 was 3 trillion yen in rdistribution and 4 trillion yen in rtotal. These values correspond to 2~3% of 180 trillion yen, nominal quarterly shipment value of the time, or 2 or 3 days nominal shipment value.

Rtotal returned in 1999Q1 (T+6) to the start level, and rdistribution in 1999Q3 (T+8).

[8-2]. Petroleum-, Non-ferrous Metal-, and Steel Product

[8-2] studies petroleum- and non-ferrous metal product where rtotal increased remarkably during the Lehman Shock period, together with steel product.

[Petroleum product]**Period around the Lehman Shock**

Supposing to be a framework for the other commodities, I present here detailed study of petroleum product.

During the period around Lehman Shock, inventory stock in petroleum product, particularly distribution inventory, accumulated dramatically.

In the quarterly GDP inventory investment estimates by commodity, rraw is the net increase in values of petroleum product stock firms hold as industrial raw materials and fuel, which does not include crude oil held by oil manufacturers. Here, focus is placed upon the petroleum product accumulated by purchasers as raw material and fuel and its subsequent “stock adjustment process”.

As the data is available till the end of 2010, in some cases figure ends before T+8. For focusing on the adjustment process, I present four figures beginning with 2008Q3~2009Q2, respectively, that show 4 inventory investments by category and rtotal.

First, I present Table 8 of quarterly petroleum inventory investment values by category and rtotal, together with nominal shipment value (not the accumulated values, unit: billion yen), and then four figures (Figures 39a~39d) on accumulated values.

Rtotal increased prominently in 2008Q4, where increase in rraw was overwhelming, followed by rdistribution, rprocess and rfinal recording negative values. Rtotal recorded a big positive value also in 2009Q1 where rraw decreased to less than the half and rdistribution increased instead, rprocess and rfinal remaining stable. In 2009Q2 only rdistribution recorded a fairly big positive value. From 2009Q1~2009Q4 rtotal recorded big negative values, where both rdistribution and rraw recorded big negative values, and in 2009Q4 rfinal also recorded a big negative value.

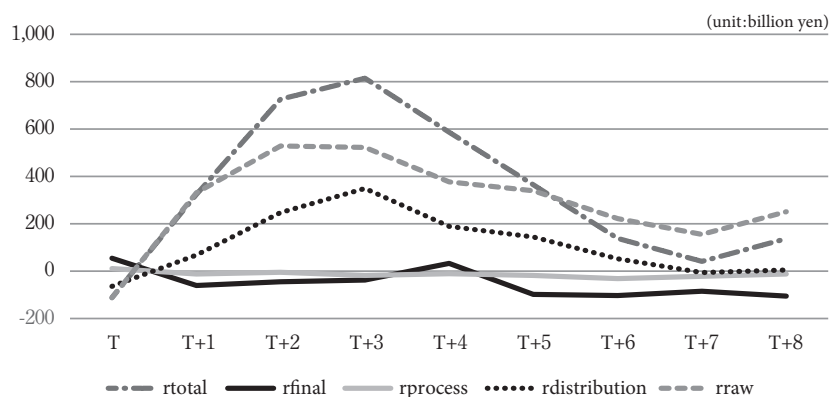
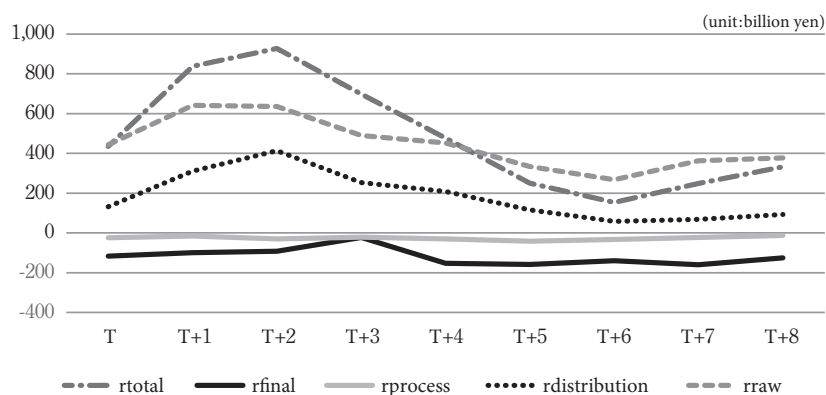
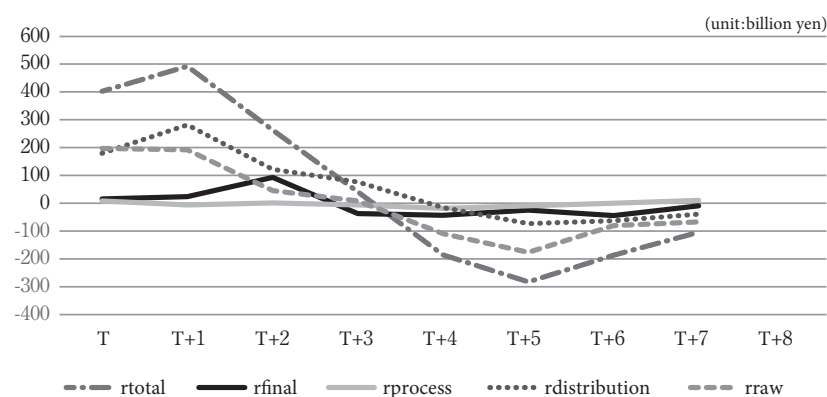
The first Figure 39a starts with the values of 2008Q3 (T=2008Q3). Although the estimates I use unchanged, the level of accumulated inventory investment values greatly differ depending on the choice of T, the starting point, with which readers receive different impressions. Like the figures on all industries accumulated values in [8-1], in [8-2]~[8-5] I show, for the period after Lehman Shock figures on T=2008Q3, and for the “Financial Crisis” on T=1997Q3.

Readers might be interested in how many months’ or days’ shipment correspond to the additionally accumulated inventory investment stock values. Here I focus on the difference between the cumulative

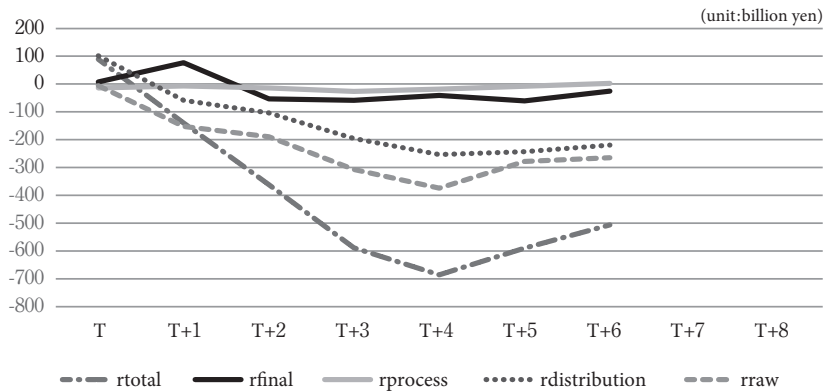
Table 8 Quarterly petroleum product inventory investment values: rtotal and by category, 2008Q1~2010Q4

(unit: billion yen)

	nsales	rtotal	rfinal	rprocess	rdistribution	rraw
2008Q1	5,472.2	-216.2	-2.5	-0.3	-61.1	-152.2
2008Q2	5,383.9	36.8	35.6	12.5	10.1	-21.5
2008Q3	6,338.5	-112.6	54.4	10.4	-64.4	-113.1
2008Q4	4,549.9	435.1	-116.0	-23.6	131.3	443.4
2009Q1	3,662.0	402.8	16.4	8.4	180.1	197.9
2009Q2	3,536.2	89.0	7.6	-14.2	101.5	-5.8
2009Q3	4,174.3	-228.6	69.7	7.7	-159.9	-146.2
2009Q4	4,423.3	-221.3	-130.4	-7.9	-45.4	-37.5
2010Q1	4,693.4	-226.9	-5.6	-12.4	-91.5	-117.5
2010Q2	4,451.5	-97.3	18.4	9.1	-57.8	-67.1
2010Q3	4,617.8	96.1	-20.3	10.0	10.6	95.8
2010Q4	4,749.5	83.0	35.2	10.2	23.9	13.6

Figure 39a Accumulated Inventory Stock Value: petroleum product, T=2008Q3**Figure 39b** Accumulated Inventory Stock Value: petroleum product, T=2008Q4**Figure 39c** Accumulated Inventory Stock Value: petroleum product, T=2009Q1

inventory investment values and the 2008Q3 values. This difference in rtotal at 2009Q1 (T+2) and 2009Q2 are 600 billion yen and 910 billion yen. As shown in the above table, nominal shipment in 2008Q4 was 4.5 trillion yen, of which 910 billion yen corresponds to 20%, that is, 18 days' shipment.⁴³⁾

Figure 39d Accumulated Inventory Stock Value: petroleum product, T=2009Q2

In petroleum product, the influence of rraw was the largest on the rtotal fluctuations, and that of rdistribution the second, rather than rprocess that has overwhelming influence in many commodities. It took one and half years for the inventory stock level to return to the start level.

Because it was an unexpected event with profound influence, the dramatic demand decrease in Japan after the Lehman Shock was an extremely exceptional situation that was anticipated to cause dramatic accumulation of inventory stock. In addition, together with non-ferrous metal product, petroleum product is exceptional in that inventory stock accumulation during this period was conspicuous. In such an exceptional case, that is, exceptional commodity and time, the accumulated inventory stock increase corresponds to mere 18 days' shipment value.

Period around the “Financial Crisis”

Upon the previous conclusion about the period around Lehman Shock, readers may wonder: How about the other period? Maybe it was not so much unexpected as the Lehman Shock, but the situation during the period of “Financial Crisis” in 1997~1999 must be still of great interest to many readers.

The collapse of Yamaichi Securities occurred in November 1997, at the end of 1997Q4. Even before this event observers were worrying about the coming depression, and therefore the beginning of “confusion” and “adjustment process” may be a little earlier. Because of this, I show a corresponding table for 1997~2002, and a figure of accumulated inventory investment stock value over 12 quarters (three years) from 1997Q3.

Compared to the period after Lehman Shock, either of the inventory accumulation or its subsequent adjustment process is very unimpressive.

[Non-ferrous metal product]

Period around the Lehman Shock

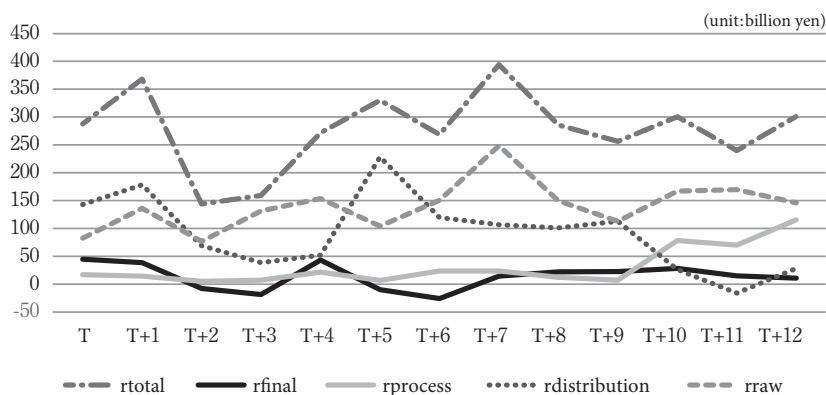
270 billion yen, the accumulated inventory investment value at the peak after the Lehman Shock (at 2009Q1, T+2) corresponds to 30% of 900 billion yen, the quarterly nominal shipment of the time, or 27 days' shipment, of which rraw and rdistribution occupied 100 billion yen, respectively.

Like petroleum product, at T+1 rraw increased remarkably and at T+2 rdistribution followed. It took one and half years for the inventory stock to return to the start level, too.

