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STRATEGIC DIMENSIONS OF CYCLICAL INDUSTRIAL DYNAMICS: A STUDY OF THE SEMICONDUCTOR INDUSTRY

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In industries that display cyclical industrial dynamics, such as the Semiconductor industry and Flat Panel Display industry, firms are forced to strategize around upturns and downturns. Some firms such as Intel and Texas Instruments have learnt how to seize advantages from such fluctuations, to launch new business ventures and products or to restructure their operations during downturns. In the Flat Panel Display industry, firms seeking to enter the industry have learnt to time their entry to coincide with downturns. Such counter-cyclical investment strategies are lending firms that master them significant advantages. This article builds on a dynamic approach to strategy to capture the principal features of strategizing during upturns and downturns, and in particular demonstrates the rewards flowing to firms that engage in counter-cyclical investment strategies.

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In industries that display cyclical industrial dynamics, such as the Semiconductor industry and Flat Panel Display industry, firms are forced to strategize around upturns and downturns. Some firms such as Intel and Texas Instruments have learnt how to seize advantages from such fluctuations, to launch new business ventures and products or to restructure their operations during downturns. In the Flat Panel Display industry, firms seeking to enter the industry have learnt to time their entry to coincide with downturns. Such counter-cyclical investment strategies are lending firms that master them significant advantages. This article builds on a dynamic approach to strategy to capture the principal features of strategizing during upturns and downturns, and in particular demonstrates the rewards flowing to firms that engage in counter-cyclical investment strategies.

Key words: industry cycle, business cycle, industrial dynamics, pro-cyclical investment, counter-cyclical investment, entry strategy

"Investing in new capacity when the industry is still in a downturn can substantially enhance a company's profitability".
--- (Achi *et al.*, 1996, p.62) (The authors are consultants from McKinsey & Company)

"Investing in new fixed assets during recession, supposedly to improve cost competitiveness and productivity, does not usually bring positive benefits and if anything, the opposite is the case."
--- (Roberts, 2003, p.36) (The author is Managing Director of PIMS Associates)

Should companies strategize around the upturns and downturns in their industries by, for example, making aggressive capital investment during the recessions? While industry consultants such as those from McKinsey and PIMS have given contradictory views based on their observations, this issue has not captured much attention from scholars in strategic management, with some notable exceptions (Mascarenhas & Aaker, 1989; Mathews, 2005; Navarro, 2005).

Yet the timing of firms' initiatives such as capital investment when taken against the backdrop of cyclical industrial dynamics carries important implications for the firm's performance. For example, Mascarenhas and Aaker (1989) demonstrated two features of investment decisions in the context of the highly cyclical oil-well drilling industry, namely that, first, companies did indeed adjust their strategic activities such as capital expenditure and asset allocation according to the stage of the cycle, and second, 'optimal' strategies varied across cycle stages. In the highly cyclical flat panel display industry, where there have been five upturns and downturns since the industry began in 1990, Mathews (2005) demonstrated that there is a striking pattern in firms' entry behavior, where not a single successful entry was engineered during an industry upturn. Navarro (2005) discussed the importance of the business cycle to companies' strategies across functions and areas, including marketing, human resource, capital expenditure, acquisition, risk management and organization culture. In the marketing literature, the pattern where firms are found to utilize recessions as times to enhance the standing of their brand, has been widely noted, such as by Srinivasan, Rangaswamy, & Lilien (2005). It has also been found that some sectors as a whole (such as the 'private-label' market) have been able to exploit fluctuations in the economy, especially the downturns of business cycles, to their advantage (Lamey *et al.*, 2007).

Given these observations, it is surprising that the strategic management literature has not devoted more effort to elaborating theoretical explanations and gathering empirical evidence regarding firms' strategizing around the cyclical dynamics in industries. This may have something to do with the largely comparative static nature of the principal frameworks utilized in strategy discourse. There is no denying the power of the Porter framework, for example, with its focus on the competitive forces at play outside the firm, and its emphasis not just on value creation but on value appropriation – right along the value chain (Porter, 1980, 1985). Nor will the newer Resource-based View be denied, with its focus on the inner resources and capabilities of the firm – captured famously by Prahalad and Hamel as the 'core competences of the corporation' – and their influence over the capacity of firms to garner advantages from their possession of rare and inimitable resources (Prahalad & Hamel, 1990). But the largely static formulation of these frameworks, that is, comparing one point in time with another, means that they can miss some of the most interesting features of strategic dynamics in industries exhibiting cyclicality. Recent developments have extended the resource-based view to a 'dynamic resource-based view', with the emphasis on the firm's capability building and transformations over different stages of the industry life cycle (Helfat & Peteraf, 2003). But the industry life cycle approach focuses on the fairly long-term dynamics of industrial evolution (see e.g. Strebel, 1987)[1], rather than the medium-term cyclical industrial dynamics which is the concern of the current paper. As we will demonstrate below, the latter usually takes place over quarters rather than years.

On the empirical front, research into the relationship between strategic behavior over upturns and downturns in industries and firm performance is relatively rare. There has of course been a vast literature discussing the policy implications of economic or business cycles, but this has largely been at the macro level, not at the level of specific industries. Most of this discussion emphasizes the negative features of business cycles in general and recessions in particular and accordingly focuses on 'stabilization' policies such as those suggested by Keynesian economists. The role of recessions as a 'cleansing period' for productivity enhancement and economic growth thus tends to be downplayed – despite a literature going back to Schumpeter (1939; 1942) and more recently encompassing the work of scholars such as Aghion & Saint-Paul (1998), Cabellero & Hammour (1991) or Saint-Paul (1993). At the firm level, some have noted that even during the depths of the Great Depression there were enterprises pursuing counter-cyclical strategies by either entering into a new market or expanding their existing capacity, resulting in marked structural shifts in industry productivity (Bresnahan & Raff, 1991; Cabellero *et al.*, 1991). While there are general discussions of such counter-cyclical strategies backed by case study or anecdotal evidences (Achi *et al.*, 1996; Rigby, 2001; Roberts, 2003), a more rigorous examination seems yet to be undertaken.

