

AN ANALYSIS OF THE INDIAN INDUSTRIAL BUSINESS CYCLE FROM 1991-2009

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It is an original contribution and has been completed during my tenure as a research scholar at the Gokhale Institute of Politics and Economics, Pune.

The thesis has not been submitted by me elsewhere for the award of any degree or diploma – part or full. The information gathered by me elsewhere for the thesis is original, true and factual. Such information as has been obtained from other documents has been duly acknowledged in the thesis. I hereby request that this thesis be considered for the awarding of the degree of ‘Doctorate of Philosophy’ to me.

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ABSTRACT

The Indian business cycle is a relatively recent phenomenon, in the sense that perturbations throughout the economy that are not dependent entirely on the vagaries of the monsoon have only really been observed since 1991. This has been largely due to the liberalization of the Indian economy during 1991 (and in the years immediately following 1991).

We have therefore analyzed the Indian business cycle for the time period 1991-2009, and attempted to answer a central question regarding the Indian business cycle: does a set of factors explain the existence and perpetuation of the Indian business cycle since 1991?

We attempt to answer this question by building a dynamic model of an industrial economy, in which a business cycle arises by the need to periodically replace fixed capital. The need for replacement arises out of nothing more than the realistic assumption of depreciation of fixed capital. In addition, the business cycle may be impacted by decisions made by the industrialists in response to observed conditions and prospects in the economy as regards actual and expected future output.

We then seek to ascertain if such a model may find empirical validation in the Indian context for the time period under consideration by comparing the output of the model to actual data from the Indian economy, sourced from the CMIE Prowess database. This comparison serves two purposes: the model stands up to empirical scrutiny, and the methodology used herein validates turning points marked out by other research done in this field.

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Chapter 1: Introduction

1. Business cycles are fluctuations (not necessarily periodic) that are observed in aggregate economic activity, and, to varying degrees of synchronicity, in all its sectors. These fluctuations are observed across multiple time series pertaining to an economy and often occur with a reasonable degree of synchronicity. The cycle consists of an expansionary component that usually occurs throughout the economy at roughly the same time, followed by a recessionary component that is similarly observed throughout the economy, at roughly the same time.

In essence, business cycles consist of fluctuations in (production of, and consumption of) output, prices and employment.

2. Perhaps the most succinct, definitive and popular definition of business cycles is the one given in Burns and Mitchell's magisterial work on business cycles, "Measuring Business Cycles" (Burns 1946):

Business cycles are a type of fluctuation found in the aggregate economic activity of nations that organize their work mainly in business enterprises: 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; this sequence of changes is recurrent but not periodic; in duration business cycles vary from more than one year to ten or twelve years; they are not divisible into shorter cycles of similar character with amplitudes approximating their own.¹

3. As mentioned in the definition cited above, business cycles are (almost tautologically) observed in those economies that “organize their work mainly in business enterprises”. In other words, business cycles are most easily and definitively observed in those economies that have a sizeable, or at least a growing, industrial sector. Economies that have been and continue to be excessively dependent on the agricultural sector will therefore not experience business cycles in the sense in which we understand them in this thesis. For that reason, among others which shall be specified later, we shall stick with the definition supplied above, and therefore date the Indian business cycle from 1991 onwards, as cycles in the Indian economy were driven by the monsoon more than anything else prior to this period.

4. Broadly speaking, the phases of the business cycle may be divided into revival, expansion, recession and contraction. Dating and measuring business cycles is a tricky endeavor, further compounded by choices regarding which time series to use, in what combination, with what frequency and for what duration. There exists a significant literature on the statistical measurement of (and further, detailed analysis of) business cycles.

5. The theory of, techniques related to the measurement of, and the underlying causes of business cycles have all been the source of much controversy over the years, and even today, consensus about any of these issues is scarcely to be found. While this thesis will cover some of this theoretical ground in some detail, it is neither convenient nor desirable in this thesis to do an exhaustive study of all the theoretical advancements in this field. As such, we shall limit ourselves to conducting a review of most of the mainstream theories along with a detailed coverage of those that are most relevant to our work herein. As regards measurement of business cycles, we will limit ourselves to the application of some of these methods. The emergence, refinement and suitability of these methods has grown to be a separate field in and of itself, and our thesis does not concern itself with this field.
6. There are three primary questions to be addressed when dealing with the theory, rather than the measurement, of business cycles. Firstly, can business cycles reasonably be said to be caused by one, or by one set of, events? Secondly, can (and should) the recessionary phase of business cycles be lessened in terms of frequency, amplitude and duration? Thirdly, assuming the answer to the second question is in the affirmative, which set of policy measures will be most effective, and what are the welfare implications of using them?
7. In our modeling, we restrict ourselves to the first question alone, and for a specific economy during a specific time period. We focus on ascertaining a reasonable cause (one

of potentially many) for the Indian business cycle, during the time period 1990-91 to the downturn of 2008-09. We construct an aggregated model and show that a reasonable cause for the Indian business cycle may be found in the replacement cycles that a manufacturing economy must necessarily face as part of its normal operations.

8. The rest of the thesis proceeds as follows. In the first chapter, we make a broad survey of the literature on business cycles in general, and conclude the chapter by focusing on those sections of the literature that are relevant to our approach. In the second chapter, we explain the development of our model, and our reasons for using said model, along with the results of our model. In the third chapter we compare these results against empirical data from the Indian economy. The fourth chapter concludes. An appendix shows in detail both the results of our model and the empirical data that has been used for testing the results of our model.

1. As mentioned earlier, business cycles are reasonably periodic fluctuations that are observed in aggregated economic activity. Business cycles as a field of study has a long and rich history, and have been examined in an academic sense for at least two hundred years, if not more (Lauderdale 1819).² Our review of the literature in this section shall focus upon the first of the three questions that have been referred to earlier, namely, the cause of business cycles.
2. Broadly speaking, the cause of business cycles can either be found in monetary factors, real factors, or a combination of the two. Accordingly, our review shall be sub-divided along these lines. We shall first focus on those theories that depend on monetary causes, subsequently moving on to the theories that focus upon real factors and finally examine theories that use a combination of the two. We shall conclude our analysis by focusing upon a school of thought that has remained somewhat under-represented in the literature, and one that we make use of in our modeling.³
3. One of the earliest papers to focus on credit was one that continues to be of significant interest in current modeling as well (Fisher 1933)⁴. Irving Fisher posits that a likely cause of depressions is the shrinkage of debt throughout the economy. In other words, the credit cycle itself is the cause of the business cycle. The chain of causation is initiated because of the need to liquidate debt, itself acquired during a phase in which producers

are (possibly unduly) optimistic about the prospective return on capital, which in turn causes distress selling, leading to an economy-wide depression of prices, thereby setting in motion the contractionary phase of the business cycle. Eventually, the process feeds upon itself, thereby accentuating the effects upon the economy. This view has resonated with many economists down the years, and a variant of the same hypothesis is also to be found repeatedly in the literature, perhaps most notably in Joseph Schumpeter's Business Cycles. "Measures of defense, efforts made by firms or households to repay loans, or by banks to call them in order to improve liquidity, drive debtors in the well-known way toward the very rocks which those measures were taken to avoid. Freezing of credits, shrinkage of deposits, and all the rest follow in due course. On the other hand, not only we, the observers, but also the *dramatis personae* realize how much there is to liquidate, or even go into hysterics about it. Then pessimistic expectation may for a time acquire a causal role."⁵ (Schumpeter 1939)

4. Another relatively early paper to conclusively establish monetary factors as a causal factor for business cycles was authored by (Hawtrey 1927)⁶. Its author, Ralph Hawtrey, held the trade cycle to be periodical fluctuations in manufacturing activity and in the price level, with the two fluctuating together. The monetary theory of the trade cycle, according to Hawtrey, holds that monetary or credit movements are necessary and sufficient conditions of the observed phenomena of the trade cycle, and that the periodicity of the said phenomena can be explained by purely monetary tendencies.

5. Hawtrey traces the development of the business cycle as having its origin in a (relatively) unregulated banking mechanism that affects first the interest rate, and thereby cash balances with the public. This subsequently impacts the inventories of the merchants, and forms the trade cycle. The upswing has the unwanted effect of reducing bank's cash reserves, setting in motion a credit contraction, which completes the trade cycle. The operative mechanism is the discount rate – made important because trade merchants are particularly sensitive to interest rate changes. In particular, traders are sensitive to short term interest rates, since these are the rates at which they are able to borrow to finance the holdings of inventories. A low rate of interest therefore acts as a stimulus to increase inventories, which in turn is an inducement to increase output. The familiar pattern of increased income and therefore increased spending results, leading to the expansionary phase of the business cycle. Increasing demand for the financing of inventories in turn leads to an increase in the same short term interest rates, which causes the downturn.
6. There has been a long standing criticism of this strand of thought, beginning most famously with Keynes, in which interest rates are either deemed to not be the primary cause at all, or even if they are *a* cause, it is long term interest rates that matter, not short term bank rates. The most relevant citation comes perhaps from (J. Hicks 1969): "It was Hawtrey's doctrine that the terms of bank lending had a direct effect on the activity of trade and industry; traders, having more to pay for credit, would seek to reduce their stocks, being therefore less willing to buy and more willing to sell. Keynes, from the start (or at least from the time of the Treatise 1930) rejected this in his opinion too simple view."

He substituted for it (or began by substituting for it) an alternative mechanism through the long rate of interest. A change in the terms of bank lending affected the long rate of interest, the terms on which business could raise long-term capital; only in this roundabout way would a change in the terms of bank lending affect the activity of industry.” In other words, business cycles are caused not so much by short-term interest rates as by fluctuations in fixed capital investments, and in turn, these investments are themselves more sensitive to long term interest rates.

7. One way of characterizing this argument is to paraphrase it as what has by now become an age-old argument: is the business cycle more affected by short or long term interest rates? While Keynes and Hawtrey themselves engaged in extended discussions of the subject, sometimes directly, and at other times indirectly, the issue remains more or less undecided, as evidenced in (Guttentag 1971), as well as (King 1996), and complicated by the stage of development an economy finds itself in (Tchakarov 2006)
8. The monetarist counter-revolution of the 1950s provided the next significant impetus to the monetary nature of the business cycle. (M. Friedman 1958) studied time series data of monetary growth and attempted to establish some relation to statistical data pertaining to the economy of the United States. The paper’s thesis was that changes in money supply, in either direction, was followed by peaks/troughs in economic activity. However, as Hawtrey himself mentions in the paper cited earlier: “It is one of the disadvantages of the statistical method that a correlation between two varying quantities

does not readily reveal which is cause and which is effect, or whether both are effects of some other cause.” Criticism of a similar nature has repeatedly been made against the methodology employed by Friedman, a particularly readable account is to be found in (Hammond 2005) .⁷ Friedman’s response to criticism of this nature was the classic Monetary History of the United States, written with Anna Schwartz (M. & Friedman 1963). The hypothesis here was that monetary policy was the cause, as opposed to being a (responsive) consequence of major recessions. Evidence for the periods 1873-1879, 1893-1894, 1907-1908, 1920-1921, 1929-1933 pertinent to the American economy showed that these were the only periods in which there was a fall in the absolute level of money, or the stock of money. It is no coincidence (or so was the position taken in the book) that these were periods of major crises in the American economy.