Table 9 Quarterly petroleum product inventory investment values: rtotal and by category, 1997Q1~2002Q4

(unit: billion yen)

	nsales	rtotal	rfinal	rprocess	rdistribution	rraw
1997Q1	3,059.2	-198.3	6.2	17.5	-99.6	-122.4
1997Q2	2,814.6	1.4	-15.1	-25.2	51.1	-9.3
1997Q3	2,940.3	288.0	45.1	17.2	143.1	82.6
1997Q4	3,096.9	80.4	-6.3	-2.6	35.7	53.6
1998Q1	2,856.6	-224.1	-46.4	-9.2	-109.3	-59.2
1998Q2	2,453.0	15.2	-10.8	1.9	-30.5	54.6
1998Q3	2,636.9	112.3	61.9	14.5	13.4	22.5
1998Q4	2,762.1	58.5	-53.1	-14.7	176.0	-49.7
1999Q1	2,429.6	-61.6	-16.0	16.8	-108.8	46.3
1999Q2	2,328.5	125.4	40.5	0.1	-12.9	97.8
1999Q3	2,663.4	-108.1	7.3	-11.4	-5.4	-98.6
1999Q4	2,947.2	-29.8	0.5	-5.0	11.6	-36.8
2000Q1	2,901.0	44.7	5.7	70.9	-86.2	54.3
2000Q2	2,740.0	-61.0	-13.1	-8.0	-42.2	2.4
2000Q3	3,099.7	61.4	-4.3	45.4	43.9	-23.6
2000Q4	3,241.6	-180.4	-26.9	-56.8	-57.9	-38.7
2001Q1	3,164.7	-111.6	-10.1	15.2	-67.5	-49.3
2001Q2	3,009.1	169.3	5.4	8.9	118.9	36.1
2001Q3	3,133.3	-20.6	34.6	23.1	-99.5	21.1
2001Q4	3,109.5	-54.9	-75.5	-49.2	69.6	0.1
2002Q1	2,967.3	136.3	41.9	3.8	24.9	65.7
2002Q2	2,918.3	-1.4	-14.0	37.3	-12.5	-12.3
2002Q3	3,142.3	-82.3	-3.3	-29.8	-20.4	-28.9
2002Q4	3,322.6	-126.8	-22.0	-11.6	-43.7	-49.5

Figure 40 Accumulated Inventory Stock Value: petroleum product, T=1997Q3

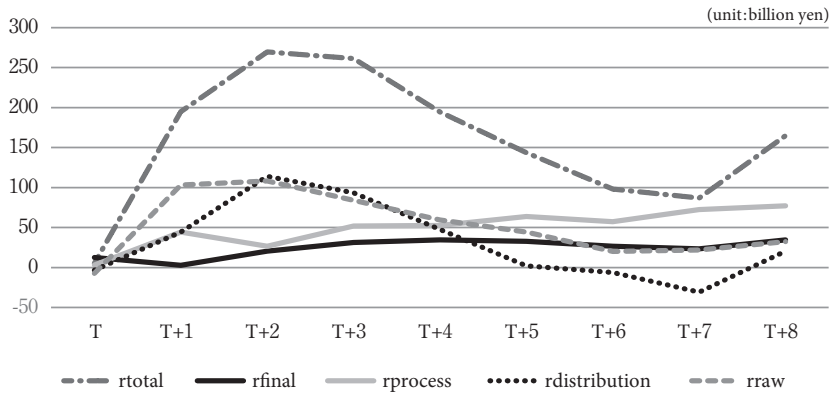
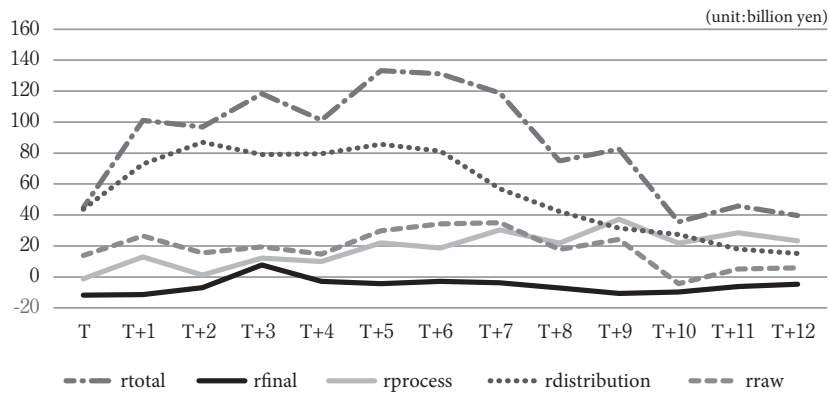
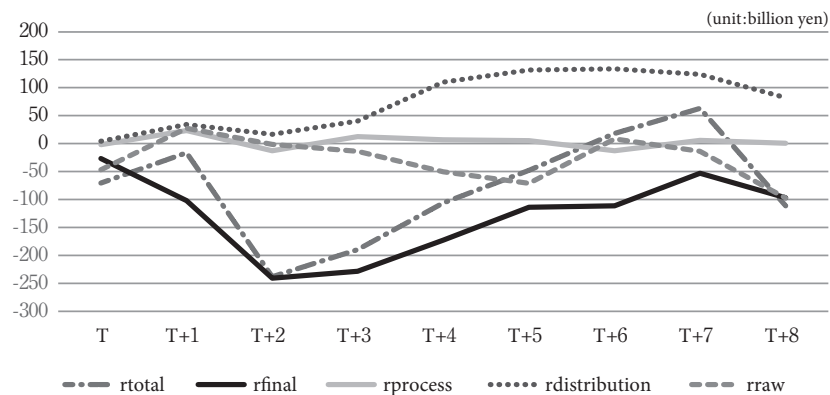
Period around the “Financial Crisis”

130 billion yen, the accumulated inventory investment value at the peak during this period (at 1998Q4, T+5) corresponds to 37% of 350 billion yen, the quarterly nominal shipment of the time, or 34 days' shipment, where the influence of rdistribution was overwhelming.⁴⁴⁾ It took two and half years for the inventory stock to return to the start level.

[Steel product]

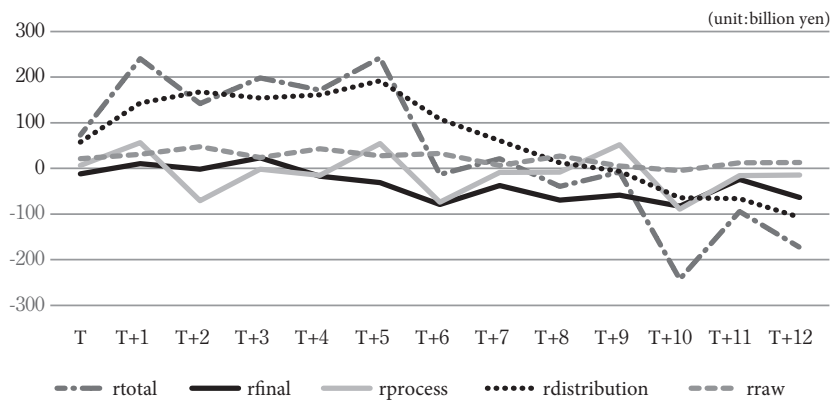
Period around the Lehman Shock

As shown in [7], during this period we find no remarkable increase in steel product inventory in-

Figure 41a Accumulated Inventory Stock Value: non-ferrous metal product, T=2008Q3**Figure 41b** Accumulated Inventory Stock Value: non-ferrous metal product, T=1997Q3**Figure 42a** Accumulated Inventory Stock Value: steel product, T=2008Q3

vestment, which suggests that there was no need for inventory stock adjustment. The remarkable reduction in rtotal in 2008Q4 (T+1) and 2009Q1, where the influence of rfinal was overwhelming, should not be part of “adjustment” process.

-200 billion yen, the accumulated inventory reduction value at the peak during this period (at 2009Q1,

Figure 42b Accumulated Inventory Stock Value: steel product, T=1997Q3

T+2) corresponds to 4% of 5 trillion yen, the quarterly nominal shipment of the time, or 4 days' shipment.

Period around the “Financial Crisis”

200 billion yen, the accumulated inventory investment value at the peak during this period (at 1998Q4, T+5) corresponds to 6% of 3.5 trillion yen, the quarterly nominal shipment of the time, or 6 days' shipment, where the influence of rdistribution was overwhelming. It took two years for the inventory stock to return to the start level.

[8-3]. Automobile and Electric-Machine

[8-3] studies automobile and electric-machine. As shown in [7], in either commodity the influence of rprocess is overwhelming in quarterly inventory investment fluctuations, but rdistribution in annual fluctuations. Accumulated inventory investment values illustrate those points more clearly.

As we see below, most observations about the fluctuations in automobile inventory investment are commonly observed in electric-machine, special- and general machinery, and also all industries.

[Automobile]

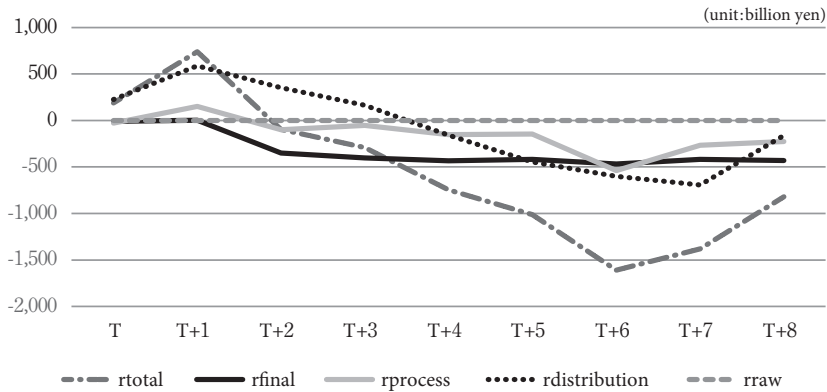
Period around the Lehman Shock

Quite often automobile has been in the news in Japan, including the drastic export decline after the Lehman Shock.

In automobile, however, after the Lehman Shock, we observe some increase in rdistribution, but almost no increase either in rfinal or rprocess. The accumulated total inventory stock in 2008Q4 was completely dissolved in the next quarter, 2009Q1, and long-lasting inventory stock reduction continued in the following quarters. It is unreasonable to see it as widely expected stock adjustment process.

It was in 2009Q2 (T+2) when the distribution stock returned to the start level. After this, the decreasing trend continued for a long time, dominating the long-run inventory investment trend in rtotal.

500 billion yen, the initial accumulated total inventory investment value, corresponds to 5% of 10 trillion yen, the quarterly shipment of the time, or 5 days' shipment. 2 trillion yen, the stock value decrease from the peak to the bottom (at the 3 quarters later, T+6) corresponds to 20 days' shipment.

Figure 43a Accumulated Inventory Stock Value: automobile, T=2008Q3

Period after the “Financial Crisis”

During the period after the “Financial Crisis” since 1997Q3, we observe wild rise and fall in accumulated inventory stock, where the influence of $r_{process}$ was overwhelming. After the peak at 1998Q4 (T+5), however, we find a clear decreasing trend in total inventory stock value, where r_{final} and $r_{distribution}$ were dominant.

500 billion yen, increase in total inventory stock value between 1998Q1 (T+2) and 1998Q4 where $r_{distribution}$ was dominant, corresponds to 10% of 10 trillion yen, the quarterly shipment of the time, or 9 days’ shipment.

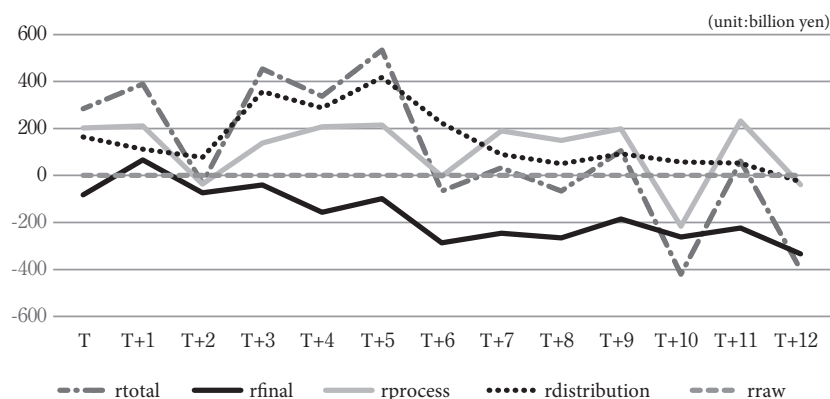
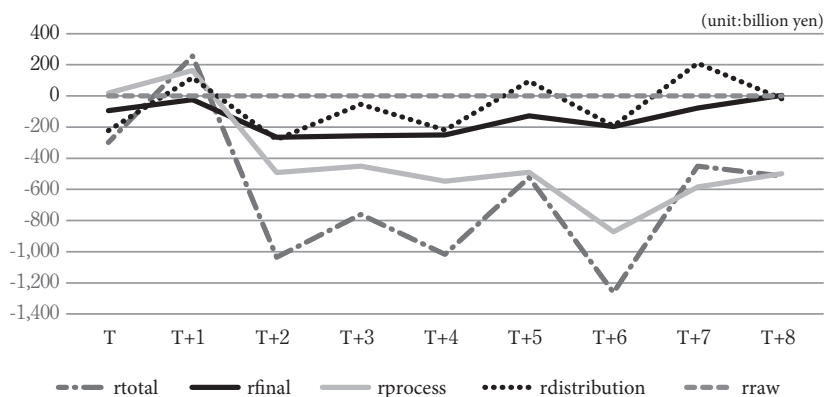
This increase in inventory stock value of 500 billion yen was accumulated between 1998Q1 and 1998Q4, during the period the difference becomes the largest, that is, from the bottom quarter to the peak quarter in above mentioned regular seasonal fluctuation. In the next quarter, r_{total} was -500 billion yen, decreasing the accumulated value to less than 0. If we assume the average of r_{total} in 1997Q1 and 1998Q1 (and also 1999Q1) as the additional value along the regular seasonal fluctuations, this 500 billion yen dissolves (disappears) almost completely.

The influence of $r_{process}$ is overwhelming in quarterly regular seasonal fluctuations in r_{total} . Its influence decreases remarkably in long-run trend in r_{total} fluctuations, however.⁴⁵⁾

Either during the period around Lehman Shock or around the “Financial Crisis”, the peak period of inventory stock accumulation was reached at the 4th quarter, when quarterly inventory investment regularly records a big positive value, much larger than the annual average. Focusing also on drastic r_{total} decline in the 1st quarter as part of regular seasonal fluctuation, above observations raise serious doubts on the following conventional wisdom: (1) Those shocks or unexpected big events result in a huge inventory stock accumulation, for the resolution of which a long-run adjustment process is necessary; (2) this kind of inventory fluctuation is a major cause of macroeconomic fluctuations. Obviously, however, as consequence of those shocks we find no notable increase in inventory stock, and therefore no need for adjustment.

[Electric-machine]

The accumulated electric-machine inventory stock value reveals almost the same features as in automobile.