Likewise we find in the field of industrial organization, where industry structure is a

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[1] In Strebel P. 1987. Organizing for innovation over an industry cycle. *Strategic Management Journal* **8**: 117-124, the term 'industry cycle' is used to describe the evolution of industries where a technological trajectory goes through a sequence of stages. The process is now more conventionally termed 'industry life cycle' (see Abernathy WJ, Utterback JM. 1978. Patterns of industrial innovation. *Technology Review* **80**: 41-47, Gort M, Klepper S. 1982. Time paths in the diffusion of product innovations. *The Economic Journal* **92**(September): 630-653, Klepper S. 1997. Industry Life Cycles. *Industrial and Corporate Change* **6**(1): 145-181.)

specific object of study, that even here studies of such issues as ‘optimal’ timing of investments in capacity expansion (or contraction) are analyzed using the real option approach and the game theory (Dixit & Pindyck, 1994; Smit & Trigeorgis, 2006; Wu & Erkoc, 2005) but issues relating to cyclical industrial dynamics tend to be glossed over.

For all these reasons, it would seem that an examination of strategizing over industry-level upturns and downturns is warranted. We have therefore embarked on a study of the timing of capacity investments in a highly cyclical industry, with a view to demonstrating in a rigorous way how strategies differ in relation to industry upturns and downturns, and whether any advantages can be detected for strategies that are clearly counter-cyclical in inspiration. In particular, our research compares and contrasts two distinct investment patterns of firms from a cyclical industrial dynamics perspective: counter-cyclical investment and pro-cyclical investment. We pose the question whether there is a systematic difference in firm’s performance between those two investment patterns. And if so, why? Our research uses the global semiconductor industry as a case study. This industry is chosen not only because of its obvious importance to the economy but also its pronounced cyclicality that has long been noted.[2]

The remainder of the paper is organized as follows. First, we introduce cyclical industrial dynamics as a key strategic setting of firms. Next, we discuss two distinct investment behaviors from the perspective of cyclical industrial dynamics, that is, counter- versus pro- cyclical investment. Third, we describe the data, the method utilized and present the empirical results. Fourth, we discuss strategic behavior of some individual companies such as Intel to check them against the findings the study. Finally, we discuss prospects

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[2] In 2004 the global semiconductor and semiconductor equipment industry in total generated US$ 243.3 billion of revenue Datamonitor. 2005. Global Semiconductors & Semiconductor Equipment: Industry Profile. Datamonitor: New York. This large-sized industry has exhibited pronounced cyclicality during the past decades, which continues being a subject of industry research. For example, a well-known set of cycles in a stylized form is given by McClean B. 2001. IC industry at the crossroads. *Semiconductor International* **24**(1): 73-75. For other works by industry experts on cyclicality of the industry, see the review in Liu W-H. 2005. Determinants of the semiconductor industry cycles. *Journal of Policy Modeling* **27**: 853-866.

for further work and the limitations of the study.

Cyclical industrial dynamics as a strategic setting

In previous studies relating firms' behavior to their cyclical economic environment, the focus has usually been on business cycles in the aggregate economy rather than industry-level cycles. Business cycles in this sense are defined as "a type of fluctuation found in the aggregate economic activity of nations […] a cycle consists of expansions occurring at about the same time in many economic activities, followed by similarly general recessions, contractions, and revivals which merge into the expansion phase of the next cycle" (Burns & Mitchell, 1946, p.3). A widely accepted chronology of the US business cycle is developed by the National Bureau of Economic Research (NBER) based on this definition.[3]

However, this way of framing cyclicality may not be appropriate for industry-level cycles, for at least two reasons. First, phases of business cycles are indicated by the coincident timing of a variety of economic indicators, notably output, employment, income and sales. For example, a recession is only recognized when the real gross domestic product (GDP), the employment, the total income and the sales are all falling. Second, highly aggregated data are employed and therefore heterogeneity across industries is ignored and missed.

By contrast, cyclical dynamics at the level of individual industries, or *industry cycles* as they are more conventionally known, may present rather different patterns. For example, Berman & Pfleeger (1997) found that while the fluctuations of a large number of industries correlate with those in the aggregate economy, there were also many industries that are not sensitive to business cycles -- such as the pharmaceutical, educational service, insurance carriers and public service industries; some other industries such as the health service industry even enjoy higher growth during recessions. In fact, it was claimed by

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[3] For a full list of reference dates for the U.S. business cycle since 1854 identified by NBER, see www.nber.org/cycles.html/

Bain & Company, a firm of strategy consultants, and cited in the *Economist*, that "in any one recession [during the 1980s and the 1990s] only 60% of all industrial sectors were actually in a downturn."[4]

The timing, duration and amplitude of industry cycles can vary widely. The study by Petersen and Strongin (1996) of about 300 manufacturing industries in the US showed that durable goods industries are approximately three times more cyclical than nondurable-goods industries. The service sector generally exhibits fewer cyclical fluctuations, and less intense fluctuations, than manufacturing activities, for reasons that have to do with difficulties involved in stocking services, in there being less capital required for service activities and the higher price and wage rigidities found in the service sector (Cuadrado-Roura & V.-Abarca, 2001). The different patterns in industry cycles come about because industries respond to exogenous common aggregate disturbances in different ways (Hornstein, 2000), or because of the endogenous mechanisms involving industry-specific factors such as the lags between investment, supply and price (Forrester, 1961; Tinbergen & Polak, 1950), or because of specific innovative activities in the industries (Geroski & Walters, 1995). While a full explanation of industry-specific cycles is beyond the scope of this paper, the cyclical asymmetry across industries does call for a more disaggregated analysis of industry cycles as the immediate setting for firms' strategizing behavior.

The analysis of industry cycles starts with their identification in some reliable and reproducible fashion. In this paper we establish a set of principles for identifying industry cycles, as a first step towards their more systematic analysis. First, we define industry cycles as a type of 'growth cycles' rather than 'classic cycles' which refer to sequences of expansions and contractions in ***levels*** of economic data. Growth cycles, by contrast, are measured as recurrent deviations from a trend. Business cycles are defined as a species of classic cycle by NBER and thus only absolute decline (increase) in economic activities

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[4] 'How was it for you?' *The Economist*, 2001, Vol. 362: 4-6

can be recognized as a downturn (upturn) of a business cycle (Zarnowitz & Ozyildirim, 2002). However, classic cycles are rarely observed in many industries where the industry data are dominated by strong trends, whether rising trends in sales/production or declining trends in price. In those contexts, cyclical dynamics are reflected in the shifting pace of growth.