9. An implication of the monetarist approach is the inefficacy of fiscal policy. While this may not be a position subscribed to by all monetarists for all possible situations, there remained broad agreement among most monetary economists about the undesirability, at the very least, of the management of the economy through purely a fiscal policy approach. Further advancement along this line of thought was made with first the Lucas Critique (Lucas 1976, December)⁸, and subsequently with the development of the Real Business Cycle Theory. The Lucas Critique states that using historical data to predict the consequences of a current policy is inherently futile, since whatever models would be used to predict the consequences would themselves be using parameters that were dependent on past policy decisions. In Lucas’ words: *“Given that the structure of an*

econometric model consists of optimal decision rules of economic agents, and that optimal decision rules vary systematically with changes in the structure of series relevant to the decision maker, it follows that any change in policy will systematically alter the structure of econometric models." The significance of this critique, and its relevance to the current thesis was that the Lucas Critique effectively disallowed **any** kind of policy analysis in modeling, save for those that would allow individuals to 'rationally' react to changes in policy at a microfoundational level. In turn, these decisions, taken at the individual level, would then have to be aggregated, in order to arrive at economy-wide changes brought about by a change in policy.

10. Real Business Cycle theory builds on this credo of the Lucas Critique. The first paper on the topic, preceding even the Lucas Critique, and the one that laid the foundations of the Real Business Cycle School was by (Muth 1961). "...expectations, since they are informed predictions of future events are essentially the same as the predictions of the relevant economic theory." In other words, the economy consists of informed agents, who make use of their knowledge in forming their expectations. Broadly speaking, the policy implications of the New Classical Approach are:
- a. Policy interventions are completely ineffectual; they have, in fact, the potential to be disruptive in a harmful fashion
 - b. Under a game-theoretic framework, where policy is a 'game' enacted between the government and the economy (or the rational agents), the government has an incentive to 'cheat' – the credibility problem.

Real business cycles theory holds, therefore, that business cycles are **caused** by an efficient response by rational economic agents to exogenous causes. In other words, short-term economic fluctuations are caused by efficient responses, and further intervention, whether fiscal or monetary, will by definition be sub-optimal. One implication, in a positive sense, is that business cycles are endogenous to an economy. Another implication, in a normative sense, is that business cycles do not warrant any policy interventions.

11. New Keynesian economics, it can be said, is a response to the New Classical school of thought (Colander 1992). It does not deny the rational expectations methodology, but assumes instead an imperfect competition approach, instead of perfectly competitive, always clearing Walrasian markets. This approach enables the New Keynesians to retain elements of sticky prices and wages – that is, of the non-neutrality of money. There are two central models within the New Keynesian framework:

- a. Models constructed on the basis of sticky prices: Firms, it is assumed face costs of adjustments when forced to consider price changes in response to changing macroeconomic conditions. Such ‘menu costs’ make prices sticky – thereby explaining, in part, the persistence of disequilibrium.
- b. Models constructed on the basis of efficiency wage theory – efficiency wage models (such as models that take into account the effects of ‘shirking’) can result in workers being unable to bid down wages - thereby making wages sticky, and therefore explaining the persistence of disequilibrium.

What is unusual, from a standard Keynesian perspective, about these models is that they assume the existence of rational agents, or the rational expectations framework – and then seek to establish the persistence of disequilibrium.

“Recently, sticky-price theorists have shown that an asymmetric aggregate supply curve arises endogenously under natural conditions. Different versions of the argument appear in (Tsiddon 1991), (Ball 1994) etc. In all cases, the crucial assumption is positive trend inflation. “In an environment with trend inflation, firms' relative prices fall automatically between nominal adjustments. In this setting, a firm does not need to make a special adjustment if a negative shock reduces its desired relative price: inflation automatically does the work. In contrast, a positive shock means that the firm's desired relative price is rising while its actual price is falling, creating a large gap between desired and actual prices. Thus a positive shock triggers quick nominal adjustment, whereas prices are sticky in response to substantial negative shocks - exactly the asymmetry that Tobin and others assume.”⁹

The chief policy prescription of the New Keynesian School is that non-intervention is not an option.

12. Although only a chapter (Chapter 22: Notes on the Trade Cycle) is given over to the theories of the trade cycle in the General Theory of Interest, Employment and Money¹⁰ (Keynes 1936), the Keynesian framework in itself brought a richness of tools which could be used to analyze trade cycle theory. Most notably, the interaction between the investment demand, the rate of interest and the consumption function could all at the

same time be used to explain changes in investment patterns, and the resultant effect on both the financial markets and consumption patterns. In fact, changes in consumption patterns due to negative results from financial markets is a factor that Keynes makes special mention of in the said chapter.

13. While there is, as has been mentioned, only one chapter specifically devoted to theories of the trade cycle in the General Theory of Interest, Employment and Money, the entire book may, of course, be construed as an attempt at unraveling the causes of business cycles, as well as means of reducing their amplitude. At various points in the book, Keynes alludes to various factors that might conceivably both cause and cure the business cycle. Interest rates, wages (and their stickiness), animal spirits and the marginal efficiency of capital, among others, are all discussed as potential causes. There is one particular cause that is hinted at but not made explicit, in Chapter 32, which is of particular interest to this thesis – replacement cycles. We shall have reason to examine this cause, and Keynes' reference(s) to it in greater detail below.

14. The first explicit model of the interaction between investment (as induced by consumption – the acceleration principle), consumption (as induced by past income – the multiplier), and resultant changes in income (and therefore the dynamic approach) – or, in other words, the multiplier-accelerator model – was put forth in (Samuelson 1939).¹¹ Briefly put, national income is dependent on government expenditure, consumption and private investment (which is induced). Consumption itself is shown to be dependent on past income, while investment in turn is held to be a function of the difference between

consumption in the current period and the previous period. As consumption itself is dependent on income, income itself is now shown to be dependent on past income. Or, as Samuelson puts it, "...in words, if we know the national income for two periods, the national income for the following period can be simply derived by taking a weighted sum".¹²

This really is the crux of the multiplier accelerator model. Investment and consumption, both in turn depending on past incomes, form the crucial determinants of current income. Fluctuations in consumption and investment are tied to past (realized) incomes, and these factors, in turn, determine current income. The coefficients in the equations determine the shape of the perturbations and their magnitude, but the essential results from a theoretical viewpoint (and especially from our perspective) are that consumption (in terms of the multiplier), investment (in terms of the accelerator) and income are inter-related by a relatively simple set-up.

- a. We come now to two strands of thought upon which the current thesis has been built. Firstly: (Marx 1872): *"It can be assumed that for the most important branches of the big industries this life cycle has now on the average a length of ten years. But the concrete figure does not matter here. So much is certain: this cycle of interconnected turn-overs stretching over a series of years, during which capital is determined through its fixed parts, provides a material basis for the periodic crises which leads businesses through successive periods of recession, average*

*activity, exaggeration, and crisis. It is true that periods during which capital is being invested are very different and dissimilar. But the crisis always marks the point of departure of a great investment, consequently – from the point of view of society as a whole – more or less a new basis for the next cycle of transformation.”*¹³ It is perhaps unfortunate that most mainstream economists are in almost complete agreement about Marx never having developed a clear theory of the business cycle, although there are repeated allusions to the periodic emergence of crises, as in the quotation above.

15. These allusions to the periodic emergence of crises have found resonance with many economists over the years, including Keynes. The relevant quote (referred to earlier) from Chapter 32 is produced below:

“Let us recur to what happens at the crisis. So long as the boom was continuing, much of the new investment showed a not unsatisfactory current yield. The disillusion comes because doubts suddenly arise concerning the reliability of the prospective yield, perhaps because the current yield shows signs of falling off, as the stock of newly produced durable goods steadily increases. If current costs of production are thought to be higher than they will be later on, that will be a further reason for a fall in the marginal efficiency of capital. Once doubt begins it spreads rapidly. Thus at the outset of the slump there is probably much capital of which the marginal efficiency has become negligible or even negative. But the interval of time, which will have to elapse before the shortage of capital

through use, decay and obsolescence causes a sufficiently obvious scarcity to increase the marginal efficiency, may be a somewhat stable function of the average durability of capital in a given epoch. If the characteristics of the epoch shift, the standard time-interval will change. If, for example, we pass from a period of increasing population into one of declining population, the characteristic phase of the cycle will be lengthened. But we have in the above a substantial reason why the duration of the slump should have a definite relationship to the length of life of durable assets and to the normal rate of growth in a given epoch.”

16. In other words, there has been a definite attempt at eliciting the cause (as also the duration) of the business cycle from nothing simpler than the (average) life of durable assets. To be clear, this is not to suggest that these economists were suggesting that this was the sole, or even primary cause of the general business cycle. Also, the current thesis also does not posit replacement cycles as the only, or primary, cause of the business cycle. However, the *idea* that business cycles may emerge from nothing more than replacement cycles, and may therefore be an inevitable part of an industrialized economy (with all of its attendant consequences) is a powerful one, and one that bears investigation. To be more specific, the prime motivation in both our modeling as well as our review of the Indian business cycle is to investigate if replacement cycles are a reason for the very cyclicity observed in series such as GDP etc. That is to say, our motivation is not so much the factor that puts the cycle in motion (of which there could be very many), as it is the factor that perpetuates the cyclical pattern itself.

17. In 1935, however, Johan Einarsen completed a study under the auspices of Ragnar Frisch at the University of Oslo, (Einarsen 1938) in which he outlined a hypothesis that pure reinvestment cycles are due to the age distribution within the stock of capital instruments in society. In other words, pure reinvestment cycles happen because a disproportionate amount of capital comes up for replacement simultaneously.