Figure 43b Accumulated Inventory Stock Value: automobile, T=1997Q3**Figure 44a** Accumulated Inventory Stock Value: electric-machine, T=2008Q3

Period around the Lehman Shock

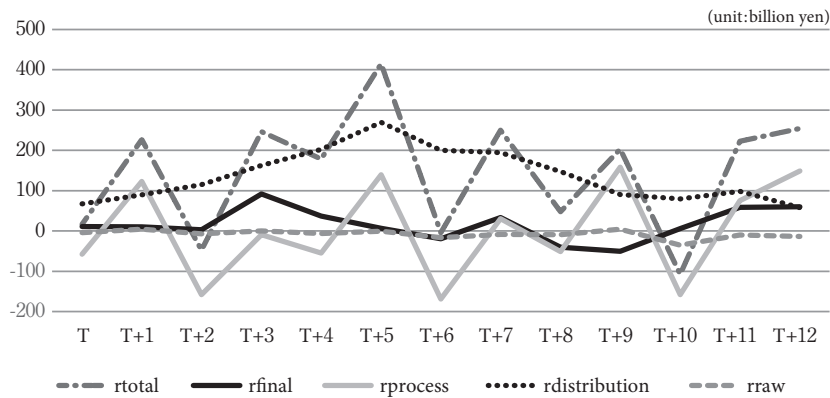
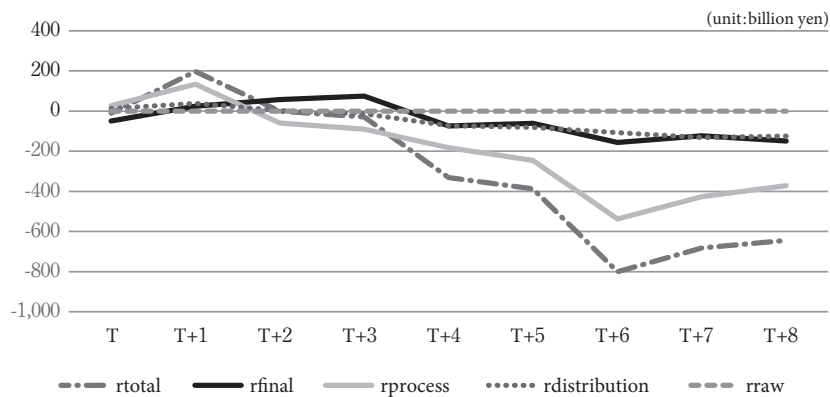
The increase in total inventory stock in 2008Q4 was small, and the accumulated value in 2009Q1 recorded a large negative value both in total inventory and inventory by any category, and remained negative for the following quarters. Rprocess and rdistribution were dominant in the repeated quarterly fluctuations.

What we find is miles away from the expectation of the conventional wisdom: unexpected situation after the Lehman Shock results in a huge inventory stock accumulation, for the resolution of which long-run adjustment process followed.

Period after the “Financial Crisis”

The fluctuation pattern of the accumulated electric-machine inventory stock value since 1997Q3 is almost the same as that of automobile, and the above comment on automobile applies here almost as it is.

400 billion yen, the difference in accumulated inventory stock value between 1998Q1 of the bottom and 1998Q4 of the peak, corresponds to 4% of 9 trillion yen, the shipment value of the time, or 4 days’

Figure 44b Accumulated Inventory Stock Value: electric-machine, T=1997Q3**Figure 45a** Accumulated Inventory Stock Value: special machinery, T=2008Q3

shipment. On this point, the above comment on automobile applies as well.

[8-4]. Special- and General Machinery

[8-4] studies special- and general machinery. Both of their accumulated inventory stock values reveal almost the same features as automobile.

In both the influence of rprocess was overwhelming in quarterly rtotat fluctuations. For the long-run trend and fluctuations, however, the influence of rdistribution was dominant, which was evident particularly during the period around Lehman Shock. In special machinery accumulated inventory stock decreased continuously since 1999Q1. In contrast, in general machinery, due to remarkable rprocess increase toward 1999Q4, realization of its decreasing trend retarded.

[Special Machinery]

Period around the Lehman Shock

During the period around Lehman Shock, special- and general machinery reveal almost the same movement in accumulated inventory stock value.

During this period I find no remarkable difference between special- and general machinery in fluctuation pattern of accumulated inventory stock values: neither its remarkable increase just after the Shock nor the adjustment process. We observe a decreasing trend in inventory stock.

Period around the “Financial Crisis”

200 billion yen, the difference in accumulated inventory stock value between 1998Q1 and 1998Q4, corresponds to 7% of 3 trillion yen, the quarterly nominal shipment of the time, or 6 days' shipment, which almost completely disappeared in the next 1999Q1.

[General machinery]

Period around the Lehman Shock

Previous comment on special machinery almost completely applies to general machinery.

Period around the “Financial Crisis”

300 billion yen, the difference in accumulated inventory stock value between 1998Q1 and 1998Q4, corresponds to 1/7 of 2 trillion yen, the quarterly nominal shipment of the time, or 13 days' shipment,

Figure 45b Accumulated Inventory Stock Value: special machinery, T=1997Q3

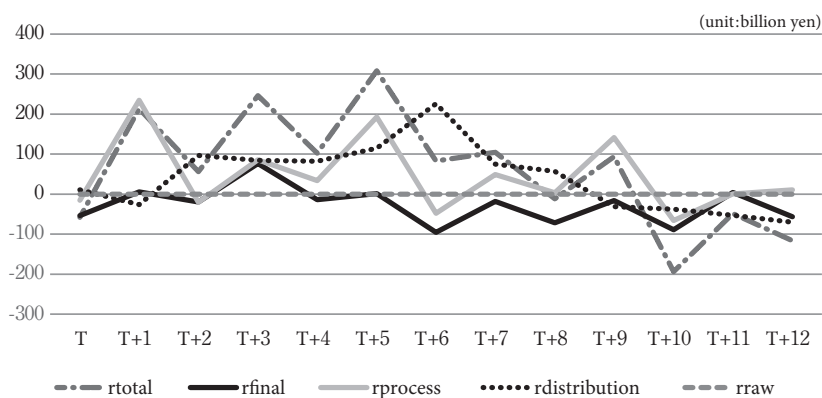


Figure 46a Accumulated Inventory Stock Value: general machinery, T=2008Q3

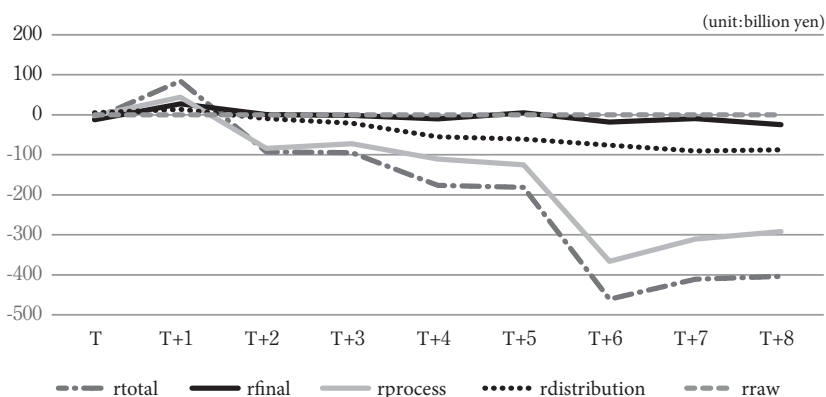
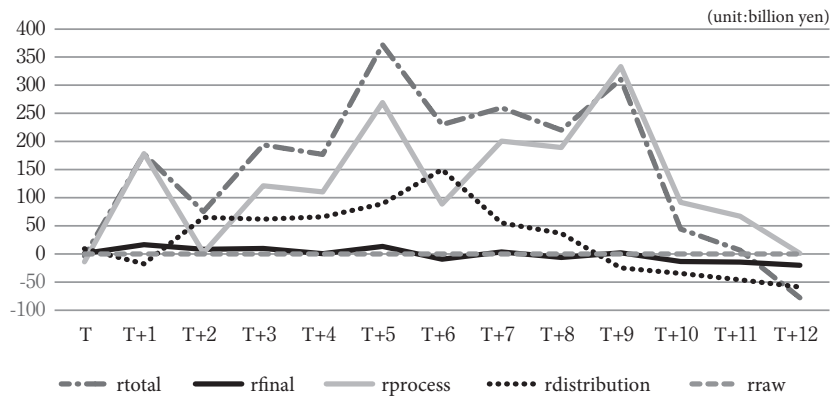


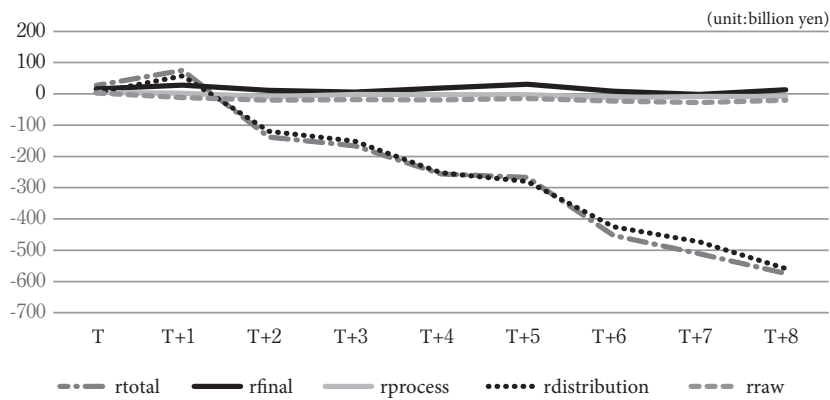
Figure 46b Accumulated Inventory Stock Value: general machinery, T=1997Q3

half of which disappeared in the next 1999Q1, and completely disappeared in 2001Q1.

[8-5]. Apparel

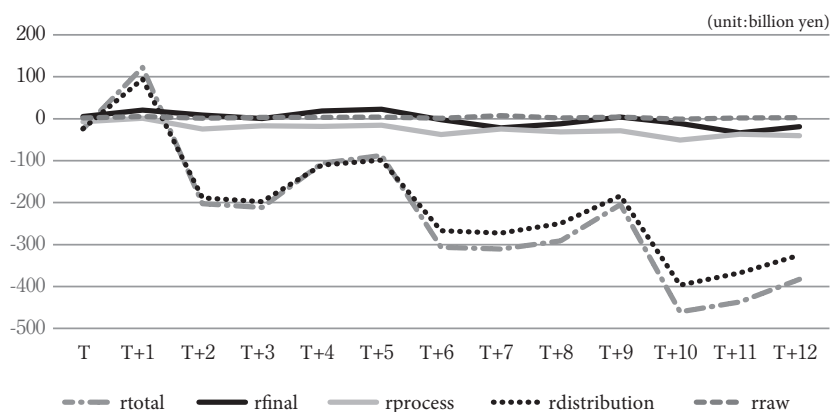
In apparel, non-durable consumption goods, in either period we find little increase in rtotal. Particularly during the period around Lehman Shock, rtotal decreased monotonically. In either period, the influence of rdistribution overwhelmed the fluctuations in rtotal, and other inventory investments by category remained consistently around 0.

Period around the Lehman Shock

Figure 47a Accumulated Inventory Stock Value: apparel, T=2008Q3

Period around the “Financial Crisis”

Figure 47b Accumulated Inventory Stock Value: apparel, T=1997Q3



[9]. Consequence of Exogenous Shock and Inventory Stock Adjustment Process: Summary and Supplements

Section [9] first summarizes the studies in [7] and [8] on the consequence of exogenous shocks, focusing on the period around Lehman Shock, and inventory investment on the following adjustment process, and next presents supplementary materials for supporting the conclusions. Following the summary in [9-1], as in [6] for [4] and [5], [9-2] confirms that we reach the same conclusions with inventory data from *Corporate Enterprise Quarterly Statistics*. Assuming a question, “Is it really possible to deliver a prompt response to ‘unexpected event’ like a dramatic demand decline after the Lehman Shock, and did firms actually deliver it?”, [9-3] presents empirical data, both from METI’s *Indices of Industrial Production Forecast* and BOJ’s (Bank of Japan) “annual projections” from *Tankan (Short-term Economic Survey of Enterprises in Japan)*, that support the view of firms’ prompt response.

[9-1]. Summary

Sections [7] and [8] studied the second issue of this research: Investigation of corporate inventory investment behavior, focusing on the consequence of an exogenous shock, unexpected situation for most economic agents involved, and its adjustment process. As an exogenous shock for investigation, I focus on the dramatic demand decline both at home and abroad after Lehman Shock, events occurred after the bankruptcy of Lehman Brothers Co. in mid-September 2008. For comparison, I placed focus also on the decline in domestic economic activity and confusion during the period called “the Financial Crisis” since the end of 1997.

Most researches on quarterly inventory investment fluctuations uses long-term time-series inventory data from quarterly SNA (GDP) statistics.⁴⁶⁾ As the second research issue of investigating the reality of inventory investment behavior in the light of cause-and-effect relationship, [7] and [8] focused on the period after Lehman Shock. As shown in [2], drastic shipment decline both at home and abroad after the Lehman Shock was so rapid and drastic that for most economic agents involved it was an unexpected

ed situation. For this reason, the inventory stock accumulation since 2008Q4 (or increase in inventory investment after 2008Q4) has been commonly expected to be the most enormous and serious scenario assumable. Also it has been expected that the subsequent investment adjustment process was the most serious and clearly observable, both in the depth and duration of adjustment process.

From examinations in [7] and [8] I drew five conclusions that are beyond expectation and shocking to many readers.

- (1) Either in inventory investment in 2008Q4 or in accumulated inventory stock increase since 2008Q4, the size of inventory investment increase, expected to be serious as a consequence of a rapid and drastic exogenous shock, was small, if any.
- (2) Primarily because there appeared little accumulation of inventory stock with the shock that would need for adjustment, I find in subsequent quarters no phenomena to be regarded as an “inventory stock adjustment” process. Over a long period after the Lehman Shock, we observe a long-lasting massive decline both in production and shipment, during which in many areas (or commodities) inventory investment continually recorded negative values.
- (3) Above points (1) and (2) commonly apply to many commodities, particularly to those with wild fluctuations in quarterly GDP inventory investment statistics.
- (4) Above points (1) and (2) commonly apply particularly to goods-in-process inventory investment whose influence has been overwhelming in many commodities’ quarterly GDP inventory investment fluctuations.
- (5) In some commodities like petroleum product, we observe phenomena different from (1) and (2). However, both the depth and duration of adjustment process fell far short of observers’ expectation, which is not remarkable enough to influence the all industries inventory investment, particularly its fluctuations. In those commodities, it was distribution- and raw material stock rather than product- and goods-in-process stock that was accumulated after the Shock.