Next we need to eliminate minor fluctuations. Identification of industry cycles should avoid the distraction of short-term fluctuations caused by random and seasonal effects. Random fluctuations may be caused by irregular and unpredictable shocks to an industry and seasonal fluctuations result from such periodic factors as temperature and timing of holidays (Makridakis, Wheelwright, & Hyndman, 1998). Our procedure needs to filter out such events.

Finally, in order to capture the cyclical industrial dynamics precisely, we propose one single industry data series as a 'benchmark' for the industry cycles generally. Fluctuations in price and sales are arguably the two most important indicators for the ups and downs of industries. In choosing between them, we note that prices in many high-tech industries, such as the semiconductor industry, have experienced drastic decline regardless of market conditions. The secular decline in prices is due not to 'recessions' in the industries but rather to innovation and to economies of scale. In fact, frequently the market expands and the industry enjoys good times even when prices are falling. For these reasons, it appears that sales/shipments data constitute a more compelling primary indicator for the general cyclical movement of the industry. This choice is in line with prior research in the area (e.g. Choi *et al.*, 1999; Liu, 2005; McClean, 2001). With these rules for identifying cycles, we now proceed to capture the key differences between the strategies under review, namely counter-cyclical and pro-cyclical investment.

Counter-cyclical and pro-cyclical investment strategies

'Counter-cyclical' or 'pro-cyclical' are terms used in the macroeconomics literature to describe policies or economic effects that work against or enhancing the trend of a business cycle. At the firm level, cycle-related behaviors are also sometimes described as ‘proactive strategies’ (Srinivasan *et al.*, 2005), such as where ‘proactive marketing’ in a recession is defined as “the organization’s interpretation of the recession as an opportunity (recession opportunity interpretation) and the development and execution of a response to capitalize on the perceived opportunity created by the change (offensive marketing response)” (2005: 111).

The counter- versus pro- cyclical behaviors can be defined in quantitative terms based on co-movement between one time series and another, usually with the reference series being business cycles measured by real GDP (Stock & Watson, 1999). The method involves extraction of cyclical components in the time series and estimation of the correlation between the cyclical components. The counter-cyclical activities would have a large negative correlation with the reference cycle whereas the pro-cyclical activities would have a positive correlation. Acyclical behavior would not have any significant correlation with the business cycle series.

In this study, we focus on a specific case of counter- versus pro- cyclical behaviors by firms, that is, responses by firms in terms of capital investment to industry cycle downturns. Strategizing during upturns, when revenues are rising, production is rising, prices and profits are rising, is relatively straightforward. As in the Porter competitive forces framework (Porter, 1980), the profits being generated are distributed according to the degree of industry rivalry, the bargaining power of suppliers upstream in the value chain and of customers downstream, and the threat posed by new entrants. Certainly some timing decisions can be made poorly, as when a firm ramps up investment slowly and allows its capacity to fall behind those of rivals. Such caution may be punished by profits that are lower than they might have been.

But it would appear that more critical strategic decisions have to be made as the industry teeters into a downturn. Here over-capacity built up during the good times becomes a liability, and as the market weakens, with prices falling, so investment is cut back, and production is cut back, and one factor feeds off another and so the downturn accelerates.

How do firms strategize in these very different circumstances? This is the question that motivates the present study.

The literature offers limited knowledge as to why companies tend to have different responses to recessions. Based on their survey of 154 senior marketing managers, Srinivasan *et al.*(2005) suggest that strategic emphasis on marketing, entrepreneurial culture and slack resources are important antecedents of the 'proactive response' to recession which often features counter-cyclical investment. They found that firms with the proactive marketing response were likely to gain better business performance measured in terms of sales growth, market share, profitability and market share. In another survey of more than 600 leading companies in the UK, Geroski and Gregg (1997) found that while the majority of firms postponed or abandoned their major capital expenditure during the recessions, some brought forward investments in plant and equipment and in marketing. In particular, 185 respondents (30 per cent of the sample) brought forward product innovation activities. For their part, Alessandri and Bettis (2003) examined the performance of 54 US public companies over both bull- and bear-markets and found that superior performers were those who pursued 'innovative strategies' that were difficult for competitors to imitate. Some studies were industry-specific. For example, Hayes and Schmitz (1987) analyzed production behavior in hog cycles over the past century and demonstrated that producers can profit from countercyclical production. In the airline industry, Liehr *et al.* (2001) adopted a systematic dynamics approach and their simulation analysis showed that counter-cyclical ordering would constitute be a superior strategy for companies in this cyclical industry.

Based on these studies, it would seem to be worth framing a hypothesis regarding performance outcomes associated with either counter-cyclical or pro-cyclical investment strategies. In particular, we predict that in the context of cyclical industrial dynamics, firms committing to a counter-cyclical investment strategy would enjoy higher growth in sales in their later development than their counterparts. We thus form the null hypothesis H_0 for testing as following:

Null hypothesis H_0: There is no difference in sales growth rate in the subsequent period between firms which increase capital investment during an industry cycle downturn and those which decrease capital investment during such a downturn.

The alternative hypothesis H_A is as follows: Firms which increase capital investment during an industry cycle downturn are likely to experience a higher growth rate in sales in the subsequent period than those which decrease capital investment during downturn.