Reinvestment cycles are due to the purchase of a new machine when an old one is either fully amortized or when the amortization has itself reached a certain level, or limit – this is opposed to the notion of the purchase of a new machine instead of an old one in the generic sense. Cyclicalities, in this sense, are dependent on three separate but interlinked factors: time distribution (of primary investment), the amplitude and frequency of reinvestment, and the percentage of capital that is not replaced (during depressions or otherwise).

18. A little space may be profitably spent in further examining the topic of reinvestment cycles. It was, and remains, an idea that did not gain too much credence in mainstream economics, although a certain flavour may be said to have percolated in some works. But for the most part, the defining work in this area appears to have been done by Einarsen¹⁴ and Isard¹⁵. Briefly put, the idea is that if (and the theory in itself doesn't qualify **why** this should happen at the precise moment at which it does happen – perhaps because of a boom due to unspecified reason, perhaps due to war, or perhaps because of some other

reason altogether) an economy should experience a boom, replacement requirements will be felt at regular time periods in the future. If all the capital goods in the economy had the same life spans (or even reasonably similar life spans – a much more reasonable assumption) cycles that would occur in the future would come close to replicating the original. Furthermore, the duration of the cycle (peak to peak) would depend almost exclusively on the lifespan of the capital good.

19. The idea was deemed meritorious enough to warrant research, but the initial results in this field of study appear to not have been too encouraging, in terms of fitting the hypothesis of reinvestment cycles in particular to industries causing the business cycle as a whole.¹⁶

20. However, further research in this field has continued, perhaps without the level of attention that it seems to deserve. Two key questions need to be answered to a reasonable degree for the thesis to hold. One, is it reasonable to assume that the depreciation rate for capital goods is relatively constant? Second, is it reasonable to assume that the life cycle of capital assets across most industries (or at the very least, basic industries) is relatively constant. In what follows, we review the existing literature on this subject.

21. Depreciation itself is a tricky concept to define, and it is safe to say that the controversy hasn't fully subsided even today. A definition that is acceptable to most economists is the classical one provided by John Hicks in "Maintaining capital intact: a further suggestion." (J. R. Hicks 1942): "Let us then define the depreciation of the original stock of capital as the difference between the total value of the goods comprising that stock as it is at the

end of the year and the value *which would have been put upon the initial stock at the beginning of the year if the events of the year had been correctly foreseen, including among those events the capital value at the end of the year.*"¹⁷ In other words: "Any theoretically satisfactory definition of depreciation requires the asset to be valued consistently at both times on the basis of the same information and expectations. If depreciation is to be calculated ex post, the best estimate must be based on the information and expectations held at the end of the period in question because they supersede those held at the beginning of the period"¹⁸

22. For the purposes of the current discussion we shall follow the annuity method of depreciation. As noted in (Parchure 2008): "It is evident that depreciation has been computed using "the annuity method" which of course is the only correct method considering that it is the only method which gives a uniform price of the product irrespective of the age of the machines by which the products may be produced [Piero Sraffa (1960)]"

23. As to our answer to the two questions raised earlier, about common depreciation rates and the constancy of the life cycle of capital assets, the answer remains somewhat controversial. Studies have been conducted at both the sectoral level as well as the economy wide level, with contrasting results. Perhaps the most definitive of these studies was the one conducted in (Ulmer 1960), in which an in-depth, detailed investigation of the hypotheses advanced by Einarsen¹⁹ was carried out. As Ulmer himself cites: "The theory of reinvestment cycles observes that if a bulge in capital formation is at any time induced by a business boom or a war, or for whatever reason, replacement requirements

at subsequent dates will tend to generate similar expansions. If all capital goods had the same life span, and if replacement decisions were based on purely mechanical considerations, subsequent cycles would duplicate the initial one exactly, and the duration from peak to peak would depend solely upon the durability of capital—except insofar as booms, depressions, wars and other “external” factors intruded. Although it is conceded that such ideal conditions are never satisfied, the existence of perceptible reinvestment cycles must rest at least upon their rough approximation. In the regulated industries, in particular, we would expect (1) a considerable degree of concentration about some average life span among the different types of plant and equipment. That is to say, most capital machinery in the same industry should have roughly the same life span and (2) some agreement between this average life span of capital machinery and the observed duration of cycles. *Neither of these conditions hold.* (Italics added)

24. Perhaps most damaging to the thesis at hand is the contention made in (Ulmer 1960) as regards reinvestment cycles – that reinvestment cycles probably have nothing to do with long cycles. In this regard, however, three points can be made that offer plausible refutations. First, as later cited by Ulmer himself, capital formation in basic, heavy industries may not be an entirely internal phenomenon. It could be triggered by events in other sectors, such as, for example the real estate sector. Secondly, the rate of depreciation itself may plausibly see an acceleration due to more intensive usage, or rapid obsolescence. And thirdly, and perhaps most pertinently, Ulmer’s rejection of Einarsen’s hypothesis is not a general, theoretical rejection. It is a particular, empirical rejection,

based upon the American economy for a particular time period. There is, therefore, room for further investigation along two different lines of thought.

25. Firstly, is it possible, in the abstract, to come up with a plausible model of an idealized economy in which a business cycle may be generated purely due to the reinvestment cycle? Were such a cycle to emerge in a theoretical model, one might then be justified in at least attempting empirical validation. Secondly, assuming the first step of this thought exercise were to meet with reasonable success, does the available data for a reasonably long time period show evidence of the presence of a replacement cycle? In other words, does the data indicate a reinvestment cycle that leads the general business cycle? If the answer to these two questions were to be positive, we posit that there may be some merit to the idea of reinvestment cycles. Note, once again, that the thesis in no way seeks to establish reinvestment cycles as the only cause, or even the primary cause of the business cycle. The effort lies in showing that (a) business cycles may be generated, and more importantly, ***perpetuated*** by nothing more than simple reinvestment cycles (b) reinvestment cycles are present in the Indian economy, and to some extent at least, lead and perpetuate the general business cycle for the Indian economy.

26. In the next section, we cover in some detail the theoretical work associated with establishing the reinvestment cycle, and its relationship with the general business cycle. Our stylized model, we aim to show, is capable of both generating as well as maintaining a business cycle.

Chapter 3: A Dynamic Model of the Business Cycle

1. Our modeling relies upon the methodology first espoused by Einarsen²⁰, itself predated by Marx's approach to the problem of the business cycle. In addition, our work is based upon a paper written by (Parchure 2008), which posits an aggregative economy whose balance sheet is examined over time, with a clearly defined replacement period for its capital stock.

2. A word about the slightly unconventional approach undertaken in the present modeling might prove profitable. As far as we are aware, no approach of the sort we have adopted herein has been used elsewhere, except for Parchure (2008). Our approach rests upon modeling the entire economy as a single, representative firm. There are many reasons for this, some of which are enumerated and discussed below.

Firstly, our attempt in our methodology is to see if we are able to come up with a fairly realistic model in which a business cycle has cause to perpetuate. If such a cycle can emerge without the additional complications of an exchange economy, without the additional complications of full information (or the lack thereof) and without any assumptions being made about forms of markets et al, then it would be reasonable to assume that such a cycle would persist with the inclusion of all of these assumptions as well; indeed, it might well have a higher amplitude on account of all of these inclusions.

Secondly, our methodology relies upon the emergence of a cycle that is tracked

across the entire economy, rather than a particular sector. From the point of view of parsimony, it seems appropriate to restrict our modeling to a single firm that is representative of the entire economy.²¹

Thirdly, and perhaps most importantly, as has already been stated previously, our attempt is to identify a cause that perpetuates the business cycle, rather than cause it. There are many potential factors that may cause the business cycle, but there has been a paucity of research on factors that perpetuate it. As such, our modeling requires the kind of framework that we have used herein, in spite of it not falling within the neat confines of any popular school of economic thought. In other words, our modeling is agnostic when it comes to underlying frameworks.

3. Does this imply that our model will not work within a more conventional framework? This is not the case. On the contrary, it may well be that a variant of our current model, built within the confines of, say, a Keynesian framework, will actually throw up a richer form of the business cycle than the relatively simplistic one that we have been able to generate. However, that is not the purpose of the present exercise, and we therefore abstain from attempting such modeling.
4. In what follows, we first describe the approach followed by Parchure (2008) in greater detail. Subsequently, we describe the modifications and additions made

to this model, to better reflect reality, and enumerate the results obtained therein.

5. The attempt in (Parchure 2008) is not so much to establish a cause for business cycles as it is to establish conditions under which Marx's law of the falling rates of profit might reasonably come into being. There is much to be said, as has been established in the previous section and is discussed in this paper, about the similarity between Marx's viewpoint about recurring crises in capitalism and Keynes' viewpoint about how trade cycles might emerge with regard to the replacement of capital. As Parchure mentions in his paper, there is considerable divergence in both the outcome as well as the assumptions made in their studies, but the similarity is nonetheless striking. However, more importantly, from the point of view of the current thesis, the conclusions arrived at in (Parchure 2008) are more important.
6. Those conclusions (relevant to the current thesis) are stated below:
 - a. If they (capitalists) are able to invest their saving, the rate of profit is prevented from declining; but if the age distribution of fixed assets is not uniform, long-run equilibrium will be achieved only by a cyclical path.

- b. The length of the business cycle is equal to the average life time of fixed assets; the greater the durability of the fixed assets the longer the periods of booms and the sharper the declines.
 - c. Increasing organic composition of capital will cause the rate of profit to decline faster than otherwise if there is a failure to invest. If not, it will cause the cycle to become more violent.
7. Of these conclusions, the second one mentioned above is perhaps the most relevant to our thesis. The emergence of a business cycle in Parchure's stylized model is not of particular relevance *because the only way a cycle can perpetuate, in the stylized model, is due to the replacement of capital*. In other words, there is neither discretionary fiscal policy, nor discretionary monetary policy (in fact, in this stylized model, there is no government). Interest rates, in and of themselves, do not play a role in causing the business cycles. Technological change is assumed away, as are market distortions. The entire economy consists of but one firm, as is described below.
8. (Parchure 2008) begins his analysis with a firm that is representative of the economy, which used fixed capital K , raw material stocks S and labour (which is paid fixed wages W) as inputs. It is assumed that r is the competitive rate of profit. Technology is assumed to be static throughout the course of the investigation.