The rapid and drastic shipment decline both at home and abroad after the Lehman Shock was an unexpected event for many economic agents involved. The inventory stock accumulation since 2008Q4 has been commonly expected to be the most enormous and serious scenario assumable both in its size and the duration of subsequent inventory adjustment process. Above conclusions (1)~(5) raise strong doubts about the validity of the conventional explanation that exogenous shocks like unexpected events are a primary cause of observed wild fluctuations in quarterly GDP inventory investment data.⁴⁷⁾

It is a conventional wisdom about inventory investment fluctuations that unexpected events are the primary cause of wild fluctuations in inventory investment for which long-lasting adjustment process is unavoidable. This view has activated researches on inventory investment fluctuations, to which many macroeconomists have been attracted. This view, particularly emphasizing the slow adjustment speed, has worked with the argument: “The adjustment speed of the market is much slower than the textbook economics assumes. The government should actively intervene into the market for appropriately deal with macroeconomic fluctuations due to inventory fluctuations and its adjustment, for example.” The conclusions of this research raise fundamental doubts also on this kind of view.

Above conclusions drawn from the study of the Japanese economy during the period around Lehman Shock also apply to the period of the “Financial Crisis” since the end of 1997. Concerning the

Japanese economy in this period, harmful effects on the whole economy of the collapses of major financial institutions that actually occurred and related disquiet and confusion in the overall financial system have attracted tremendous interest. The period of the “Financial Crisis” in Japan elapsed without enforcing effective policies, from the study of which I drew the same conclusions. They would have serious implications to the evaluation of government countermeasures adopted in countries represented by the US during the period around Lehman Shock.

Following Sections [4] and [5], in Section [6] I suggested: in investigating the reality of inventory investment and the fluctuations generating mechanisms where promptness is inessential, we should switch focus from the quarterly GDP estimates to the annual SNA estimates, and make active use of micro-based source statistics like IIP and *Corporate Enterprise Statistics*. The goods-in-process inventory investment (rprocess), overwhelming in wild fluctuations, particularly its regular seasonal fluctuations, of quarterly inventory investment (rtotal) reported little remarkable variations during the period after Lehman Shock. In some commodities with notable inventory accumulation it was distribution- and raw material inventory investment that dominated the rtotal fluctuations. In this point, the studies in [7] and [8] support the suggestion of [6] that raised doubts on the conventional view to emphasize the inventory investment estimates in quarterly GDP statistics, focusing on its wild fluctuations.

[9-2]. Materials from *Corporate Enterprise Quarterly Statistics Inventory Data*

As shown in [6], *Corporate Enterprise Quarterly Statistics* (CEQS) plays a critical role in obtaining the quarterly inventory investment estimates. The inventory investment, the net increase in inventory stock, in quarterly GDP statistics is estimated by commodity from business accounting inventory stock data.

Remarkable regular seasonal fluctuations are observed both in inventory stock- and its variation values from CEQS published by industry, which summarize the reports from corporations. [9-2] shows that the basic conclusion summarized in [9-1] also holds in study with inventory data from CEQS. On the relationship between the inventory investment estimates (commodity-based) of quarterly GDP statistics and the inventory data (firm-industry based) of CEQS, see the above explanation in [6].

Inventory investment in the manufacturing sector, and wholesaling- and retailing sector

The two figures (Figures 18a and 18b) for inventory investment in the manufacturing sector, shown above in [6], in 2008Q4 the level of inventory investment, either in total inventory or inventory by category, was nearly 0, lower than the previous 4th quarter average and also rather lower than the preceding 2008Q3. Simply, in 2008Q4 we observe no inventory stock accumulation. In 2009Q1, both in total inventory and inventory by category, inventory investment recorded a big negative value. The size of the decline from the preceding quarter was remarkably larger than the previous 1st quarter average. The inventory investment in the next quarter, 2009Q2, was nearly 0. By any standard, we find no notable phenomena to be regarded as vast inventory stock accumulation and subsequent inventory adjustment process expected as consequences of unexpected rapid and drastic shipment reduction as an exogenous shock. This point is clear also from the subsequent figures on accumulated inventory stock values by quarter. Inventory investment in each 2008 quarter was lower than that of corresponding 2007 quarter, and the value was still lower in 2009 quarter than in 2008 with the only exception of the 4th quarter that is slightly higher.

The same conclusion holds for the inventory investment in the manufacturing sector under the “Financial Crisis” since 1997Q4.

From the study of inventory investment in the wholesaling- and retailing sector recall Figures 20a, b and 21a, b), bearing in mind the comparison with distribution inventory investment in quarterly GDP statistics, we draw the same conclusion. Both in wholesaling- and retailing sector, in 2008Q4 inventory investment were nearly 0, rather lower than the other 4th quarter levels. In 2009Q1 inventory investment in wholesaling sector was remarkably lower than the other 1st quarter levels, which returned to 0 in the next 2009Q2. In retailing sector in 2009Q1 inventory investment was slightly below 0, and reported a big negative value in 2009Q2, and a big positive value in 2009Q3. In either sector, we find no notable phenomena to be regarded as vast inventory stock accumulation and subsequent inventory adjustment process.

The same conclusion holds for the inventory investment both in wholesaling- and retailing sector under the “Financial Crisis” since 1997Q4.

Inventory investment by industry

I report here the result of the study, using CEQS data, of five industries: petroleum- and coal product manufacturing, steel, industrial machinery manufacturing, automobile and automotive parts manufacturing, and construction. CEQS studies the inventory investment by firms in all size categories, that is, the whole industry. I use the CEQS data till 2012Q3 (unit: million yen).

Petroleum- and Coal Product Manufacturing

In petroleum- and coal product manufacturing industry, raw material inventory occupied more than 40% of the total inventory stock, and product- and goods-in-process stocks 30% and 20%, respectively. The ratio of inventory stock to the total assets had been more than 10%, which began to rise since mid-2000, reaching 25% recently.

Inventory stock value rose from 10 trillion yen to 25 trillion yen recently. Inventory investment in 2008Q4 (not in 2009Q1) recorded -1 trillion yen, corresponding to 4% of inventory stock, and -250 billion yen in 1998Q1 corresponds to 2.5%.

Before the year of 2000 fairly clear regular seasonal fluctuations were observed, which, however, are

Figure 48a Inventory Investment:
petroleum- and coal product manufacturing industry, all size, quarterly, 2006Q1~2012Q3, CEQS

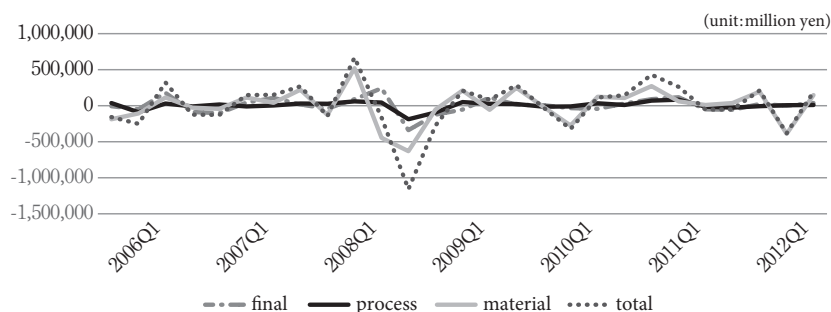
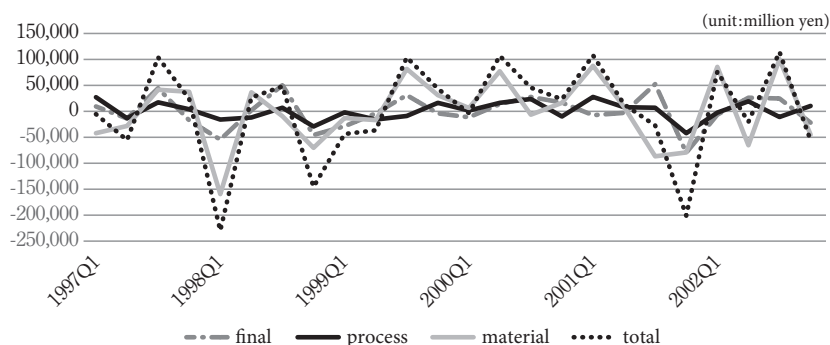
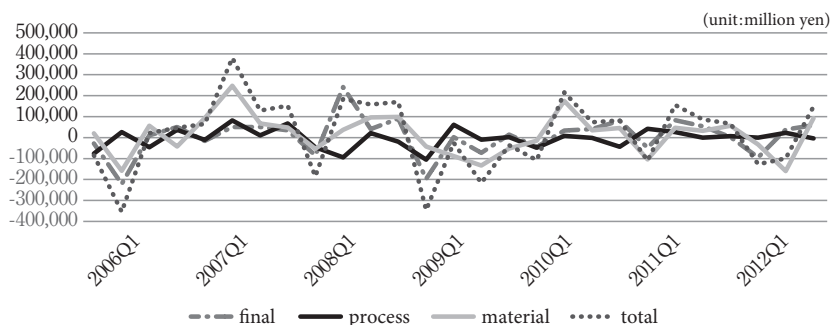


Figure 48b Inventory Investment:

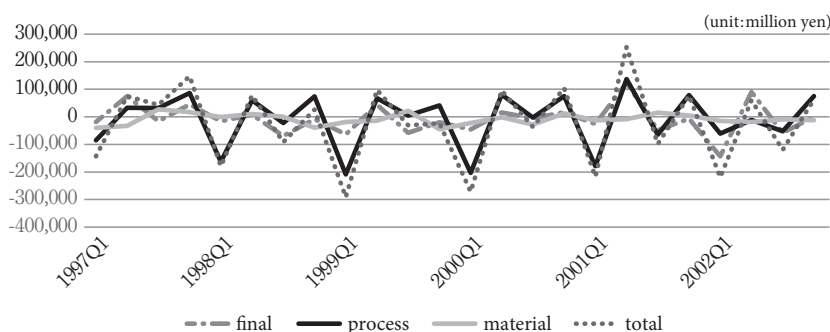
petroleum- and coal product manufacturing industry, all size, quarterly, 1997Q1~2002Q4, CEQS

**Figure 49a** Inventory Investment:

steel product manufacturing industry, all size, quarterly, 2006Q1~2012Q3, CEQS

**Figure 49b** Inventory Investment:

steel product manufacturing industry, all size, quarterly, 1997Q1~2002Q4, CEQS



not recently. Particularly, a big negative value in 2008Q4 is striking.

Accumulation of inventory stock since 2008Q4, its expected peak quarter, and subsequent stock adjustment were observed. The same applies to the period of “Financial Crisis” since 1997Q4.

Including 2011Q2, just after the Great East Japan Earthquake, in any shock periods we find no notable inventory accumulation.

Steel Manufacturing

In steel manufacturing industry, raw material inventory had occupied 35% of the total inventory stock, which rose to more than mid-40% level recently. Product inventory occupied more than 30%, and goods-in-process inventory decreased from more than 30% to less than 20%. The ratio of inventory stock to the total assets had been more than 10%, which began to rise since mid-2000, reaching 15% recently.

Inventory stock value decreased from 3 trillion yen to 2 trillion yen, and again increased to more than 3 trillion yen recently. Inventory investment in 2009Q1 recorded -300 billion yen, corresponding to 10% of inventory stock, and -300 billion yen in 1998Q1 corresponds to 15%.

Before the year of 2000 we observe fairly clear regular seasonal fluctuations, but after that we find some disarray in regularity.

Inventory investment in 2008Q4 was not particularly large, whose absolute value was by far smaller than that of corresponding negative value in 2009Q1. During the period around Lehman Shock neither notable inventory stock accumulation nor subsequent stock adjustment process was observed. The same applies to the period of “Financial Crisis” since 1997Q4.

Including 2011Q2, just after the Great East Japan Earthquake, in any shock periods we find no notable inventory accumulation.

Figure 50a Inventory Investment:
industrial machinery manufacturing industry, all size, quarterly, 2006Q1~2012Q3, CEQS

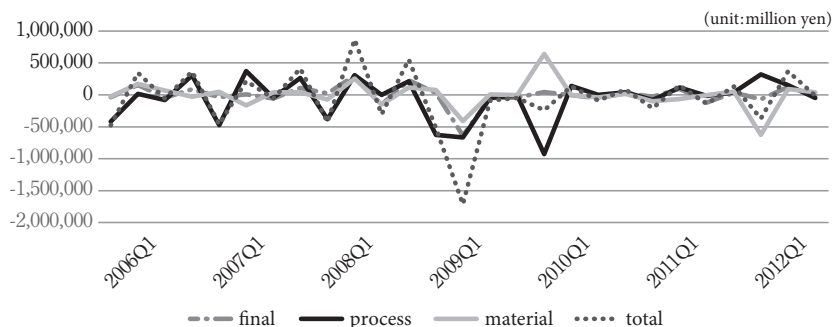
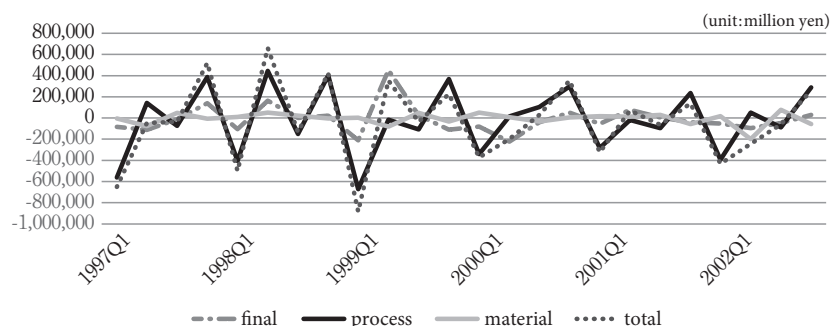


Figure 50b Inventory Investment:
industrial machinery manufacturing industry, all size, quarterly, 1997Q1~2002Q4, CEQS



Industrial Machinery Manufacturing

In industrial machinery manufacturing industry, goods-in-process inventory consistently occupied more than 50% of the total inventory stock, although after 2010 it decreased to mid-30%, returning to the former level recently. The share of product inventory decreased from more than 30% to more than 20% and again rose to 25% recently. That of raw material inventory remained stable at less than 20%, with the exception of less than 40% in 2010~2011. The ratio of inventory stock to the total assets has been more than 10%.