Semiconductor industry data

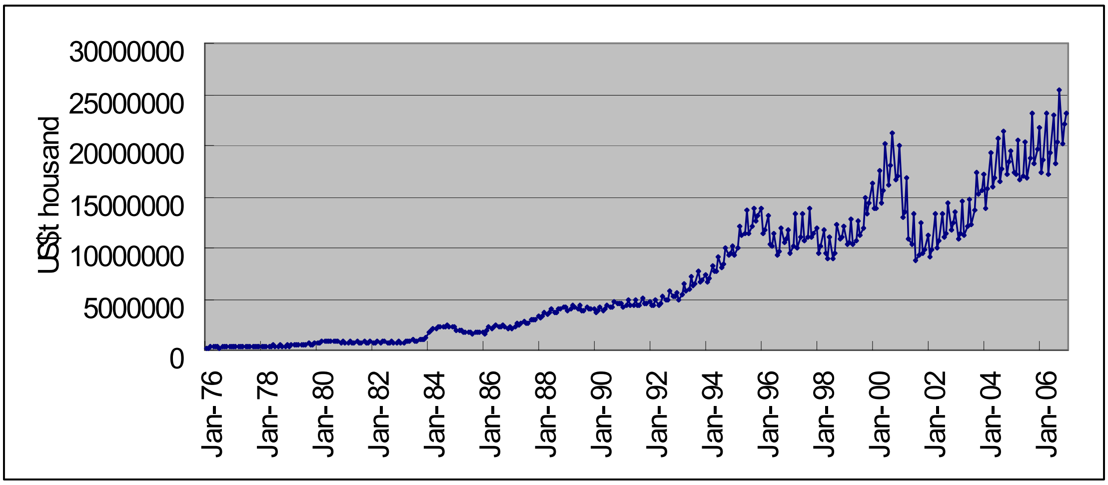
The global semiconductor industry constitutes the context of this study. The industry level data are available from the Semiconductor Industry Association (SIA) and the firm-level data are obtained from IC Insights. The data sources are summarized in Table 1.

Table 1 Description of the data series

Data	Source	Description	Coverage	Frequency
Global Semiconductor Billing	Semiconductor Industry Association	Total revenue in current US$ of the worldwide semiconductor market	1976-present	Monthly
Global Semiconductor Capacity Addition	Semiconductor Industry Association	Total wafer start capacity of the integrated circuit manufacturing industry (8 inch equivalent) of the global semiconductor industry	1994-2004Q3	Biannually (1994H1-1996H2)/Quarterly(1997Q1-2004Q3)
Semiconductor Firms Sales and Capital Spending	IC Insights	Sales and capital expenditure statistics of 75 major firms in the global semiconductor industry through 1993 to 2003	1993-2004	Annually

The first time series we make use of is monthly revenues of worldwide semiconductor manufacturers in current US dollars, from 1976 on -- plotted in Figure 1. It is clear that the series is dominated by strong upward trend, as well as featuring many small fluctuations that look as though they might be cyclical in character.

Figure 1 Global Semiconductor Billing, 1976-2006



Source of primary data: Semiconductor Industry Association

The second series we refer to is that of capacity fluctuations, captured as the series of total wafer start capacity of the integrated circuit manufacturing industry; this is taken as an approximation of the global semiconductor capacity addition, as plotted in Figure 2.[5]

Figure 2 Worldwide Semiconductor Wafer - Fab Capacity Addition

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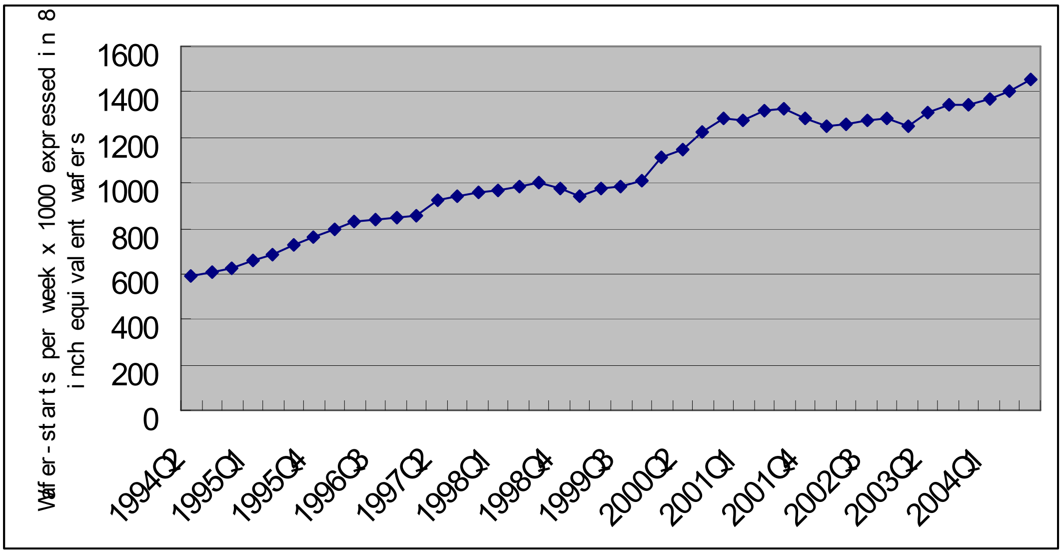
[5] The series is in the biannual frequency for the period from 1994 to 1996, and in the quarterly for the remaining period. For reason of consistence, the current study utilizes the method established by Lisman and Sandee Lisman JHC, Sandee J. 1964. Derivation of quarterly figures from annual data. *Applied Statistics* **13**(2): 87-90 to derive the quarterly values from biannual totals. This procedure, though relatively simple, generates good adaptation of the figures in the low frequency to those in the high frequency and has been adopted by many later studies Fielding D. 2003. Modelling Political Instability and Economic Performance: Israeli Investment during the Intifada. *Economica* **70**(277): 159-187, Guerrero VM, Pena D. 2000. Linear Combination of Restrictions and Forecasts in Time Series Analysis. *Journal of Forecasting* **19**(2): 103-122.