For a firm such as this, it's balance sheet may be represented thus:

Table 1: Balance Sheet of a representative firm

Liabilities	Assets
Equity E	K Fixed Capital
	S Stocks
	W Wage Fund
Total Liabilities	Total

9. As per Parchure (2008):

“The gross national product of this economy is obtained as follows:

$$\frac{K}{\sum d_t} + (S + W)(1 + r) = G \quad (1)$$

where $d_t = 1/(1+r)^t$ is the discount factor for year t so that the first term of equation (1) shows the annuity that must be charged every period to recover the value of the fixed capital with profit over the n periods of its life. The annuity splits into two parts, one representing the depreciation charge and the other representing the net profit on the book value of the fixed asset. The second term shows the working capital including the stocks of raw materials and/or spare parts

required to maintain fixed assets and wages advanced to workers. The gross national product G may be expressed as PQ where P is the price of production and Q is the gross output. The net national product is simply the gross national product less stocks consumed and depreciation, alternatively expressed as wages plus net profit.

Net profit itself is expressed as $\pi = r(B + S + W)$ where B is the book value of the asset.

Furthermore, if we suppose the fixed assets to be new, the depreciation charges and book value (unrecovered investment) over the years are given below:

$$D_t = (1 + r)^{t-1} \left[\frac{1}{\sum d_t} - r \right] K \quad t = 1 \dots n \quad (2)$$

$$B_t = \left[(1 + r)^t - \frac{\sum_{0}^{t-1} (1 + r)^t}{\sum d_t} \right] K \quad t = 1 \dots n \quad (3)$$

It is evident that depreciation has been computed using “the annuity method” which of course is the only correct method considering that it is the only method which gives a uniform price of the product irrespective of the age of the machines by which the products may be produced [Piero Sraffa (1960)]”

10. Parchure proceeds to demonstrate that a balance sheet as simplistic as this is capable of generating a business cycle, purely on the basis of the entirely reasonable assumption that capital machinery (or alternatively put, the fixed capital) will need to be replaced after it has been completely depreciated. We expand upon this model, and incorporate certain additional assumptions about the representative firm, so as to more closely approximate reality. The model itself, and its attendant assumptions have been explained in what follows.
11. As has been mentioned earlier, the model in this thesis is an extension of the model that has been used in Parchure (2008) and explained above. However, our extension makes some modifications to the underlying assumptions, which make the model richer in the sense that it now more closely approximates decisions that a capitalist might undertake, given the choices available to him. Specifically:
 - a. We no longer assume that savings must necessarily equal investment in the economy. It is possible, indeed probable, that the capitalist will base his decisions on sales realized in the previous year, and accordingly scale up (or down) his business activity in the current year. Accordingly, we posit that the capitalist may now choose to increase his cash balances in case the economy shows a recessionary trend (or conversely, decrease his cash balances and increase the amount of total assets in the firm in case the economy shows an expansionary trend).
 - b. The logic behind this is an attempt at introducing within our representative economy the famous 'animal spirits' hypothesis formulated by Keynes.

Specifically, the way in which this model diverges from Parchure (2008) is in hypothesizing that the business cycle may well change, and in fact increase in amplitude, given the decisions made by the capitalist in response to his assessment of the state of the economy.

12. Based upon the model shown earlier, it is assumed that the representative firm has datum as shown in Table 2. Capital (K) = 1000, Stock/Raw Material (S)=Wages (W)=500. In addition, we assume that the firm owner chooses to retain a portion of his assets as cash-on-hand, to be used as deemed fit in response to an uncertain future. Note that the assets side of the balance sheet is neatly split into a ratio that corresponds to:

Fixed Assets: Cash on Hand: Wages: Stock (40:20:20:20)

This completes the description of the assets on the firm's balance sheet.

Table 2: Balance Sheet at the start of Year 1

Year 1	Assets		Liabilities	
	Machine	1000	Equity	1250
			Short Term	
	Cash on Hand	500	Debt	625
	Wages	500	Long Term Debt	625
	Stock	500		
	Total	2500	Total	2500

13. On the liabilities side, it is assumed that the firm owner chooses to fund part of his balance sheet through debt, which itself is divided equally (at the outset) into short and long term debt. Also note that the debt to equity ratio at the outset is 1:1. This ratio may (and indeed does) change over time in response to changing conditions in our representative economy. The capitalist may choose to incur additional debt in order to finance an expansion of his fixed assets in response to an expansionary phase in the economy. The methodology followed is based for the most part on (Parchure 2008). We assume that the machinery works with constant efficiency over its life, and that wages are fully consumed and profits wholly saved.

Prices determination in our economy is a simple matter of applying a markup over and above the cost of production, which themselves are split up as wages and raw material costs. Accordingly: $(s + w)(1 + m) = P$. It is important to note that m , the markup in this case is assumed to have a value that translates into a profit rate of 20% on invested capital.

Table 3: P&L Account at the end of Year 1

GNP	1718.745
Less Cost of Goods Sold	1000
Less Interest Costs	187.5
Less Depreciation	281.2445
Net Profit	250

14. Given the assumptions of the model, the Return On Equity turns out to be 20% (a net profit of 250 on equity of 1250). Of the gross profits, a part is used to pay back both the long term and short term debts, while the remainder is 'ploughed' back into operations for the next year.

Is it reasonable to assume that the remainder, after paying off the debt, will necessarily be ploughed back into the operations of the firm itself? Might not the temptation to save a part of the proceeds arise? As has already been mentioned

in (Parchure 2008), there is very good reason indeed for assuming exactly this to be the case:

“What can capitalists do with the gross profit of a year? There are only three alternatives; to invest it in interest bearing instruments, to use it to buy shares or to buy more fixed assets and working capital. Keeping in mind that we are referring to the capitalist class as a whole it is clear that the first two alternatives can only result in a falling rate of profit: if invested in interest bearing instruments the prices of these instruments would rise and bring down the realized return, if invested in shares it would drive up the prices of shares and bring down the earnings yield. So, while a few capitalists may access these alternatives, any attempt to do so by all will only bring down the rate of profit. Although the discussion of these alternatives is, strictly speaking, outside the ambit of Marx’s model, it does suggest that excessive deployment of saving in deposits, bonds or stocks will only result in falling rates of profits / yields.

Only the third alternative, that of deploying the entire gross profit for accumulation of fixed and working capital, and ensuring that gross saving = gross investment, will maintain the rate of profit.”

As has been explained above however, we diverge from the model in Parchure (2008) in assuming that investment may in fact be **more** than savings. Therefore, on the basis of the not unreasonable assumption of the share of fixed capital being fixed as a percentage of the assets, the balance sheet for the second year is constructed, with one important qualification. The firm owner, on the back of the

strong performance seen in the first year, chooses to draw down upon his cash balances. In practice, the model works thus: the capitalist takes into account the net fixed assets available to him at the end of the first year, notes that his ROE has been 20%, and is therefore able to account for the additional funds available to him in the next year. This amount he then proceeds to distribute between the purchase of a new machine, and additions to stocks, wages and cash on hand, such that the additional amount distributed between the four is in the ratio of 40:20:20:20 respectively.

15. In other words, the firm owner has decided to augment fixed capital during a boom period, while choosing to not lower debt as a percentage of liabilities. This results in the balance sheet shown below:

Table 4: Balance Sheet at the end of Year 1

Year 2	Assets		Liabilities	
	Machine	1490.622	Equity	1250
	Less Depreciation	-281.245		
	Net Fixed Assets	1209.378		
	Cash on Hand	300	Short Term Debt	750
	Wages	745.3111	Long Term Debt	750
	Stock	745.3111	Reserves	250
	Total	3000	Total	3000

The profit and loss account is as follows:

Table 5: P&L Account at the End of Year 2

GNP	2484.069
Less Cost of Goods Sold	1490.622253
Less Interest Costs	225
Less Depreciation	468.4471094
Net Profit	300

The rate of profit remains unchanged at 20%, while the economy continues to be in an expansionary phase, with GNP increasing at a rate of 45%.

16. Such an economy now proceeds to grow along the lines described. It bears repetition: the emergence of the business cycle in this case is entirely because of the depreciation of fixed capital and decisions made by the capitalist as regards his balance sheet and his assessment of the economy's prospects in the year to come (based upon the economy's performance in the preceding year)

17. As per the methodology used in (Parchure 2008): “At the end of the third year, however, the computations must be recalibrated. That is because the first machine of 1000 will expire. The gross profit of that year must be allocated between the fixed and working capital in such a way as to maintain the technological ratio of fixed to working capital. If that ratio is f , then the allocation will be done by solving.

$$(dF_1 + dF_2 + x) = f (S_3 + W_3 + y) \quad 7(a)$$

$$x + y = \text{Gross Profit} \quad 7(b)$$

where dF_1 , dF_2 are the new machines purchased in years 1 and 2, $S_3 + W_3$ is the working capital

in year 3, x is the allocation to machines and y the allocation to working capital.”

Accordingly:

Table 6: Balance Sheet at the end of Year 2

Year 3	Assets		Liabilities	
	Machine	1994.846	Equity	1250
	Depreciation	-749.692		
	Net Fixed Assets	1245.154		
	Cash on Hand	360	Short Term Debt	900
	Wages	997.4229	Long Term Debt	900
	Stock	997.4229	Reserves	550
	Total	3600	Total	3600

Table 7: Profit and Loss Account for Year 3

Sales Revenue	3317.081
Gross Profits	1322.235
Annuity	910.1374
Equated Annual	
Instalment	394.1793
Plough Back	928.0562
Depreciation	692.2355
Net Profit Account	360

Table 8: Balance Sheet at the end of Year 3

Year 4	Assets		Liabilities	
	Machine	1904.771	Equity	1250
	Depreciation	-441.927		
	Net Fixed Assets	1462.844		
	Cash on Hand	952.3854	Short Term Debt	1080
	Wages	952.3854	Long Term Debt	1080
	Stock	952.3854	Reserves	910
	Total	4320	Total	4320

Table 9: Profit and Loss Account for Year 4

Sales Revenue	3273.814
Gross Profits	1369.044
Annuity	869.0412
Equated Annual Instalment	473.0151
Plough Back	896.0284
Depreciation	613.0436
Net Profit Account	432

18. In our case, the methodology must necessarily be tweaked a little, since cash-on-hand is drawn down on a discretionary basis, which is explained below. Of the balance sheet in the following year, a certain proportion is to be kept aside for the purposes of cash on hand balances, stocks and wages, the sum total of which must bear a fixed proportion to total assets. Of the remainder, a part is accounted for on the basis of the depreciated value of the fixed asset, while the remainder is further proportionately distributed between wages, stocks and cash on hand in the succeeding year.
19. (Parchure 2008) does not incorporate any kind of discretionary decision making on part of the capitalist in his model. In contrast, in the model contained herein,

we assume that the capitalist will choose to draw down upon his cash balances during good times, and invest in increasing his firms output. This is not merely a reasonable assumption, but a rather crucial one. In Keynesian terms, this would be a reflection of the capitalist's "animal spirits" – given an encouraging expansion that is observable throughout the economy, it is only natural that the capitalist will want to both produce as well as sell more. Increasing production can be done in one of two ways: using existing production capacity in a more intensive fashion, or if this avenue is exhausted, increasing production capacity itself. Conversely, if the capitalist were to observe that the economy was not doing so well, he would be tempted to hoard cash, and let alone increase production capacity, would instead be tempted to save for rainy days ahead. This much is fairly straightforward reasoning, and we therefore incorporate this step into our modeling.