Inventory stock value underwent a lot of changes between 3 trillion yen and 6 trillion yen. Inventory investment in 2009Q2 recorded -1.7 trillion yen, which corresponds to 30% of 6 trillion yen, inventory stock value of 2008Q4 (previous peak). -910 billion yen in 1999Q1 corresponds to 20% of the inventory stock value at the same period.

We observe a regular seasonal fluctuation consistently, although sometimes fluctuation range changes remarkably. Fluctuation range does not necessarily expand during shock periods.

No remarkable inventory investment increase in 2008Q4 was observed, and it recorded a large negative value in 2009Q1. Neither during the period around Lehman Shock nor around the "Financial Crisis" we find remarkable inventory stock accumulation or subsequent stock adjustment process. No such phenomenon was observed after the Great East Japan Earthquake.

Automobile and Automotive Parts Manufacturing

In automobile and automotive parts manufacturing industry, the share of goods-in-process inventory to the total inventory stock rose around 2000 from mid-30% to more than 40%, and remained less than 40% since then. The share of product inventory decreased gradually from less than 50%, and since 2000 remained stable at 40%. That of raw material inventory rose from less than 20% to more than 20% in mid-2000, further rising to less than 30%. The ratio of inventory stock to the total assets decreased from 7~8% to 5% and became stable.

Inventory stock value consistently reports 25 trillion yen, of which 500 billion yen, the absolute value of inventory investment both in 2007Q2 and 2009Q1, corresponds to 2%, and 400 billion yen, its maximum absolute value during the period around 2000, less than 2%.

We consistently observe a regular seasonal fluctuation with stable fluctuation range.

We observe no remarkable inventory investment increase in 2008Q4, but its big negative value in 2009Q1. Neither during the period around Lehman Shock nor around the "Financial Crisis" we find remarkable inventory stock accumulation or subsequent stock adjustment process. No such phenomenon was observed after the Great East Japan Earthquake.

Construction⁴⁸⁾

In construction industry, goods-in-process inventory occupied 80% of the total inventory stock, and raw material inventory 16~17%. The ratio of inventory stock to the total assets has consistently decreased from 30% to the recent value of 15%.

8 trillion yen, the maximum absolute value of inventory investment in the second half of the 1990s, corresponds to 25% of more than 30 trillion yen, the inventory stock value of the time. Although in the second half of the 2000s the maximum absolute value decreased to 4 trillion yen, the ratio did not de-

Figure 51a Inventory Investment:
automobile and automotive parts manufacturing industry, all size, quarterly, 2006Q1~2012Q3, CEQS

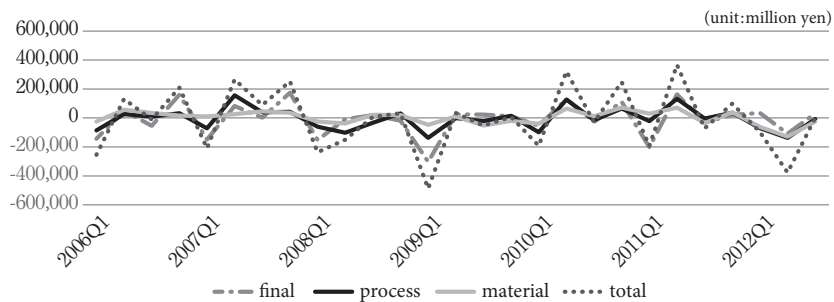


Figure 51b Inventory Investment:
automobile and automotive parts manufacturing industry, all size, quarterly, 1997Q1~2002Q4, CEQS

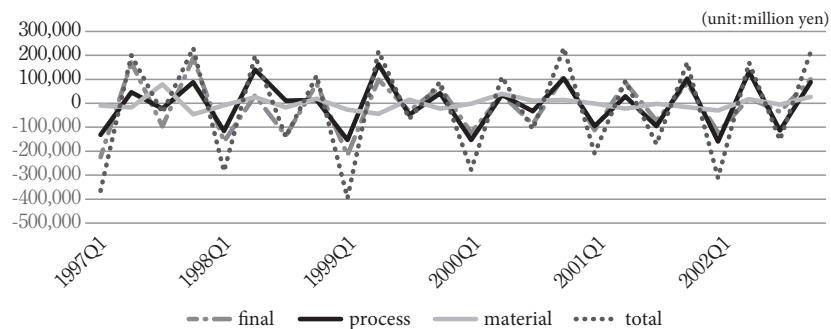
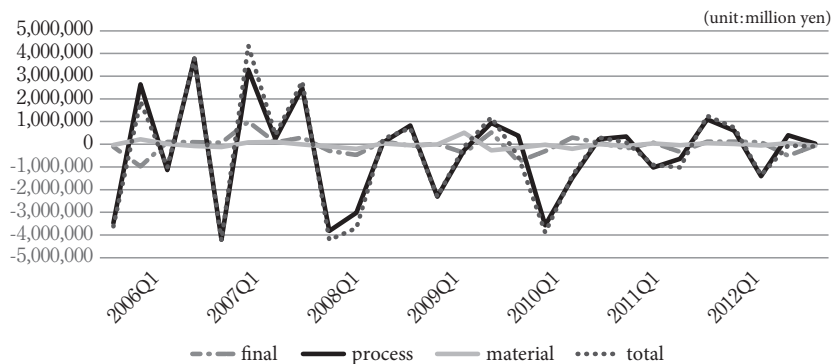


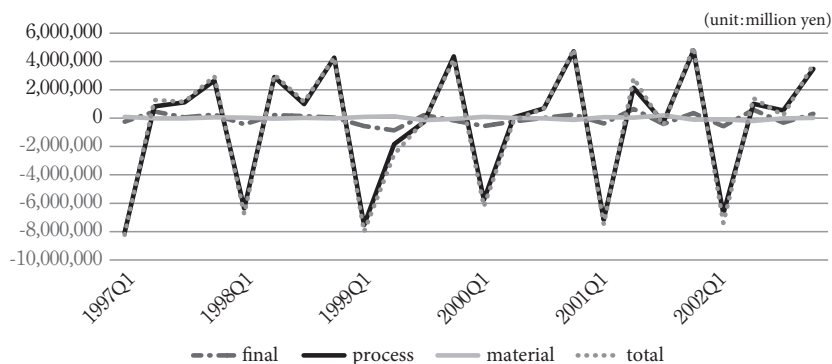
Figure 52a Inventory Investment: construction industry, all size, quarterly, 2006Q1~2012Q3, CEQS



crease as the inventory stock value became less than 15 trillion yen.

As a whole we observe a consistent and clear declining trend in inventory stock value, on which we observe an M-shaped regular seasonal fluctuation. The decline trend became more impressive since 2008.

We observe no remarkable inventory investment increase in 2008Q4, but its big negative value in 2009Q1. Neither during the period around Lehman Shock nor around the “Financial Crisis” we find re-

Figure 52b Inventory Investment: construction industry, all size, quarterly, 1997Q1–2002Q4, CEQS

markable inventory stock accumulation or subsequent stock adjustment process. No such phenomenon was observed after the Great East Japan Earthquake.

[9-3]. METI's *Indices of Industrial Production Forecast* and BOJ's *Tankan Annual Projections*

Sections [7] and [8] studied Japanese firm's inventory investment behavior, focusing on the consequence of exogenous shocks and subsequent stock adjustment process, like the Japanese economy under an unexpected situation with rapid and drastic demand decline after the Lehman Shock. The conclusions of the study raise serious questions on the validity of the leading view that exogenous shocks like unexpected situations are effective explanation for observed wild fluctuations in quarterly inventory investment.

Readers would be surprised at the conclusions, together both with the previous conclusions about regular seasonal fluctuation in quarterly GDP statistics summarized in [6] and the observation from *Indices of Industrial Production* reported in [2] that monthly indices of shipment and production behave in unison. Some would be confronted with following puzzle: "How long will it take for producers to recognize such a sudden demand decline, to determine countermeasures upon managerial judgment drawn from newly collected information about its size and duration, and coordinating actions both with sections inside the firm and with contracting partners? It must take a fairly long time to effectively enforce appropriate countermeasures in production. How such prompt responses are feasible? Is it actually possible to enforce them effectively?"⁴⁹⁾

As reference materials for studying this puzzle, [9-3] reports the investigation results of METI's (Ministry of Economy, Trade, and Industry) *Indices of Industrial Production Forecast* and BOJ's *Tankan* (Short-term Economic Survey of Enterprises in Japan) "annual projections", focusing on the revision process in production- or business plans during the period after shocks.

Indices of Industrial Production Forecast surveys 195 commodities from *Manufacturing Industry Production Forecasting Survey*. It is a monthly survey of firms selected from large producers in decreasing order of production volume to the cumulative total of 80% in each commodity under survey. At the end of every month it surveys the actual production of previous month, the production plan for the present month, and the production plan for the next month, whose deadline is the 10th of the present month, and the response rate 100%.⁵⁰⁾

I report here two figures on the whole manufacturing sector, for 2008~Nov. 2011.

Figure 53 shows the actual production (hereafter, Actual), production plan for the present month (Present), and production plan for the next month (Next) of each month. For example, on the vertical direction on 200901 (January 2009) readers find three values: Next reported on 10 December 2008, Present reported on 10 January 2009, and Actual reported on 10 February 2009.

Until February 2009 when production decreased drastically, Present was slightly higher than Actual, and Next higher than Present, in some cases more than 10% higher. Even after Actual reversing a downward trend, it took a month for Present to reverse the trend, and more for Next.⁵¹⁾

Two points are particularly important. First, two indices of production plan (Present and Next) began to decrease immediately when the actual production index (Actual) began to decrease. Second, along such a rapid and drastic production decrease process, three production indices did not significantly deviate. Those points suggest that production plans are appropriately formulated and flexibly revised even on monthly base.

The next Figure 54 illustrates the degree of attainment of Next, for which I obtained three indices: rate of forecast revision (RFR)=(Present-Next)/Next*100, degree of attainment (DA)=(Actual-Present)/Next*100, and degree of attainment 2 (DA2)=(Actual-Next)/Next*100 (=RFR+DA).

During the period after Lehman Shock, DA reported -7%, the largest absolute value, in January 2009, and DA2 reported -15% in March 2009 when DA-3%. Not only during the period of drastic demand decrease but also after the reversion of declining trend, all the indices recorded negative values, that is, Present and Next remained below Actual. Moreover, Next was revised to more pessimistic Present, which was still optimistic than Actual. In this sense, production plans are flexibly revised even on monthly base, but not sufficiently accurate.

The absolute values of those indices after the Great East Japan Earthquake exceeded the maximum absolute values after the Lehman Shock.

Next, I report from the study of BOJ's *Tankan* "annual projections". BOJ's *Tankan* is a quarterly survey on more than 10,000 firms, conducted in June, September, December and March of the next year, of which "annual projections" is a part. I use here annual sales projections, for which, dividing a year (actually fiscal year beginning in April) into two periods, from April to September (1st half year)

Figure 53 Indices of Production Forecast and Realization: manufacturing sector

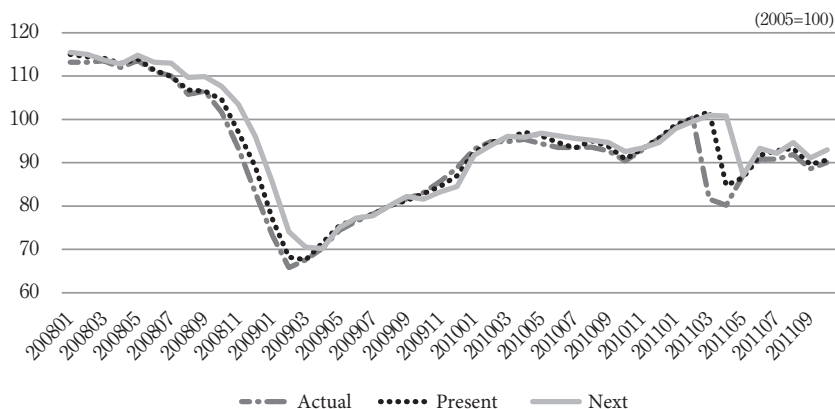


Figure 54 Revision- and Realization Rates of Production Forecasts:
manufacturing sector

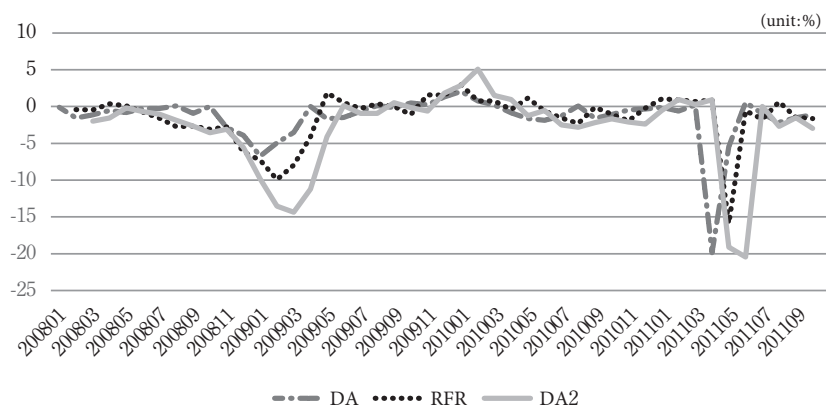
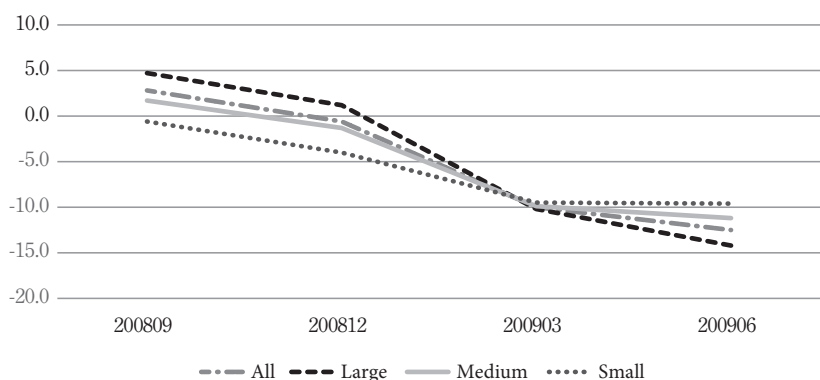


Figure 55 Revisions and Realization of Annual Sales Plan:
FY2008-2H, manufacturing, year-to-year change (%), BOJ



and from October to next year's March (2nd half year), it surveys production plans (projections) six times in total. For example, on the sales projections for the 1st half year of FY(fiscal year)2008, it surveys in March, June, September, December of 2008 and March and June of 2009. The March survey is conducted in February and March, and called the March issue.