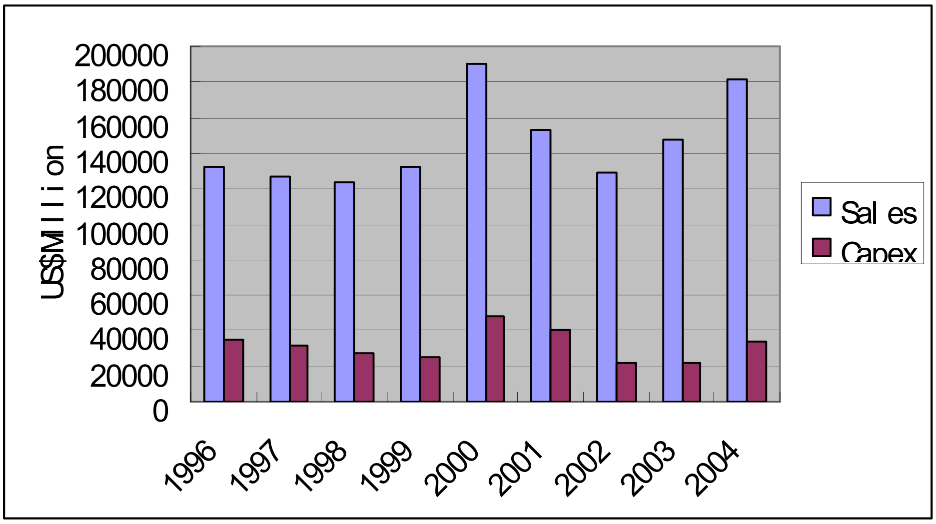


Source of primary data: Semiconductor Industry Association

Finally, the firm-level capital expenditure and sales data captured annually during the period from 1993 to 2004 are obtained from *IC Insights*, a market research firm specializing in the semiconductor industry. While the population consists of 75 major semiconductor companies in the world, not all these companies have complete series through the period. For the purpose of this analysis, only 59 of the companies have the capital expenditure data through 1996, 1997 and 1998 *and* the sales revenue data over the period 1999-2004.[6] The total sales revenue and capex of the 59 companies are shown in Figure 3.

Figure 3 Total Sales and Capex of the Companies in the Sample

[6] See below for more details.



Source of primary data: *IC Insights*

We now proceed to disaggregate this data on sales and capex to bring out the effect of the cyclical fluctuations revealed in Charts 1 and 2.

Methods and empirical results

Identifying the Industry Cycle

We first derive the industry cycle of the global semiconductor industry from the industry data series, viz. Global Semiconductor Billing, based on the principles we specified above, utilizing the following procedure:

(1) First, the seasonal component in the series is captured and eliminated using the Census X-12 procedure. The series are then taken in natural logarithms;

(2) Second, the remaining series is de-trended by the Hodrick-Prescott (HP) filter which removes components with very high and very low frequencies;

(3) Third, the turning points are finally determined in the HP filter-generated cycles based on a set of dating rules.

The US Census X-12 procedure employed in this study is the latest variation of the Census II method developed by the US Census Bureau and is among the most widely used methods by governments and other agencies for seasonal adjustment of time series.[7] We utilize the sophisticated HP filter to achieve the trend-cycle decomposition of the seasonally adjusted series. We choose this filter over more traditional de-trending methods such as linear de-trending and first-differencing (or taking growth rate form) because these methods can distort the frequencies and amplitudes of the cycles revealed (Baxter & King, 1999; Zarnowitz *et al.*, 2002). For example, the widely used first-differencing is considered a filter that re-weights the series strongly towards the higher frequency noises (Lamey *et al.*, 2007; Stock *et al.*, 1999). Comparing twelve widely used detrending methods, Canova (1999) concludes that the Hodrick-Prescott (HP) filter (Hodrick & Prescott, 1997) and the Baxter-King (BK) (or the band-pass) filter (Baxter et al., 1999) outperform others in reproducing closest the cycles of the NBER benchmark. By using different approaches, the HP filter and the BK filter both extract very low and very high frequencies from time series, generating the nonlinear trend of the series. The former computes a smoothed series by minimizing the variance of the original series around the smoothed series while the latter lets cyclical components with the durations in a band 'passes through' and filters out remaining cycles (Quantitative Micro Software, 2005). Given the fact that the HP filter does not require determination of the filter 'bands', we propose to use the HP filter as our trend-cycle decomposition filter.

By consulting the methods by NBER (see e.g. Bry & Boschan, 1971) and by the Central Statistic Office (CSO) in the UK for dating business cycles, as well as works for dating other economic cycles such as inflation cycles (Artis *et al.*, 1995; Binner, Bissoondeeal, & Mullineux, 2005), we also impose a set of rules to the HP filter-generated series to determine the major upturns and downturns of the industry cycles -- with the key rule being that 'no phase is to be counted if it does not last at least three quarters'.[8]

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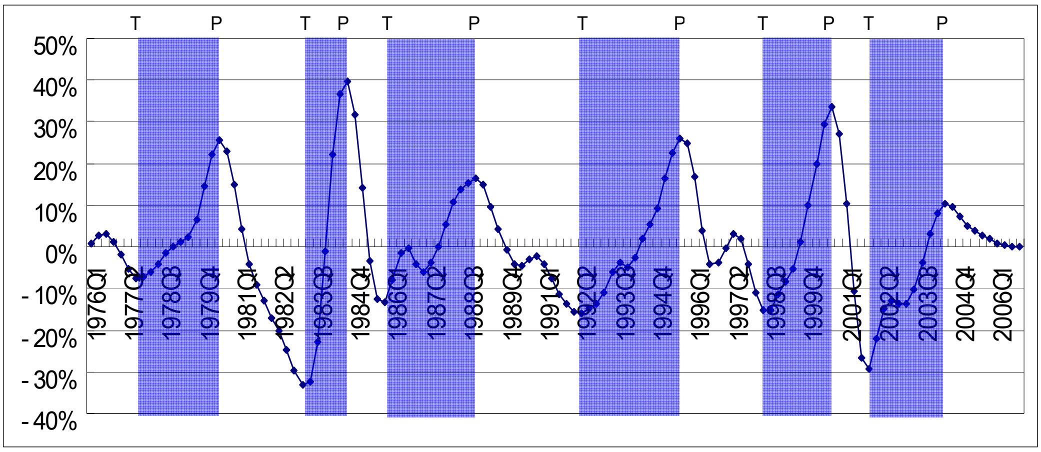
[7] See http://www.census.gov/srd/www/x12a/ for articles concerning the X-12 method and the downloadable programs.

[8] These rules are described in the appendix.

This procedure is now applied to the industry data series. The presentation of the resulting industry cycles is given in Figure 4, with the major turning points being marked with either P (for peaks) or T (for troughs).