20. It only remains for us to assign a set of rules which the firm owner would be assumed to use to draw down (up) his cash balances in response to increasing (decreasing) growth rates for the economy. We have used the following set of rules:

If GNP growth rate greater than 40%, cash on hand to be reduced to 10%

If GNP growth rate greater than 30%, cash on hand to be reduced to 15%

If GNP growth rate greater than 20%, cash on hand to be reduced to 20%

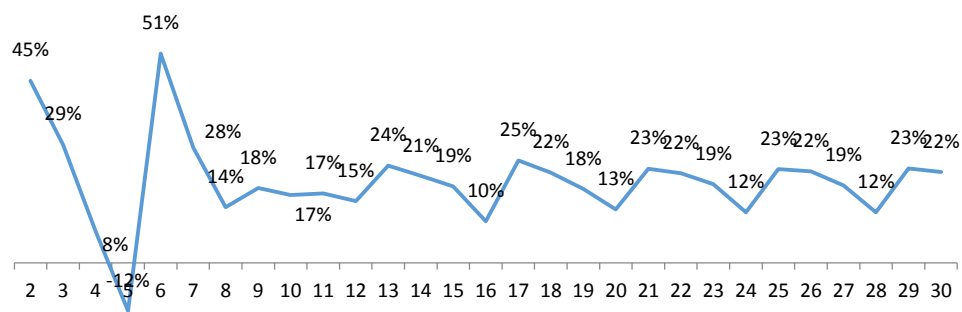
If GNP growth rate greater than 10%, cash on hand to be reduced to 25%

On the basis of these assumptions, the economy is traced over a period of thirty years.

The resultant variables from such a trace are shown in the table below.

Also shown below is the business cycle generated as a result of our stylized economy.

Figure 1: Business Cycle Generated by the Model



As can be seen, the business cycle shows large amplitudes at the outset, but quickly settles into an (undying) pattern that replicates itself from the 8th year onwards. In other words, the business cycle never stabilizes completely, but instead settles into a pattern that oscillates in a seemingly fixed pattern.

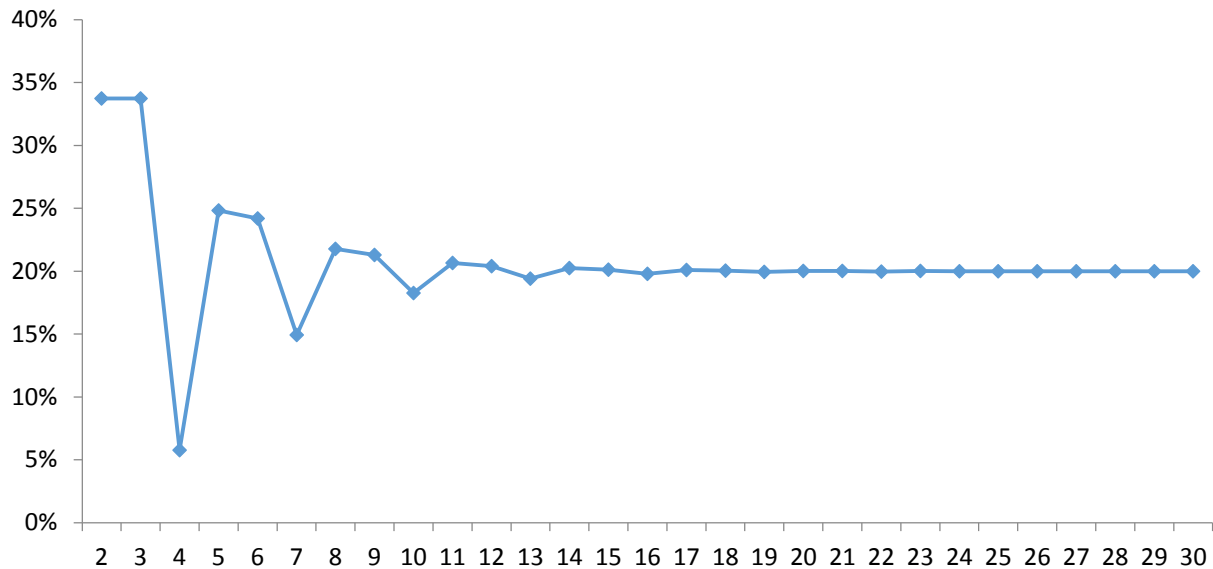


Figure 2: Business Cycle Graph from Parchure (2008) - Sales Growth Rate

When compared to the business cycle generated by the modeling methodology used in Parchure (2008), it is interesting to note that the business cycle perpetuates in the present instance, as opposed to the cycle shown in Figure 2 above. The reason the cycle shows an undying pattern, instead of settling into a steady growth rate of 20% as in Parchure (2008), is because of our assumption of deploying cash on hand in response to changing business cycle conditions.

Stated differently, a set of relatively simple assumptions about an economy that is represented as a single firm (fixed life of fixed capital, variable cash on hand, simple debt-equity structure, fixed rate of profit) gives rise to a business cycle purely on the basis of a required replacement cycle.

21. What should we expect from the construction of such a model in terms of the relationships between the three key variables at play in our model (sales (or GDP) growth rate, cash on hand growth rate and Gross Fixed Asset (GFA) growth rate)? The relationship between the three variables on a cotemporaneous correlation basis has been shown in the table below:

Table 10: Cotemporaneous correlation between Gross Fixed Asset, GDP and cash on hand growth rates from the model

Correlation Analysis	Correlation
GFA Gr Rt & c.o.h Gr Rt	-88%
GFA and GDP Gr Rt	95%
c.o.h and GDP Gr Rt	-24%

As expected, there is a strong and negative correlation between the growth rate for Gross Fixed Assets and cash on hand, for GFA will increase specifically in the year in which cash on hand is reduced by the capitalist. For the same reason, sales will increase in the year in which Gross Fixed Assets will increase. This is important because our model specifically predicts that in an economy in which business cycles are observable, the relationship between GDP and GFA should hold true, certainly in terms of directionality. In the next chapter, our empirical validation should be able to validate these claims.

Additionally, we also take a look at the correlation between the sources of funds (debt + retained earnings + depreciation) and uses of funds (addition to GFA and non-cash current assets), which comes in at 97.27%. If the correlation for the empirical data in the next section were to be of a similar magnitude, that would be further evidence that the model has merit.