Here I focus on the 4,500 firms in the manufacturing sector. Firms are divided into 3 categories by the size of paid-in capital: large firms with more than 1 billion yen, medium sized firms with 100 million~1 billion yen, and small firms with 20 million~100 million yen. For each three category and all firms, I create indices for change in sales projections or actual sales on year-over-year basis (%).⁵²⁾

Two points are of our primary concern: At what time sales projections are revised in such a turbulent period as the Lehman Shock?; and is there any difference by firm size in the timing and revision range?

Figure 55 shows the result focusing on the 2nd half of FY2008 which is the only place we find notable revision during the period around Lehman Shock.

Annual sales projections for the 2nd half of FY2008 began to drastically decrease in December sur-

vey, accelerated in the March (of 2009, the end of the fiscal year) survey, and further revised downward in June survey. Comparison with the above mentioned monthly *Indices of Industrial Production*, it tells that projection revision developed in parallel with actual production. Indices by firms size tells that in smaller firms the rate of production decline was smaller and the start of projection revision earlier.⁵³⁾

[10]. Implications

Quarterly SNA inventory statistics, both in estimating process and substance, is diverse across countries

Using Japanese data, this study investigates the inventory investment of Japanese firms and industries and related observations. Obviously, the conclusions are involved directly in the Japanese phenomena during the period under study. Nonetheless, the content and conclusions of this study would have important implications in multiple research issues in many countries outside Japan, including inventory investment related statistics and phenomena, the relationship between inventory investment- and macroeconomic fluctuations, and the effectiveness of monetary policy.

The statistics generation, both in the choice in estimation method and in the content, is subjected to various restrictions, particularly that of the source statistics availability including the timing of their availability. The quarterly GDP inventory investment estimates in Japan, the principal examination object of this study, is no exception. Particularly, in countries other than Japan, quarterly SNA statistics produced in response to strong demand emphasizing promptness, including “changes in inventories” or inventory investment, seem to be estimated under constraints stricter than Japan. Either in or outside Japan, inventory investment estimates and researches using them have rarely been closely examined, focusing even on the biases and tics they might include, through tracing back to source statistics and their uses.

OECD [2012, p.14] explains that only eleven OECD countries utilize enterprise surveys in estimating “changes in inventories”, only part of which are allowed to use both monthly- and quarterly statistics as the situation demands, like in Japan where together with *The Census of Manufacturers* (annual) as the basic framework, quarterly statistics like *Corporate Enterprise Quarterly Statistics* and monthly *Indices of Industrial Production* (IIP) based on *The Current Survey of Production* are all available. For example, seven countries “derive total stock change as a residual by deducting all other components of final expenditure from total GDP”. Therefore, OECD offers a caution: “If applied uncritically, all errors in other estimates accumulate in the estimate for changes in inventories.”⁵⁴⁾

Now many readers are careful enough not to rivet their eyes on the relationship between wild fluctuations in quarterly SNA inventory investment data and macroeconomic fluctuations, without careful examination of accurate correspondence and deviations between various statistics like “inventory investment estimates” and the reality of inventory stock or inventory investment behavior.⁵⁵⁾

For inventory investment data estimation, Japan is an ideal OECD country, with generous source statistics availability.⁵⁶⁾ I do not argue that the conclusions of this research, drawn from the Japanese quarterly GDP inventory statistics, directly apply to studies in other countries. I do not argue that a similar situation or more serious situations are present (and left unnoticed and untouched) in many countries, either. I believe, however, many readers recognize that they will stimulate the interest both in the

study of inventory data in other countries focusing on its estimation process and source statistics, and in the great variety of inventory investment. It is my hope that pretty soon comparative investigation over relevant information from many countries becomes feasible.

This research investigated both the inventory investment behavior of Japanese firms and related statistics, covering multiple areas such as estimation methods and actual content of statistics, notes and restrictions in its use, and use of related studies. The conclusions raise important issues including those for reexamination of previous studies and reconstruction of relevant statistics, from the problem setting for inventory investment research to the examination and use of their results. A proposal of this research mentioned in [9-1] suggests a future direction: In investigating the reality of inventory investment and the fluctuations generating mechanisms where promptness is inessential, we should switch focus from the quarterly GDP estimates to the annual SNA estimates, and make active use of micro-based source statistics like IIP and *Corporate Enterprise Statistics*.

Diverse content of inventory stock and inventory investment

Both the study of Japanese quarterly GDP inventory investment estimates and the investigation of the consequence and subsequent inventory stock adjustment in Japan expected to occur in response to a large exogenous shock after the Lehman Shock raise strong doubts at least concerning Japan on the validity of assumption that inventory investment fluctuation is a major cause of macroeconomic fluctuation. This conclusion has important implications both for the evaluation of previous studies on inventory investment and its fluctuation and for the direction of relevant future studies.

The intensity and magnitude of fluctuations in quarterly GDP inventory investment estimates has not accurately reflected the actual inventory investment fluctuation. Instead, it has vastly overstated the actual fluctuations, and moreover both the direction of included deviations and its degrees are unclear. Focusing on this, many researchers would recognize that the importance of investigation on inventory investment behavior and its fluctuation primarily based on quarterly SNA inventory statistics would decrease significantly. At least, growing interest would be directed to the substance of related statistics and the search for alternative sources of appropriate information.⁵⁷⁾

Fluctuation in goods-in-process inventory investment is dominant in wild fluctuation in quarterly GDP inventory investment statistics, which disappears in annual GDP inventory investment statistics almost completely. In annual statistics, the influence of goods-in-process inventory investment radically decreases, and instead that of distribution- and raw material inventory investment become dominant. When researchers switch the focus of examination from quarterly- to annual estimates, both the basic image of inventory investment and the study objectives will accordingly change, switching the focus of attention from goods-in-process- (and product-) to distribution- and raw material inventory investment.

Raw material inventory stock in SNA statistics is not the value of raw material stock held by manufacturers of the commodity in question, but the value of stock of commodity in question held as raw material inventory stock by its users.⁵⁸⁾ For this reason, either for distribution- or raw material inventory stock, enterprise surveys on production and inventory focusing on manufacturers which are widely used in many countries, such as *The Census of Manufacturers* and *Indices of Industrial Production* in Japan and *Survey of Current Business* in the U.S., cannot be directly used.

For example, Feldstein and Auerbach [1976] investigated “the behavior of inventories in durable-manufacturing industries, the most volatile components of business inventories”, focusing on “the real value both of finished-goods inventories and of the inventories of purchased materials and goods in process” (p.352). On this research design, in addition to above mentioned issue of choice in the materials and focus of study, from observations in Japan after the Lehman Shock this paper raises a question about the validity of assumed judgment that inventory investment in durable-manufacturing industries is “the most volatile components of business inventories”.⁵⁹⁾

Further implications...

Together with the conclusion that the quarterly GDP estimates overemphasize the inventory investment fluctuations, the study of exogenous shocks, focusing on the situation after Lehman Shock, on the inventory stock accumulation as a consequence and subsequent adjustment process have important implications on multiple fronts. What follows is a part.

The conclusions have an impact of the basic understanding and studies on the market function and its “imperfections”. A leading theory argues: Unexpected shocks and errors in prediction result in vast amount and value of inventory stock accumulation, for which long-term adjustment process follow; these processes has been a major cause of wild macroeconomic fluctuations. The conclusion of this study raises a serious doubt to this theory, suggesting that it overemphasizes the “imperfections” in the market’s supply-demand adjustment function.⁶⁰⁾

This study of inventory investment and related statistics might have a big impact on the debates over the effectiveness of monetary policy, including the one over “financial accelerator”. The Fall 1995 issue of *Journal of Economic Perspectives* featured articles on Monetary Transmission Mechanism. Following Introduction (Mishkin, 1995) and Taylor [1995], Bernanke *et al.* [1995, p.27] write at the opening: “Most economists would agree that, at least in the short run, monetary policy can significantly influence the course of the real economy. ... There is far less agreement, however, about exactly how monetary policy exerts its influence: the same research that has established that changes in monetary policy are eventually followed by changes in output is largely silent about what happens in the interim. To a great extent, empirical analysis of the effects of monetary policy has treated the monetary transmission mechanism itself as a ‘black box’.”

From the long-term debate over various issues, I focus on the following point on “financial accelerator”.⁶¹⁾ Blinder and Maccini [1991, p.82] point: “[L]ittle influence of real interest rates on inventory investment can be found empirically.” To this, Kashyap *et al.* [1994], examining the inventory investment behaviors in the US manufacturing sector during 1981–1982 recession, refute that monetary policy had effect through effect on inventory investment by small businesses. This argument, by way of researches including Gertler and Gilchrist [1994], developed to Bernanke *et al.* [1996, 1999]. The latter, “The Financial Accelerator in a Quantitative Business Cycle Framework” in *Handbook of Macroeconomics*, Volume 1, declares at the opening (p.1343)⁶²⁾: “The principal objective ... is to show that credit-market imperfections can be incorporated into standard macroeconomic models in a relatively straightforward yet rigorous way”.

Bernanke *et al.* [1996] write at the opening: “The ‘small shocks, large cycles’ puzzle motivates our paper” (p.1), and argue that “credit-market imperfections”, exerting serious impact discriminatorily on

small businesses, have grave impact on inventory investment behavior, particularly of small businesses. They continue: "We refer to the amplification of initial shocks brought about by changes in credit-market conditions as *the financial accelerator*."

The "imperfections" and constraints in financial market have been debated actively, using such various expressions as credit-market imperfections, liquidity constraint, and financing-constraint. However, little has been achieved empirically in related studies, many readers recognizing the problems "largely unsolved" (Blanchard, 2009, p.216).⁶³⁾

Even if a leading argument on credit-market imperfections is theoretically valid, the empirical conclusions of this research raise strong doubts on the effectiveness of financial accelerator theory.⁶⁴⁾

[11]. Conclusion

Knowledge is not like a stock or ore, sitting there waiting to be mined. It is an extremely heterogeneous assortment of information in continuous flux. Only a small part of it is of any use to someone at a particular point of time, and it takes effort and resources to access, retrieve, and adapt it to one's own use. ... A major aspect of learning is that the unknown keeps expanding as we learn. This should be looked at positively. It is much better this way...especially for those of us who are engaged in research" (Griliches, 1994, pp.16, 18).

The above commentary of Professor Zvi Griliches, from his presidential address to the American Economic Association, entitled "Productivity, R&D, and the Data Constraints", in January 1994, applies directly to macroeconomic fluctuations, inventory investment, firm behavior, and the market functions.

Readers may have a negative image with this research, strongly impressed by examining critically and raising grave and destructive questions to the conventional wisdom about the macroeconomic fluctuations, particularly inventory investment fluctuations, inventory investment, firm behavior, and the market functions. Nonetheless, not a few readers would strongly recognize the importance of the liberation from the restraint and spell of wrong conventional wisdom, I believe.

For more than half a century, inventory investment has attracted wide attention of macroeconomists as a major cause of short-term macroeconomic fluctuations. Studies of past quarterly data often conclude that too high or too low inventory stock took on average 8 or 12 quarters for adjustment, and repeatedly the processes and mechanisms involved have become the focus of many major studies. Emphasizing the long-lasting adjustment process for resolving accumulated inventory stock (in fact of not so big size), many conclude that "the market adjustment does not work so quickly as many economists assume, and its supply-demand adjustment is not so effective and efficient." Yet microeconomists and business people familiar with corporate behavior have frequently expressed misgivings about the enterprise.

Going into the data estimation process and source statistics, this research investigated the quarterly SNA (GDP) inventory investment statistics on which most inventory studies primarily depend. From two perspectives this research investigated for 1994–2010 the inventory investment statistics and inventory investment behavior in Japanese industries, the conclusions of which raise grave doubts on the leading view of inventory investment research.