Figure 4 The Semiconductor Industry Cycle



Source: Authors' calculation based on data from SIA

To make use of the firm-level data (that are of annual frequency), the industry cycles are aligned with the calendar years according to whether the majority of time in the year is spent within an upturn or a downturn. The years of upturns and downturns are suggested in Table 2.

Table 2 Semiconductor Industry Cycle with Calendar Year

Upturn	Downturn
1978, 1979	1980, 1981, 1982
1983, 1984	1985
1986, 1987, 1988	1989, 1990, 1991
1992, 1993, 1994, 1995	1996, 1997, 998
1999, 2000	2001
2002, 2003	

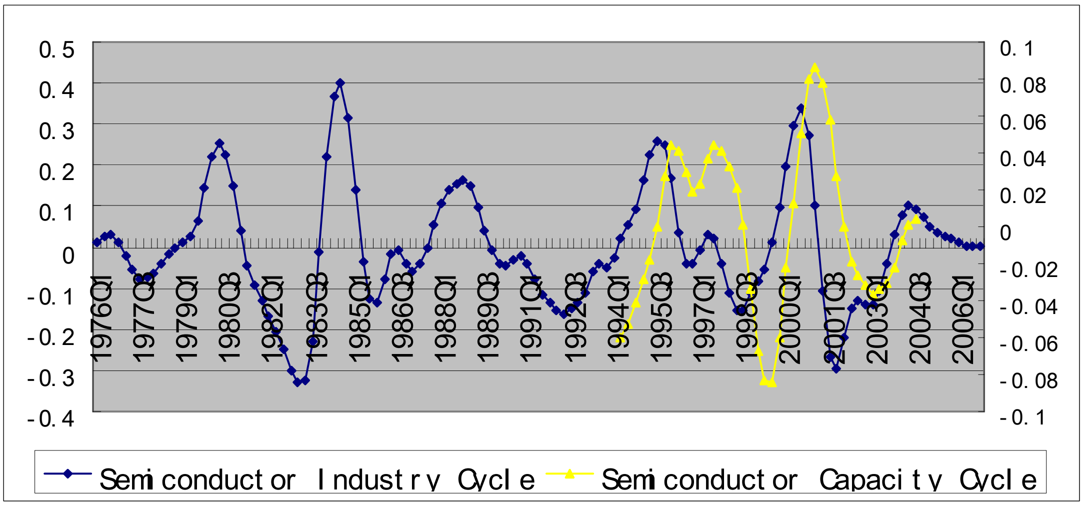
Source: Authors' calculation

The results are broadly in line with those reported by industry consultants such as IC Insights.

Identifying the Counter- versus Pro- Cyclical Investment strategies

In this study, we use both straightforward and more quantitative methods for identifying counter- or pro- cyclical investment in industry cycle downturn. First, we estimate the overall investment pattern of the industry using the capacity data. The co-movement between the cyclical component derived from the capacity series and the industry cycle measured by sales is illustrated in Figure 5. It is found that there is a time lag between capital investment and capacity expansion. Following Stock *et al.*(1999), we calculate the correlations based on both current value of capacity data and the lagged values. The results are reported in Table 3.

Figure 5 Semiconductors Industry Cycle and Semiconductor Capacity Cycle



Source: Authors' calculation based on data from SIA

Table 3 Correlation of the cyclical component of the capacity data series and the industry cycle series

Capacity	lag=0	lag=1	lag=2	lag=3	lag=4	lag=5	lag=6	lag=7	lag=8
Correlation	.114	.448**	.675**	.758**	.717**	.595**	.439**	.278	.133

Notes: ** Correlation is significant at the 0.01 level (2-tailed)

The correlation statistics confirm the visual inspection of the co-movement of the two series with a time lag. The correlation is largest when the time lag is between two and four quarters. According to the Semiconductor Industry Association, the average equipment procurement lead time is about 6–12 months (2 to 4 quarters) (Wu *et al.*, 2005). Thus we see that there is clear evidence of the pro-cyclical investment behavior of the industry taken as a whole. The issue is: are firms that buck this trend experiencing any benefit from doing so?

To answer this, we examine investment behavior at the firm level. We denote the firms that increase their capital expenditure in an industry cycle downturn, as measured by average annual growth rate, as ‘counter-cyclical’ firms, and those with decreasing capital expenditure as ‘pro-cyclical’ firms. Two industry cycle downturns can be identified during the period covered by our firm-level data, viz. the 1996-1998 downturn and the steep 2001 downturn. However our analysis concerns only the 1996-98 downturn because it appears that the 2001 downturn is too recent for the ‘kick’ in subsequent revenues to show up as yet. In this context, 27 firms can be classified as being in the pro-cyclical category in our sample while 32 are in the counter-cyclical category. The top ten companies of each category in terms of the sales in 1996 (viz. the first year of the downturn) and their average annual growth rate in capex over 1996-1998 are listed in Table 4.

Table 4 Top Ten Companies in Pro- versus Counter- Cyclical Camp in the 1996-98 Industry Cycle Downturn

	Pro-cyclical firms		Counter-cyclical firms	
Rank	Name	Capex Growth 96-98 (%)	Name	Capex Growth 96-98 (%)
1	NEC Electronics	-18.40	Intel	7.87
2	Toshiba Semiconductor	-18.18	Texas Instruments	2.10
3	Freescale Semiconductor	-2.65	IBM Microelectronics	1.93
4	Samsung Semiconductor	-29.94	Sony Semiconductor	3.49

5	Mitsubishi Semiconductor	-33.28	Agere Systems	18.26
6	Hynix Semiconductor	-51.02	Micron Technology	20.64
7	Fujitsu Electronic Devices	-30.48	Advanced Micro Devices	19.75
8	STMicroelectronics	-1.41	Taiwan Semiconductor Manufacturing	9.83
9	Philips Semiconductors	-15.32	LSI Logic	20.40
10	Matsushita/Panasonic	-26.36	Atmel	14.82

Source: Authors' calculation based on data from *IC Insights*

We now compare the sales revenues of firms from the two groups as of 1998. As suggested by the t-test with the result reported in Table 5, although the average revenue of pro-cyclical firms was slightly higher than that of counter-cyclical firms, no significant difference is found between the two groups at least in the last year of the industry cycle downturn.