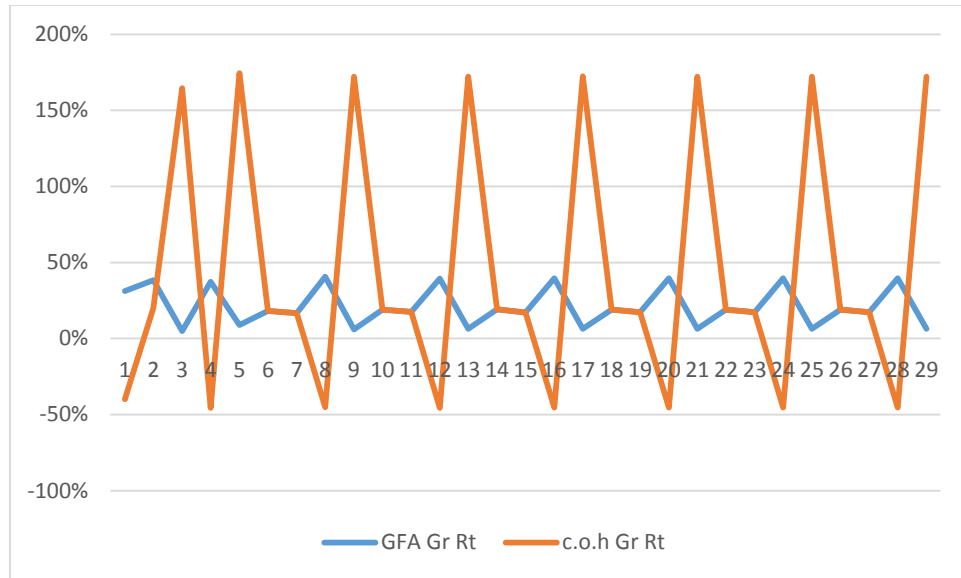


Figure 3: GFA and cash on hand growth rates over time

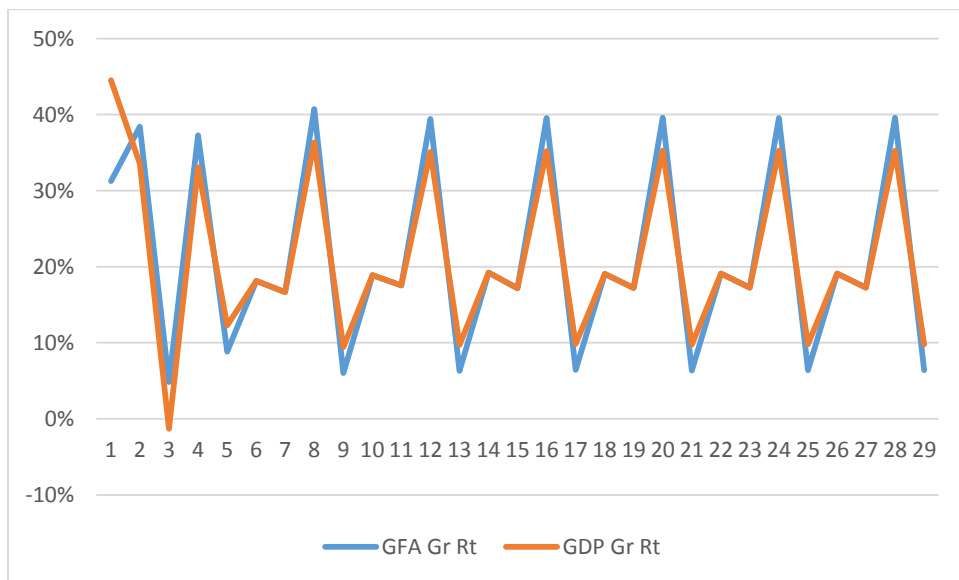


Figure 4: GFA and GDP Growth Rates

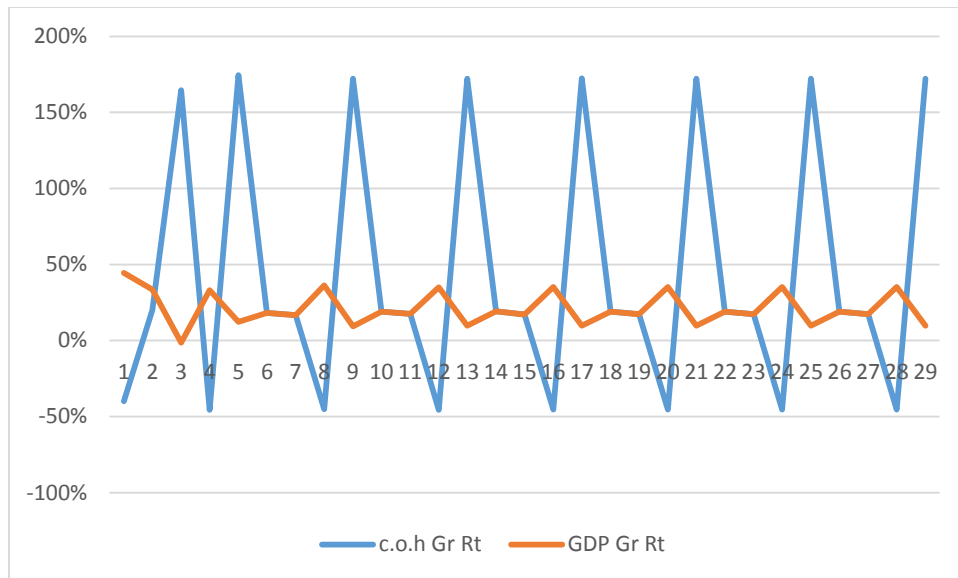


Figure 5: GDP and cash on hand growth rate

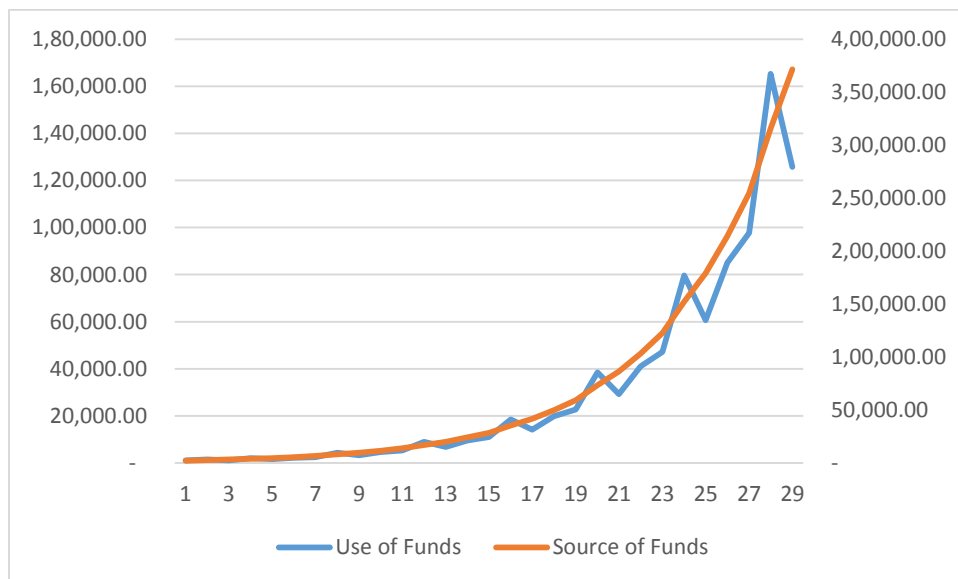


Figure 6: Sources of Funds Vs Use of Funds

22. Some comments about the shortcomings of this model are perhaps in order. We have put aside (without too much loss of generality) some factors that might have made the model more realistic, such as a variable rate of profit or the rate of

capacity utilization. Activist monetary policy and fiscal policy are also ignored, as is the question of intra and inter-sectoral linkages. The international economy, technology shocks, financial crises and other plausible reasons that have taken up much of the space in recent literature on business cycles are also excluded from the current modeling. In spite of (indeed, because of), these exclusions, the case for a self-generating business cycle becomes relatively stronger. This self-generating business cycle can then, of course, be impacted by relaxing the assumptions of the model and incorporating additional complexity.

23. Three primary results are all but guaranteed by the model in its very construction. As explained above, the model relies upon drawing down of cash balances when the growth rate associated with sales increases in line with the conditions explained above. In addition, there should also exist a negative contemporaneous correlation between cash on hand and gross fixed assets. Finally, as a corollary, there should be a rather high and positive degree of correlation between sales and gross fixed assets.
24. Of the two aims that this thesis has in principal, this section seeks to expand upon the first, namely, to conduct a thought experiment in which a business cycle might perpetuate itself on grounds of the necessity of replacing the physical capital stock a representative firm might possess. Having built a model that achieves this aim, it now remains for us to verify that the three relationships built upon above (namely, a negative relationship between cash balances and sales; a negative relationship between cash balances and gross fixed assets and finally, a positive

relationship between sales and gross fixed assets) are indeed to be seen in the empirical data associated with the Indian economy. It is towards this that we now turn.

27. In this section, it is our intention to answer one primary question: how does our hypothetical economy measure up against data from an actual economy? In order to make such a comparison, we use aggregated firm level data (comparable to our model) from the Indian economy for the period 1991-2009. Specifically, we use time series data generated by aggregating across all listed firms as present in the CMIE database for the said period. In addition, annual IIP data and GDP data, sourced from MOSPI and RBI respectively, are also used as points of comparison. However, before we begin answering this question in some detail, it will be necessary to review conditions in the Indian economy for the time period under consideration, i.e. 1991-2009.

28. As recently as about ten years ago, asking whether the Indian economy experienced business cycles *at all* was a relevant question, let alone questions regarding their causes and effects. Writing in 2002, Ila Patnaik and Rachna Sharma asked this question itself (Patnaik 2008): “To approach the study of business cycles in India the researcher has to first ask some basic questions. The first and most important of these is: does the Indian economy witness business cycles? Until now there is no general consensus on this issue. Only if the answer is yes, does this question need to be followed by other questions such as what are patterns in the cycles, what are the explanations of these cycles, how can they be predicted, can monetary and fiscal policy impact them, etc.”²²

As Patnaik and Sharma mention in their paper, “monsoon cycles” was perhaps a better description of cycles in the Indian economy prior to 1991. “In the literature on business

cycles competing economic theories that seek to explain cycles in market economies are usually based on factors such as the stickiness of prices, wages or the role of expectations, technology and information asymmetries. In the Indian economy it was mainly monsoon cycles rather than market related factors that caused a decline in GDP. The usefulness of this evidence to understand and predict market related business cycles or to develop leading indicators that predict them is therefore limited.”

Corroboration for the view espoused by (Patnaik 2008) is to be had from many researchers who have worked on business cycles both pre- and post-1991. VS Chitre, in an exhaustive study of the Indian business cycle from 1957 to 1982 echoes the point made above (V. Chitre 1986), and further evidence is also to be found in a later paper by the same author (V. Chitre 2001) along with (Dua 2000), (Gangopadhyay 1997) and (Mall 1999)

29. It is for this reason, primarily, that our investigation of the business cycle begins from 1991. While the share of manufacturing as a share of GDP even today remains stubbornly stuck at 17.2%, it is certainly more important, and more indicative of the state of the Indian economy than earlier. However, if one is able to see the replacement cycle predict to a reasonably satisfactory degree the GDP of the manufacturing sector alone, it would go a long way towards bolstering the hypothesis presented herein.
30. What can, therefore, be said about the Indian business cycle after 1991? In many respects, the Indian business cycle has begun to look more like that of an industrialized, developed

economy. There is, of course, some metaphorical distance to be traversed before India can be confidently labeled as such, but the fact remains that India is already well down the path of modern industrialization. As Chetan Ghate, Radhika Pandey and Ila Patnaik explain in their paper (Ghate 2013), “Has India emerged? Business Cycle facts from a stylized economy”: “In terms of similarities, we find that output (Real GDP) has become less volatile in the post-liberalisation period; investment has become significantly procyclical in the post-liberalisation period; the correlation of imports with GDP has also increased; net exports have become counter-cyclical; the volatility in prices and government expenditure has decreased in the post liberalisation period; and the absolute volatility in nominal exchange rate has declined. Further, our results using quarterly data are consistent with the findings of the annual data analysis for the post 1991 period. This suggests that in many key respects, the Indian business cycle shows a growing resemblance with those of the developed economies. In terms of differences, the Indian business cycle features also resemble features of developing economies. While output volatility has fallen, it still remains high. In addition, consumption is more volatile than output. Further, government expenditure is not strongly counter-cyclical with respect to output, as in advanced economies.” (A. & Shah 2010) reiterates this point tellingly.

In other words, India has not yet become a fully industrialized nation. That being said, 1991-1992 seems to be a period during which India decisively set forth on a decidedly manufacturing-intensive route, at least in comparison to what occurred earlier. For comparisons sake, we present a table from the same paper cited above:

Table 11: Business Cycle Statistics for the Indian Economy using annual data: Pre (1971-1991) and post (1991-2009) reform period (From: Has India emerged? Business cycle stylized facts from a transitioning economy)

Business Cycle Statistics for the Indian Economy using annual data Pre(1971-1991) and post (1991-2009) reform period						
	Pre-reform Period (1971-1991)			Post Reform Period (1992-2009)		
	Std. Dev.	Rel. Std. Dev.	Cont. Corr.	Std. Dev.	Rel. Std. Dev.	Cont. Corr.
Real GDP	2.24	1	1	1.78	1	1
Pvt. Cons.	1.94	0.086	0.69	1.87	1.05	0.89
Investment	3.55	1.57	0.5	5.1	2.85	0.77
CPI	5.96	2.64	-0.16	3.49	1.95	0.29
Exports	6	2.66	0.1	7.71	4.31	0.33
Imports	8.71	3.87	-0.1	9.61	5.38	0.7
Govt. Expenditure	5.62	2.62	0.5	4.6	2.58	-0.26
Net Exports	0.8	0.3	0.12	1.1	0.65	-0.69
Nominal Exchange Rate	5.54	2.46	0.4	5.35	3	-0.48

In particular, note the sharp change in the contemporaneous correlation between both private consumption and investment with regards to Real GDP during the two different time periods being compared here. Private consumption steps up from 0.69 to 0.89 from 1971-1991 and thereafter, while during the same period of comparison, investment moves up from 0.5 to 0.77.