Even among OECD countries, quarterly SNA inventory investment statistics varies widely both its

availability and the substance in estimation method and source statistics, which also varies at different periods. In addition, like the two quick estimates and two final estimates in Japan, often there are more than one set of quarterly SNA estimates. For this reason, in this paper I focus on the 1st final estimates of Japan during the period after adopting 93SNA, and hope for comparable study results on other countries.

Japan during this period is an ideal OECD country for quarterly SNA inventory investment statistics, with generous source statistics availability and well-established estimation method. For this research I am allowed to use estimates both by commodity and by inventory category that are obtained as intermediate product for quarterly SNA inventory investment estimates. In addition, in Japan various inventory-investment-related information is available as complimentary materials.

A leading basic view of inventory investment that it fluctuates wildly is widely accepted, which forms the common basis for research on inventory investment behavior. The first subject of the study is the examination, going into the data estimation process and source statistics, of inventory investment statistics, focusing on the causes of fluctuations. The conclusion of the first study subject raises a grave doubt on the validity of this basic view: A dominant portion of wild fluctuation we observe in quarterly GDP inventory investment statistics is due to its estimation process and source statistics, and at least in Japan the quarterly GDP inventory investment statistics does not accurately report the reality of inventory investment behavior. From this, I conclude: In investigating the reality of inventory investment and the fluctuations generating mechanisms where promptness is inessential, we should switch focus from the quarterly GDP estimates to the annual SNA estimates, and make active use of micro-based source statistics like IIP and *Corporate Enterprise Statistics*.

The conclusion of the first study subject raises a strong doubt on the validity of a leading basic view of inventory investment behavior. As the second study subject, I examine the validity of this basic view through a detailed case study. Focusing on the Japanese economy during the period after Lehman Shock in the fall of 2008, I closely investigated the inventory stock accumulation and subsequent inventory stock adjustment process the leading view strongly expected to occur in response to a rapid and drastic demand decline, an unexpected exogenous shock. Even in such a situation where the most serious consequence must have occurred, little inventory stock accumulation was observed in many industries and the industry as a whole, and no remarkable fluctuations to be regarded as its adjustment process was found, either. Those results also raise serious doubts on the leading basic view of inventory investment that it fluctuates wildly. This conclusion is consistent both with an alternative view of inventory investment as part of rational corporate behavior and with observations drawn from micro-based source statistics.

The conclusions of this research, drawn from the Japanese quarterly GDP inventory statistics, will stimulate the interest both in the study of inventory data in other countries focusing on its estimation process and source statistics, and in the great variety of inventory investment. At the same time, the conclusions pose a serious doubt on the validity of the basic view of inventory investment that it wildly fluctuates, leading to its re-examination. The conclusions pose a grave implication not only for re-evaluation of the literature in inventory investment variations but also for other research topics in macroeconomics like monetary transmission mechanisms including “financial accelerator” theory. “This should be looked at positively. It is much better this way...especially for those of us who are engaged in re-

search" (Griliches).

[12]. (Appendix): Inventory Investment Decision-making Process, Inventory Investment Function, and Data Availability Constraint

With wild fluctuations, particularly with huge share of fluctuations in GDP in contrast to a tiny fraction of its size in GDP, quarterly SNA (GDP) inventory investment statistics has attracted wide attention among economists and business people as a major cause of violent macroeconomic fluctuations. The conclusions of this research, that fluctuations in quarterly SNA inventory investment statistics has not appropriately and accurately corresponded to the reality of inventory investment and that inventory stock accumulation and its subsequent stock adjustment due to exogenous shocks and prediction failures have been significantly smaller than the conventional wisdom assumes, will decrease not only in Japan but also all over the world the interest in studies on the reality of inventory investment fluctuations and mechanisms involved. The research direction and objectives might experience a major change as well.

Notwithstanding, interest on the inventory investment decision-making mechanism, and on specification and estimation of inventory investment function will never disappear. It is indispensable to constructing econometric macro-models. Although not within the agenda of this research, for reference materials for those future challenges, in [12] I record related points I found on the way of this research, at the end illustrating a risk of neglecting the influence of regular seasonal fluctuations I emphasized.

Whose inventory and what category of inventory?

There is a wide range of variations in inventory, inventory stock, or inventory investment. Even if it may be useful for simplicity, it will incur a tremendous cost to assume that the same mechanism for all inventory and study the decision making mechanism in representative inventory investment behavior formulation. It might be more serious in inventory investment function than in equipment investment function.

Either for annual- or quarterly SNA (GDP) statistics, inventory investment value is estimated, by four categories of raw material-, goods-in-process-, product-, and distribution inventory, respectively, with different method and from different source statistics.⁶⁵⁾ In addition, principal decision-making agent of inventory investment varies greatly, by industry and commodity, by time period, and by inventory investment category. Facing a considerable diversity in inventory, both specifying and estimating the inventory investment function must proceed with difficulty. Neglecting the diversity will be risky and incur a huge cost.

The influence of goods-in-process inventory investment fluctuations is overwhelming in quarterly GDP inventory investment statistics, which almost entirely disappears in annual statistics. In annual statistics, the fluctuations in total inventory investment by themselves decrease remarkably, where distribution- and raw material inventory become dominant. Distribution inventory primarily held by distribution firms and goods-in-process by manufacturers are basically different in decision-making firms and also in decision-making mechanisms.⁶⁶⁾

Who makes decisions? How interests of firms are coordinated?

Researcher will face a tough challenge of how to deal with the cooperation- and rivalry relations among firms involved.

No one would deny the basic framework to analyze the inventory investment and its fluctuations as part of optimizing behavior of rational decision-making agents. However, each industry is composed of multi-stages (manufacturing- and distribution process, respectively, is usually multistage), and also is mutually interdependent and works closely with neighboring industries. Even under severe constraints of data availability, many researchers feel odd as excessively simplified assumption about a basic choice to explain inventory investment fluctuations (in macro-data) as a consequence of specific agents' (quite often, an agent's) optimizing behavior.

For example, many manufacturers of automobile, auto parts, raw material, and production equipment, together with many distributors, transportation-, and finance companies, participate in the automobile production-distribution process. Suppose the total automobile inventory investment optimization problem. Who plays the leading role in this optimization decision making? How it is enforced, coordinating the interests of participants involved? Typically an auto parts manufacturer trade with multiple automobile manufacturers. The same holds for trades between auto parts- and materials manufacturers, and automobile manufacturers and production equipment manufacturers. An automobile dealer does not always trade with an automobile manufacturer.

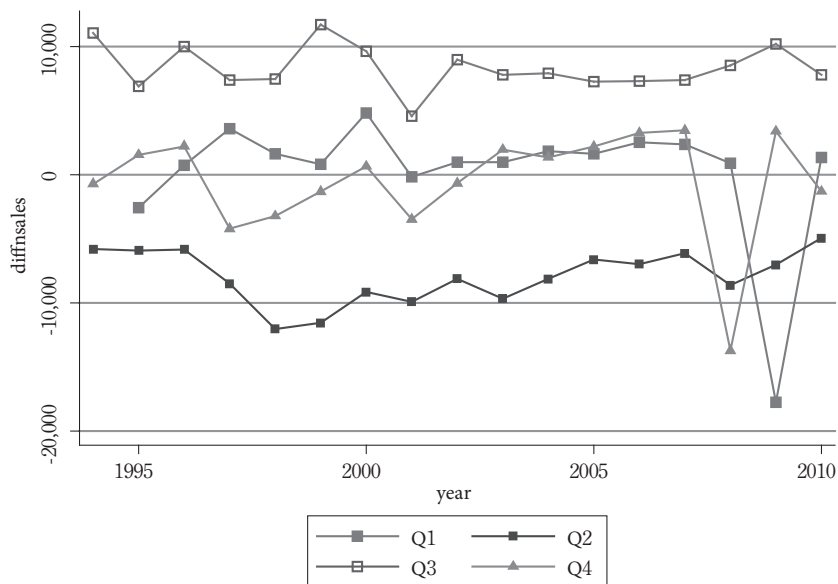
Obviously, it incurs a huge cost for an automobile manufacturer to enforce its "optimization policy" to pursue its own maximum profit, neglecting the interests of auto parts- and materials manufacturers and distributors. Even if an automobile manufacturer tries its best in coordinating the interests of various firms included, its decision on such a vastly complicated problem like the one of centralized planned economy will not be blessedly accepted by most participants. The one finally reached will be significantly different from the solution of a single agent's optimization problem.

This research used the quarterly GDP inventory investment statistics by four inventory categories and by ninety one commodities, with which I could focus on some aspects of the interdependent relations on the production-distribution process. As part of the results, I find that the influence of goods-in-process inventory is overwhelming in quarterly inventory investment statistics, while that of distribution stock is dominant in annual statistics. Notwithstanding, no effective measure to investigate such following issues are not available, yet: Who are the leading decision makers?; How the interests of firms involved are coordinated?; and What actually occur on the spot? For an effective challenge in studying the inventory investment decision making mechanisms and in specifying and estimating inventory investment function, researchers need to prepare themselves for the possibility of encountering and struggling with those difficulties.

A tragic comedy?: consequence of neglecting regular seasonal fluctuations

Last of all, I illustrate a picture, a situation like a tragic comedy that will result as a consequence of neglecting regular seasonal fluctuations. Suppose that a researcher estimates an inventory investment function on the basis of a view that inventory stock level is adjusted so as to maintain a constant ratio of shipment value (or inventory stock works closely with shipment value).

Next figure shows the all industries' quarter-over-quarter change in nominal shipment value (diffn-

Figure 56 Movement by quarter of all industries diffnsales

sales: real shipment value is unavailable), from Q1 to Q4 separately. We find a similar kind of regular seasonal fluctuations like in inventory investment shown above in [5], e.g., Figure 13.

Note the relative positions of each quarter's line, which is different from the inventory investment's lines. The line with small black box (■) almost always at the bottom indicates the Q2 estimates, the line with large white box (□) on the top the Q3, the line with large black box (■) and the line with small black triangle (▲) both at the middle the Q1 and Q4, respectively. With the exception of the values in 2008Q4 and 2009Q1, the relative positions remain extremely stable, implying that there is a clear and stable regular seasonal fluctuation.

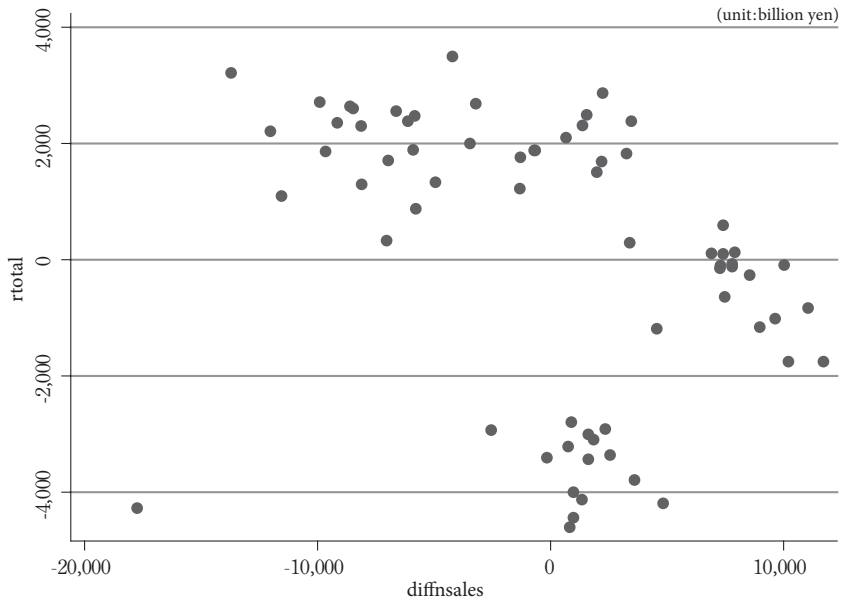
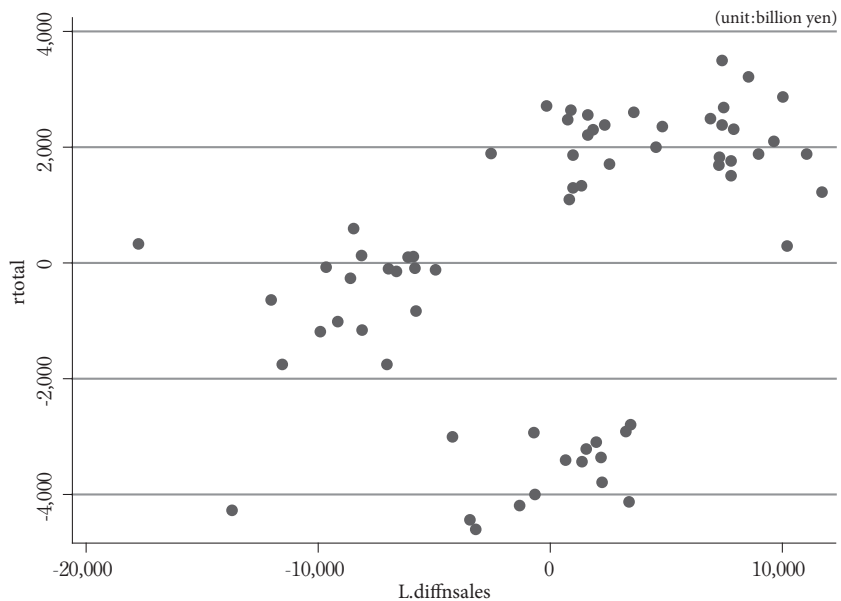
Suppose calculate the coefficients of correlation between diffnsales and rtotal, including lagged variables, neglecting the existence of regular seasonal fluctuations. Due to strong influence of regular seasonal fluctuations, we expect to find statistically significant coefficients, with sign reversals depending on the choice in lag-structure.