Table 5 Comparison of the Sales of Firms in the Two Groups in 1998

Group Statistics					t-test for Equality of Means		
Group	Number of Firms	Mean of Sales (1998)	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
Pro-cyclical	27	2583	2486.9	478.6	1.000	57	.322
Counter-cyclical	32	1677	4114.7	727.4			

Testing the Hypothesis

Would the two groups of firms display difference in their sales revenues growth in the period subsequent to the industry cycle downturn 1996-1998? To investigate this possibility, we examine sales revenues over the period 1999-2004 for the 59 firms and compare the growth performance of the two groups of firms using t-test. The two groups of firms exhibit clear differences in sales growth, whether measured in terms of average annual growth or compounded average growth. The differences in sales growth in the subsequent period (up to 2004) between the two groups of firms (as shown in Figure 6) seem substantial, by either measure.[9] In the first set of data (for compounded sales growth) the mean increase in sales growth is 6.5% for pro-cyclical firms and 13.1% for counter-cyclical firms. In the case of simple average sales growth, the mean annual change for pro-cyclical firms is 11.2% while for counter-cyclical firms it is 19.8% -- with the latter being 6.7 per cent higher than the former. The results of the two-tailed t-test for testing the significance of the difference are reported in Table 6 and Table 7. The results suggest that the differences, in the simple average changes and the compounded average changes, are both statistically significant at less than 5 per cent of significance level. Therefore the null hypothesis is rejected.

What then have we shown? We have taken two groups of firms with contrasting investment strategies, one group pro-cyclical and the other counter-cyclical, and measured their sales revenues not just immediately after the 1996-1998 downturn but over the entire cycle lasting from 1999 to 2004. Over the course of this cycle, we have demonstrated that the counter-cyclical firms experienced sales growth of 19.8 percent, as compared with 11.2 percent in simple terms for firms pursuing the pro-cyclical strategy. Similar differences were found when sales growth is measured in compound form. Thus we conclude, through such rigorous demonstration, that firms which bucked the trend and engaged in counter-cyclical investment, were rewarded for their trouble.

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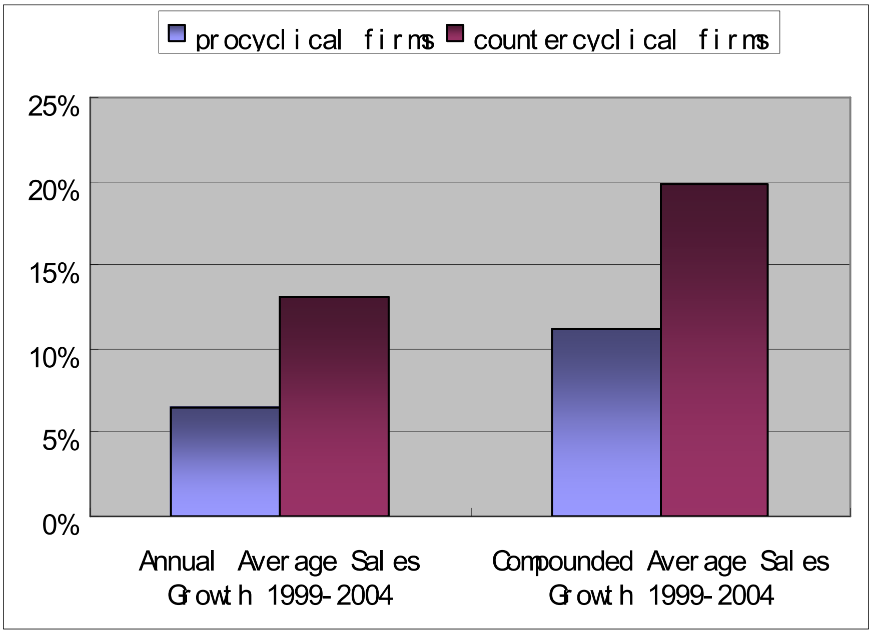
[9] Given that the sample size is relatively small and that firms are assumed to be independent, the independent two-sample t-test seems appropriate for testing the hypothesis (Cooper & Schindler, 2003).

Figure 6 Subsequent sales growth of pro-cyclical capex and counter-cyclical capex in the semiconductor industry



Source: Authors' calculation based on data obtained from IC Insights

Table 6 Compounded average sales growth consequent on pro-cyclical or anti-cyclical investment during 1996-98 downturn

Group Statistics					t-test for Equality of Means		
Group	Number of Firms	Mean of Compounded Sales Growth	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
Pro-cyclical	27	.0650	.07836	.01508	-2.68	57	.010
Counter-cyclical	32	.1311	.10626	.01878			

Table 7 Average sales growth consequent on pro-cyclical or anti-cyclical investment during 1996-98 downturn

Group Statistics					t-test for Equality of Means		
Group	Number of Firms	Mean of Annual Sales Growth	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)

Pro-cyclical	27	.1123	.08916	.01716	-2.59	57	.012
Counter-cyclical	32	.1978	.15003	.02652			

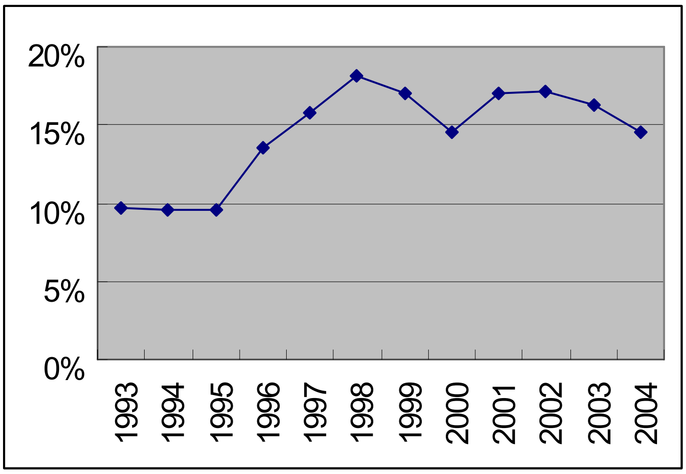
Discussion

In cyclical industries such as semiconductors, some leading firms have successfully strategized around the timing of investment. For example, the 1996-98 downturn saw some significant initiatives taken in the semiconductor industry which have had lasting impact. Texas Instruments (TI) used the downturn to complete its transition from a general purpose IC company with a large DRAM portfolio to a specialist producer of digital signal processing and analogue ICs needed by a wide range of digital products producers – such as mobile phone manufacturing companies. TI sold off its major DRAM business activities – including plants in Italy, in Texas, and its jointly owned facilities in Singapore and Japan. The buyer was Micron, which was also taking advantage of the downturn to expand its capacity as a focused and low-cost DRAM producer – moving up to 2nd or 3rd position in the world as a result of these acquisitions from TI. So the downturn served as a convenient time for restructuring on the part of both companies.