More than any statistical exercises that aim to “prove” that 1991 was a clean break for the Indian economy, we find it instructive to compare performances during these periods, and as mentioned above, the difference is stark enough to justify the choice of our time period.

31. As has been detailed in the previous section, we have attempted to build a model (an aggregative macroeconomic model) that is capable of perpetuating a business cycle via the channel of replacement cycles. While the model performs satisfactorily in terms of generating a business cycle perpetuated by replacement cycles, there remains the crucial

step of empirical validation. In order to validate our model empirically, we have aggregated balance sheet data of all companies available on the Prowess database at CMIE. Measuring output in any modern economy is a risky business, because of potential errors relating to measurement, methodology and coherence. The GDP series is the one most widely accepted as the best available proxy for output, while in India's case, the Index of Industrial Production is also touted as a viable candidate.

32. When it comes to Gross Domestic Product, there are two obvious problems. Firstly, agriculture is included within India's GDP. This is of course not in and of itself a problem, since agriculture should by definition be a component of GDP. The problem lies in the fact that fluctuations in the agricultural output cycle will be almost always be impacted primarily by the vagaries of the monsoon, and will not necessarily reflect business conditions. As Radhika Pandey, Ila Patnaik and Ajay Shah mention in their working paper, "Dating Business Cycles in India" (Radhika Pandey 2016): "The impact of agriculture on the supply of raw material and food price on the one hand, and demand for non-agricultural products on the other was much stronger when the economy was a closed economy with a large agriculture sector. Decline in the share of agriculture implies that monsoon shocks matter less for the economy". Secondly, expenditure incurred by the government is also included as a component of GDP. Once again, the fact that government expenditure is included is not in and of itself a problem as far as measurement of GDP goes. However, government expenditure itself tends to be problematic from the point of view of business cycles for at least two important reasons. Firstly, most goods that are produced by the government and government owned

firms/entities are best regarded as intermediate goods. Secondly, and perhaps more importantly, since most government produced goods and services are not sold in the market, it is very difficult to impute market based prices to them. Therefore, utilizing GDP as a proxy for output might create a series of problems.

33. For this reason, we have preferred to use the aggregated, annual data from the CMIE database (Prowess) as a proxy for nationwide output. As mentioned in “India Transformed? Insights from the Firm Level 1988-2005” by (Laura Alfaro 2009): “About one-third of the firms in Prowess are publicly listed firms. The companies covered account for more than 70% of industrial output, 75% of corporate taxes, and more than 95% of excise taxes collected by the Government of India (Centre for Monitoring the Indian Economy). Prowess covers firms in the organized sector, which refers to registered companies that submit financial statements. According to the Government, “The organized sector comprises enterprises for which the statistics are available from the budget documents or reports etc. On the other hand the unorganized sector refers to those enterprises whose activities or collection of data is not regulated under any legal provision or do not maintain any regular accounts” (Informal Sector in India: Approaches for Social Security, Government of India, page 2, 2000). Indian firms are required by the 1956 Companies Act to disclose information on capacities, production and sales in their annual reports. All listed companies are included in the database regardless of whether financials are available or not.” That is to say, while it is true that the Prowess data is a proxy to GDP, in this case, it makes sense to use it, because our modeling is at the firm level in the organized manufacturing sector, whose most appropriate representation is

the Prowess database. The Prowess database contains information gleaned from the annual report of individual companies (both listed as well as non-listed). In cases where a firm is listed on a stock exchange, information shared with the stock exchange is also utilized. The net sales (aggregated) of all of these firms is used as a proxy for output during the course of empirical validation.

The reason we have preferred to use annual, rather than quarterly data is because annual data implies that seasonality will not be a concern. Therefore, we have preferred to go with annual level data. Furthermore, quarterly GDP data is not available all the way back until 1991 in the case of officially available Indian statistics; this is true for almost all relevant macroeconomic statistics. For these reasons, utilizing annual data makes sense from the point of view of the current thesis.

34. In order to validate whether the model built in the previous sections stands up to empirical scrutiny, data downloaded from the Prowess database has been utilized, as has been already mentioned. The following variables were used, of those available:

- a. Net sales
- b. Cash balance
- c. Debt
- d. Short term bank borrowings
- e. Long term bank borrowings
- f. Current liabilities
- g. Current assets
- h. Profit after tax

i. Gross Fixed Assets

35. For each of these metrics, data is available from 1991, through until March 2010.

However, for each of these metrics, we have constructed a 3MA (Moving Average) series.

This has been principally to smoothen out any short-term irregularities in the data. In our

exercise, we have used three year moving averages as a moving average of a higher order

(four or more) tends to smoothen out the data too much, and also reduces the amount

of data available for analysis as our period of analysis must necessarily begin from 1991.

Growth rates for the relevant series have been calculated as used as points of comparison

with the theoretical results. In addition, these series also help us establish reference

points for dating the Indian business cycle.

36. There are two primary aims to this section. Firstly, it is important to ascertain if the

empirical data follows more or less the same patterns as have been established in the

model. Were the same patterns to be seen, it would lend empirical credence to our

theoretical efforts. Secondly, the attempt in this section is to use data from a wide variety

of sources in order to establish the turning points of the Indian business cycle. Hitherto,

attempts at dating the turning points of the Indian cycle have relied, for the most part, on

quarterly data. Dating of these cycles using annual data is an exercise that should shed

light on two ancillary questions: one, does the annual data reveal the same set of turning

points as other methodologies and two, do all data sources reflect, in part or otherwise,

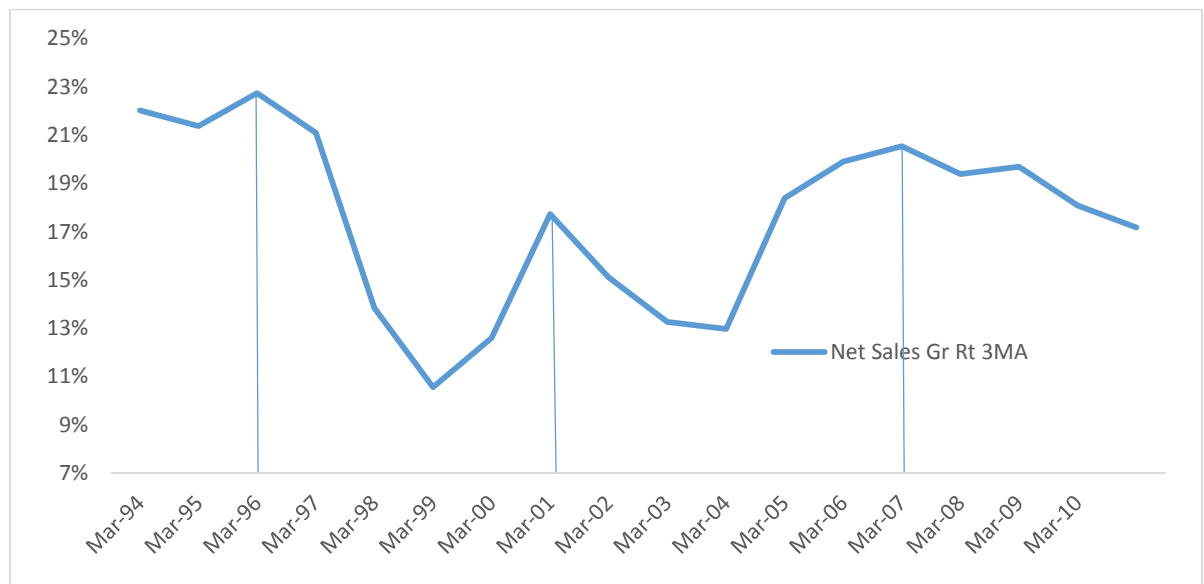
the same reference cycle?

37. In order to ascertain the answers to these questions, it is necessary first to look at the

business cycle for two variables that we will be using as reference cycles in this section.

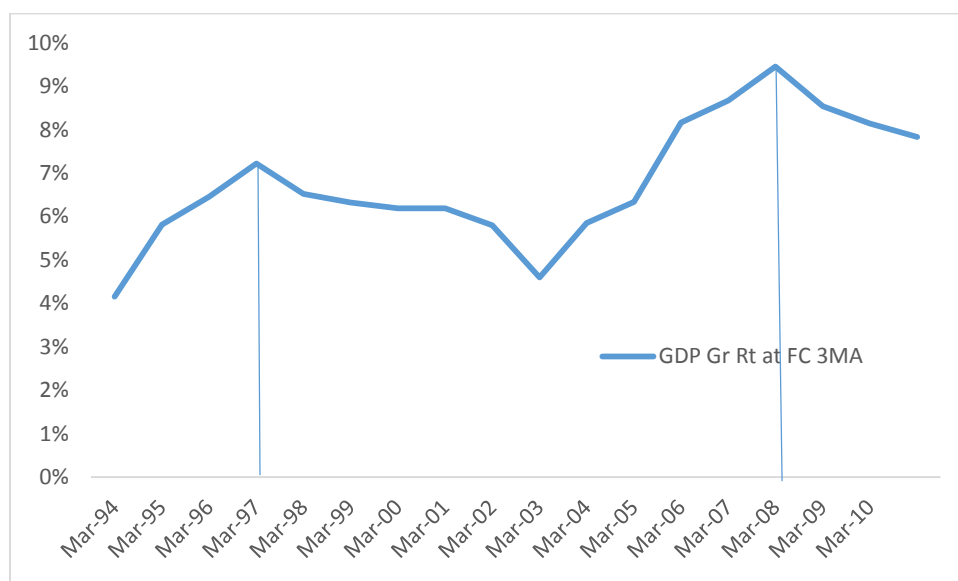
The first of these variables is net sales, as per our discussion above, while the second is the GDP growth rate cycle. The first of these is presented below:

Figure 7: Net Sales Growth Rate (3 Period MA) 1994-2010



As explained earlier, net sales refer to the sum of net sales across listed companies at an annual level, for all firms for which data is available within the Prowess database for all years since 1991 until 2012. This data shows three distinct peaks in the Indian business cycle since 1991, achieved during the years 1996-97, 2001-02 and 2007-08. This is in line with results shown in almost all business cycle research associated with the Indian economy.