Next three figures shows the scattered diagrams for rtotal on the vertical axis and diffnsales on the horizontal axis, and the first figure for no-lags, the second for -1 lag for diffnsales (L. diffnsales), and the third for +1 lag for diffnsales (F. diffnsales). Readers who argue the forward-looking behavior of firms might be satisfied with the result of the third figure.

As expected, with diffnsales we find a negative correlation. The correlation coefficient is $\rho = -0.3621$.

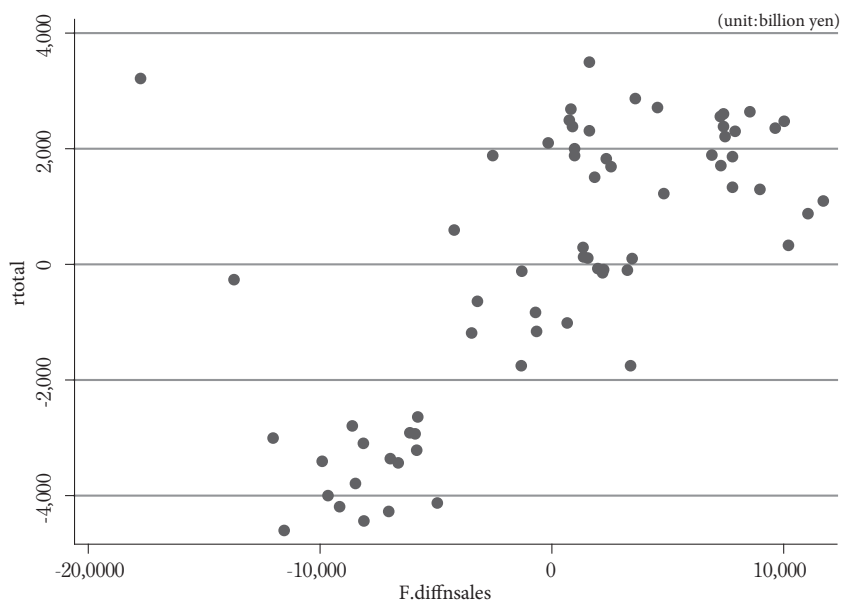
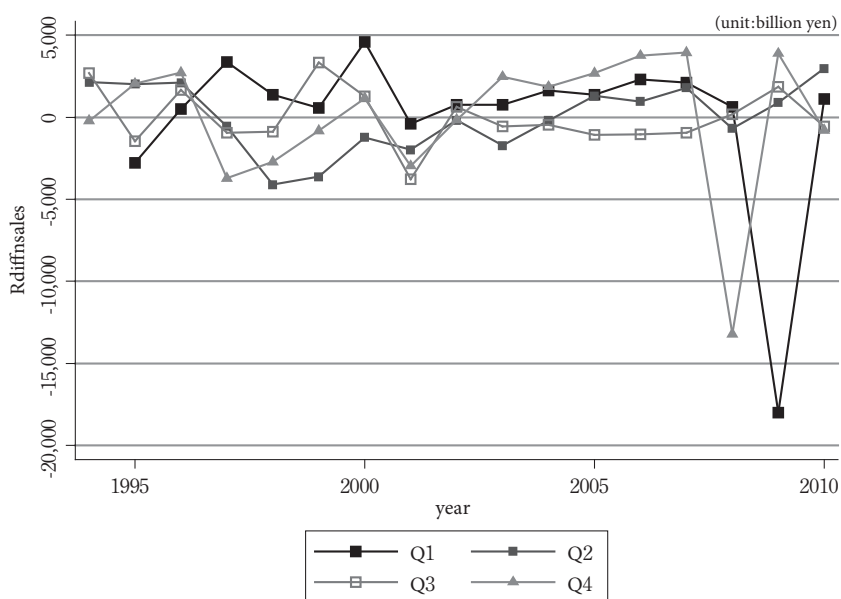
As expected, with L. diffnsales we find a positive correlation. The correlation coefficient is $\rho = 0.4206$. Some readers might think that firms tend to replenish inventory stock with one quarter lag.

Among the 3 cases, the correlation coefficient is the highest in this case with F. diffnsales, with positive sign, $\rho = 0.6799$. Some readers who argue the forward-looking behavior of firms might be very much satisfied with the result. The t-value of the regression coefficient in a simple regression is 7.48, and adj. $R^2 = 0.4541$.

Figure 57a L. diffnsales vs. rtotal: all industries, 1994~2010**Figure 57b** L. diffnsales vs. rttotal: all industries, 1994~2010

Replacing the vertical axis variable to Rrtotal (revised rttotal), three correlation coefficients become -0.0991, 0.1869, and 0.0937. As expected, all coefficients are statistically insignificant.

Next Figure 58 shows the all industries revised quarter-over-quarter change in nominal shipment value, Rdiffnsales, from Q1 to Q4. Rdiffnsales is obtained by subtracting its average quarterly value

Figure 57c F. diffnsales vs. rtotal: all industries, 1994~2010**Figure 58** Movement by quarter of all industries Rdiffnsales

from estimates in each quarter, as in [5].

Three correlation coefficients between rtotal (as in the first three cases) and Rdiffnsales with lag of 0, -1, and +1 are -0.0550, 0.0961, -0.0528, respectively. As expected, all coefficients are statistically insignificant.

Last of all, three correlation coefficients between Rrtotal and Rdiffnsales with lag of 0, -1, and +1

are -0.1943, 0.3644, -0.1853, respectively. Now the second one with -1 lag is statistically significant, with positive sign. Replacing lags (-1, +1) with (-2, +2), the absolute values to the correlation coefficients increase to 0.3709 and -0.2319, respectively.

Nobody hopes to see this kind of study report to appear, particularly emphasizing the first three cases, I believe.

- 41) In November 1997 "Financial Crisis" suddenly grew apparent in Japan. It was on 22 November 1997 that Yamaichi Securities gave up the idea of self-resuscitation, on which many Japanese clearly remember the apologizing press conference by the newly appointed president. On November 3 Sanyo Securities filed a bankruptcy-reorganization plan, on 17th Hokkaido Takushoku Bank announced that, giving up the idea of self-resuscitation, it transferred business to Hokuyo Bank, and on 26th of the same month Tokuyo City Bank gave up the idea of self-resuscitation on which the Finance Minister and the Bank of Japan Chairman released statements. For more details, see Miwa [2008, pp. 6–8].
- 42) "If not for the adjustment of accumulated inventory stock, what caused this dramatic total decline and its continuation?" emerges to readers as a new puzzle. It is not an agenda of this study, however. By association, see the Appendix (Section [12]) of this paper.
- 43) Real shipment value data is unavailable, and instead I use the nominal shipment value data. For this, 18 days may be slightly overvalued.
- 44) If the process started from 40 billion yen at T, the difference reduces to 100 billion yen, corresponding to 28 days' shipment.
- 45) I will not repeat below, but readers should note that this point applies to almost all commodities with the exception of petroleum- and non-ferrous metal product and apparel, and also to all industries.
- 46) For example, Kashyap *et al.* [1994] that studied the influence of restrictive monetary policy during the 1981~1982 recession is exceptional.
- 47) For example, Feldstein and Auerbach [1976, p.362] wrote: "[E]conomists have been interested in the sales-forecast error as a source of unanticipated inventory accumulation at least since the publication in 1941 of Metzler's theoretical study of inventory cycle." Economists addressing the causes and mechanism for inventory investment fluctuations are to face a new challenge of excluding from the list of leading candidates of causes unexpected events like the dramatic demand decline in Japan during the period around Lehman Shock.
- 48) In CEQS the inventory stock value of construction industry was slightly less than 40 trillion yen in the first half of 1990s, which has decreased to the recent level of its one-third. In SNA, therefore in quarterly GDP estimates, construction (commodity number: 59) consistently records 0 for total inventory investment, and therefore goods-in-process inventory investment. In SNA, inventory investment value is estimated through commodity-flow method as changes in inventory stock value, and goods-in-process stock in construction industry, like still-in-construction buildings, are mostly included in fixed capital formation. As mentioned in [6] the inventory stock value of all manufacturing industry in the first half of 1990 in CEQS was 40 trillion yen, almost equivalent to that of construction industry of the time.
- 49) Some readers may wonder: "The basic assumption that it was an unexpected situation is further away from the mark?"
- 50) For more details, see the METI's Homepage.
- 51) With the Earthquake in March 2011, production decreased drastically particularly in March and April, the influence of which is reflected in Present and Next in one or two months later.
- 52) For more information, see FAQ Explanations on BOJ's Homepage.

- 53) Note that *Indices of Industrial Production* and *Indices of Production Forecast* are commodity-based, and BOJ's *Tankan* is firm-based.
- 54) For more details, see Table 7. Change in Inventories: Summary of sources used (pp.31–32). OECD [2012] is the current version of the document first published in 1979.
- 55) They would argue: We have to carefully check the accuracy in correspondence of the results therefore the objects of the study to its original targets and objectives, concerning the researches based on problem setting like “Is inventory fluctuation pro-cyclical or counter-cyclical?” or “How long is the cycle duration? Isn't the inventory cycle a synthetic form of multiple cycles with different wavelengths?” Many inventory cycle studies use a long-term quarterly time series data, primarily paying attention to the correlation validity. Obviously, correlation is different from causality.
- 56) Readers still sympathizing with the conventional view of the Japanese economy that has had a strong preference to emphasize its special and idiosyncratic features might overlook the conclusions with smile, arguing that “it must be a part of its idiosyncrasy.” For readers who feel at odds with the conventional view of the Japanese economy or are interested in another view, see Miwa and Ramseyer [2006].
- 57) In many countries, like in Japan, overwhelmingly strong demand for quick supply of quarterly SNA statistics including inventory investment estimates might have a powerful effect on the statistics-making process. It seems a good choice not to excessively emphasize the association with the quick (or preliminary) estimates at the time of obtaining quarterly final (revised) estimates, and also to make effort in improving the accuracy in quick estimates. Unless placing special emphasis on the prompt report, researchers should take the annual estimates as basic materials, and in using quarterly estimates strongly keep in mind that they are the products under extremely severe constraints including the availability of source statistics.
- 58) For example, raw material inventory stock of steel product in SNA statistics is not the raw material inventory stock of iron ore and coal held by steel manufacturers but steel product held by automobile manufacturers and construction companies as material stock for their economic activities.
- 59) Although the importance and the researchers' interest might decrease, as a research topic the significance of inventory investment behavior studies, and as its part estimation of inventory investment function, will not disappear. On this point, see Section [12] of this paper.
- 60) At the opening of “Price Adjustment in the Long Run” in “Chapter 16. Money and Business Cycles II: Sticky Prices and Nominal Wage Rates”, Barro [2008, p.397] writes: “Our analysis of the new Keynesian model applies in the short run, when we do not allow for adjustments in the prices, $P(j)$, set by each firm j . In the longer run, the prices adjust, and these adjustments tend to undo the real effects from a change in the nominal quantity of money, M .” The conclusion of this study gives an answer to a familiar question: “How long is ‘the long run’?”
- 61) About “the monetary transmission mechanism: the process through which monetary policy decisions are transmitted into changes in real GDP and inflation”, Taylor [1995, p.11] in the same issue writes at the opening: “There are, of course, many different views of the monetary transmission mechanism. These views differ in the emphasis they place on money, credit, interest rates, exchange rates, asset prices or the role of commercial banks and other financial institutions.” On the situation after the Lehman Shock, he comments (pp.41–42): “In the recent crisis, many have viewed the reduction in credit flows as more systemic than the interest rate changes because certain credit markets did freeze up, but there is still little empirical evidence supporting this view.”
- 62) This article begins: “The canonical real business cycle model and the textbook Keynesian IS-LM model differ in many fundamental ways. However, these two standard frameworks for macroeconomic analysis do share one strong implication: Except for the term structure of real interest rates, which, together with expectations of future payouts, determines real asset prices, in these models conditions in financial and credit markets do not affect the real economy.”

- 63) For more details on this point, see Miwa [2013, pp.205–6, notes 6, 7]. The argument since Kashyap *et al.* [1994] emphasizing the credit-market imperfections assumes that small businesses under severe constraints on the access to capital markets like CP market are particularly vulnerable to restrictive monetary policy. Using firm-level-data on Japanese business firm's financing behavior, Miwa [2012] draws three conclusions: (1) The ratio of bank borrowings to total assets has been in every firm size category by far lower than the conventional wisdom assumes; (2) Particularly the ratio further decreased remarkably since the 2000s under the "quantity easing zero-interest rate" monetary policy; (3) The ratio has been the lower, the smaller the firm size category. For example, recently in the smallest firm size category with paid-in capital from 10 million yen to 20 million yen, the share of small businesses with zero short-term borrowing from financial institutions is at the level of two thirds. For the reality in detail of small business financing that has been emphasized to be under severe financing constraints, see Miwa [2011].
- 64) Also on the cause of the rapid world trade contraction after the Lehman Shock, often called the Great Trade Collapse, a leading view emphasize the role of inventories.
- 65) The estimation method adopted in the US seems basically not to be different. For the US method on inventory estimation, see p. 7–6 of GDP estimation manual of URL (<http://www.bea.gov/national/pdf/NIPAhandbookch7.pdf>). As in Japan it is estimated by 4 categories.
- 66) Ramey and West [1999, p.887] make a short comment, entitling "3.4. Whose inventories?": "Indeed, a large fraction of the inventory literature focuses on manufacturers' finished goods inventories, often in six two-digit industries that are known as 'production to stock'. To some, in fact, the model is not a particularly attractive one for studying any other types of inventories [e.g., Blinder and Maccini (1991)]."

Reference

All references are given at the end of Part I of this article, at volume 79, issue 3, page 76–77 of this journal.

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