Intel took advantage of the 1996-98 downturn to invest in new state-of-the-art fabrication technology, particularly production technology that enabled Intel to move to larger wafers and to capture the twin goals of low power and high efficiency. At the same time Intel launched a series of diversifications, investing in downstream products such as PC motherboards and consumer products like mobile phones – to the extreme annoyance of its customer firms who produced these products with Intel chips. In the event these were not successful diversifications, and Intel withdrew from the end-user markets. But it had further and more effective diversifications in mind, and as soon as the next downturn hit, in 2001, *Intel* was engaging again in massive counter-cyclical investment, building capacity in new generation fabrication lines, and in new business areas such as digital signal processors (to challenge TI) and a variety of new chips to drive the digital economy, such as WiFi and WiMax chips.[10]

In fact, Intel has consistently acted as a 'counter-cyclical investor' over the past two industry cycle downturns covered by our data, with its average capex increasing by 9 per cent over the 1996-98 downturn and by 10 per cent over the 2001 downturn. It appears that the firm has been well rewarded for pursuing this extraordinary strategy. As shown in Figure 7, its market share reached 18 per cent in 1998 up from 9.5 per cent in 1995, and rose a further 3 per cent in the 2001 downturn, both successes taking place during the industry cycle downturns.

Figure 7 Market Share of Intel, 1993-2004



Source: Authors' calculation based on data obtained from *IC Insights*

While there has been much discussion over the ways that firms might devise for 'weathering the bad time' (Navarro, 2005; Shama, 1993), the counter-cyclical strategy represents a fresh and innovative response, and one that we believe has been rarely examined in any systematic way. The quantitative analysis of the sales performance of the group of 'counter-cyclical' firms in the semiconductor industry performed in this paper and the illustration of the behavior by leading firms such as *Intel* constitute, we believe, a rigorous demonstration of the positive impact of a counter-cyclical investment

[10] See the cover story in Business Week on March 8, 2004 "Intel: What is Craig Barrett up to?" by Cliff Edwards.

strategy during a downturn.

Limitations and future research

This study has sought to open up a new frontier in the scholarship of cyclical industrial dynamics. It has distinguished between the cyclical dynamics found at the national level (viz. business cycles) and at industry level (viz. industry cycles) and has highlighted the latter as a key strategic setting for firms. While we believe that cyclical industrial dynamics constitute the most immediate setting, further research may be able to focus on more detailed analysis. We view the capital investment in downturns as a significant driver of future growth of firms. In this study, we did not differentiate types of capital investment. However, Saint-Paul (1993) argued that not all investments are likely to have equal effect thus counter-cyclical investment should only be made for those ‘productivity-improving’ activities. Shama (1993) suggested that the impact of recessions, or downturns, may vary between small and large companies; this could be investigated using the methods we present above. Future research can thus investigate the implication of investment by firms during downturns towards different activities.

Players and observers in all industries bemoan downturns, and see them purely as times of distress, when firms are forced into closure, when workers are laid off, when revenues, profits, prices and investment fall – it’s all bad news. Yet in reality capitalism would fail as a system without downturns. They are the necessary episodes for recovery, for ‘rebooting’, for renewal, for an opportunity for a change in industry leadership, when new firms can enter the industry and when old and tired firms can exit, or be taken over. We believe that it is timely to look at downturns, from a strategy perspective and from a wider economic perspective as well. The remark by John Bowman, Executive Editor of the trade journal *Electronic Business,* echoes the dynamics of these situations:

> “Volatility creates opportunities for everyone. Downturns produce buy opportunities for investors and acquisition-minded companies. Upturns produce excitement among investors and entrepreneurs, which enhances opportunities for capitalization. And the churning cycles themselves promote chances to gain -- or lose -- market share, a condition that generally benefits the best and brightest companies. That's a good thing -- right?”

Bowman (2002)

Firms such as Intel, Texas Instruments, Micron and IBM Microelectronics have made a major discovery in their ability to profit from industry cyclical downturns. These business successes now call for complementary innovations in the field of strategizing theoretical frameworks.

Appendix

Rules for Determining Final Turning Points of the Industry Cycle

The following four rules are imposed on the HP filter-generated cycles in this study in order to determine the major peaks and troughs of the industry cycles:

1. Peaks should follow troughs and vice versa (to eliminate situations where a peak might be followed shortly after by another peak);
2. No phase (upturn or downturn) is to be counted if it does not last at least three quarters (to eliminate minor fluctuations);
3. A turning point is to be taken as the most extreme (quarterly) value between two phases – except at the beginning and end of the series; and
4. Turning points are not to be recognized within three quarters of the beginning or end of the series.

The key criterion being imposed in this set of rules is the three-quarter rule to eliminate sub-cycles of the major industry cycles that are in the focus of this study. The rule is consistent with Artis et al. (1995) and Binner et al.(2005) etc.; but different from CSO (12 months) or from Bry and Boschan (1971) at NBER (5 months). As opposed to the Bry-Boschan NBER approach, which sets a five-month rule (for monthly series), it is estimated that application of this approach to the industry data would generate too many cycles. For example, in the semiconductor sector ten cycles would be identified instead of the generally recognized six. Using the 12-month rule (four quarters) on the other hand, may eliminate cycles that are seen as important. So the study adopts three quarters (nine months) because this seems appropriate.

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