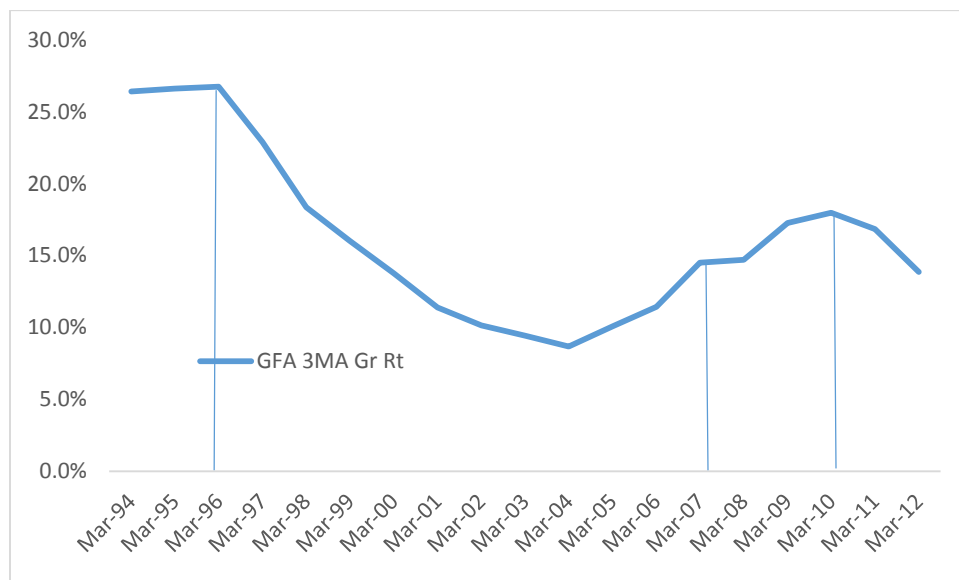
Figure 8: GDP Growth Rate (3 Period MA) 1994-2010



The GDP growth rate cycle shows much the same results, with some additional points of interest. Firstly, while the three peaks evidenced in the Net Sales cycles appear here as well, the peak of 2000-01 isn't as prominent as in the earlier chart. Secondly, the revival phase 2004 onwards is placed in much sharper relief than in the earlier chart. However, that there was a major downturn in the Indian economy in the years 1996-97, 2000-01 and 2007-08 is clear from this analysis.

38. A question that naturally arises, given the methodology followed in this thesis, is whether the addition to gross fixed asset series mirror the movements seen in the reference cycle. In other words, one would expect, on the basis of our theoretical modeling, a measure of pro-cyclicality between addition to gross fixed assets and net sales. The correlation between Net Sales and Gross Fixed Assets comes in at 98%, indicating a very strong and positive correlation between the two variables of interest, and confirming the results predicted in our modeling from the previous section.

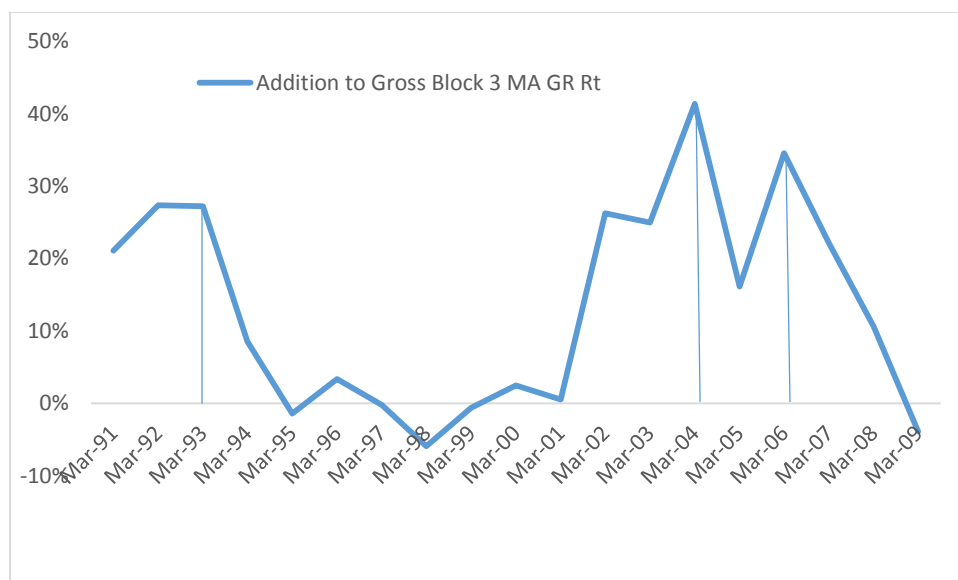
Figure 9: GFA Growth Rate (3 Period MA) 1994-2010



As can be seen in the chart above, the peak of 1996 is well corroborated in the gross fixed asset cycle as well. Two points of interest make themselves apparent in the chart,

however. In the first instance, the peak of 2001 is conspicuous by its absence, while the downturn in the latter case starts well after 2008. Two reasons can be posited for this. Firstly, the additions to gross block themselves may have happened at such a large scale and rate immediately post liberalization that the excess capacity generated during that time period may well have lasted the second turning point in the Indian economy. Secondly, as far as the 2008 recession is concerned, it may well be (once again) that the addition to gross block tapered off, leading eventually to a tapering off the GFA cycle itself. Both these points manifest themselves in the chart below:

Figure 10: Addition to Gross Block Growth Rate (3 Period MA) 1991-2010



In fact, the addition to gross block series shows a very high, and consistent, level in the first three years after the 1991 reforms, before going through a prolonged slump that only receded after 2001. Subsequently, the boom phase in this case lasted for over five years,

and it is only since then that the series truly dipped into what might be termed as a recessionary phase.

In addition, in order to provide further credence to our hypothesis, we have also employed a test of Granger causality. As is well known, the Granger causality test seeks to establish the fact that a series x “Granger causes” a series y by showing that past values of x **and** y predict y better than past values of y alone. Happily, this is the case in our analysis, wherein a one period lag of GFA (3 period moving average) along with past values of Net Sales (3 period moving average) is significantly better (at the 5% level) at predicting current values of Net Sales, than past lagged values of Net Sales alone.¹

Figure 11: Granger Causality Analysis of 3MA Net Sales, 3MA Gross Fixed Assets

```
> grangertest(netsales3ma~gfa3ma, order=1, data=gcdatal)
Granger causality test

Model 1: netsales3ma ~ Lags(netsales3ma, 1:1) + Lags(gfa3ma, 1:1)
Model 2: netsales3ma ~ Lags(netsales3ma, 1:1)
   Res.Df Df       F    Pr(>F)
1      16   0      NA      NA
2      17  -1  4.4841 0.05022 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
> |
```

39. However, the correlation between sales and cash balances turns out to be positive in the case of data pertaining to the Indian economy, as is to be expected. Firms will naturally choose to increase their cash balances during expansionary phases. Our modeling in the previous section, however, is built upon an assumption that the capitalist will in fact

¹ Sectoral analysis of GFA “Granger-causing” Net Sales has also been done and is shown separately in an appendix.

reduce cash balances during an expansionary phase in order to expand productive capacity. The reason for this seeming discrepancy is that the expansion of productive capacity in our modeling comes from a reduction in cash balances. Empirical analysis shows that such expansions tend to happen because of an increase in debt, infusions of equity, or sales of extant assets. However, corroboration with our model is to be obtained via the steps enumerated below.

While it is certainly true that firms tend to draw up cash balances over time, and indeed have done so in the case of the Indian economy since 1991, the **rate** of increase in cash balances may well show a cyclical pattern. In other words, a regression of the natural logarithm of net sales explaining cash balances will have a positive slope, but will also show cyclical perturbations around the trend. This is shown in the chart below.

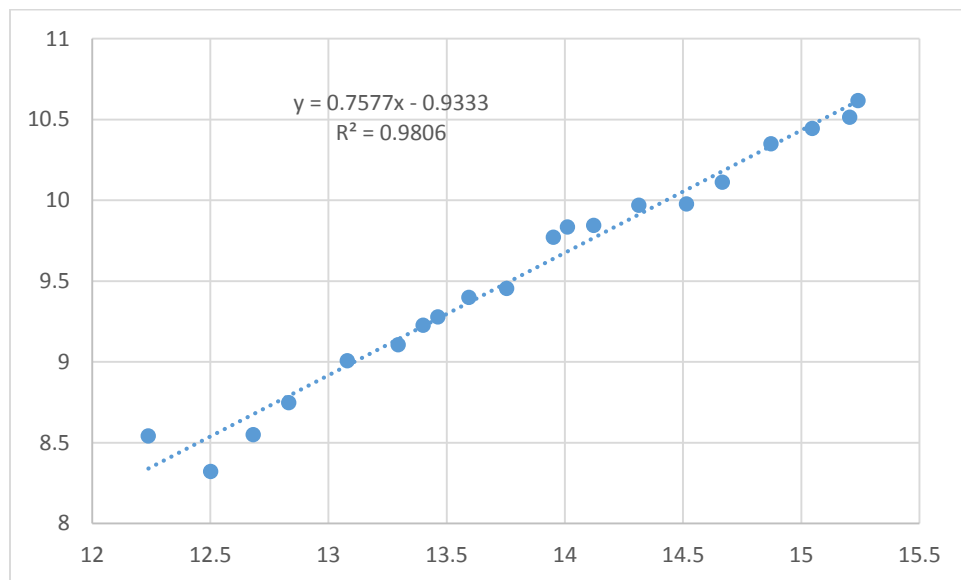


Figure 12: Regression of the natural logarithm of Net Sales on Cash Balances

The statistical significance of the regression output is given in the table below.

Table 12: Regression Output of the regression of natural logarithm of net sales on the natural logarithm of cash balances

SUMMARY OUTPUT						
Regression Statistics						
Multiple R	0.990258135					
R Square	0.980611175					
Adjusted R Square	0.979534018					
Standard Error	0.09989654					
Observations	20					
ANOVA						
	df	SS	MS	F	Significance F	
Regression	1	9.084870412	9.084870412	910.369811	7.24539E-17	
Residual	18	0.179627735	0.009979319			
Total	19	9.264498147				
	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	-0.933286898	0.348258061	-2.67987163	0.01529093	-1.664949934	-0.201623861
In Net Sales	0.757731411	0.025113449	30.17233519	7.24539E-17	0.704970012	0.81049281

As can be seen from the table, the coefficient is positive (.7577) and significant, with the value of the t-statistic coming in at 30.172.

We now correlate the residuals from our regression exercise with first the growth rate of total inventory, and second with the growth rate of gross fixed assets. In each case, we should expect the correlation to be negative, since we hypothesize that while there is a baseline increase in cash balances given an increase in net sales, the perturbations are to be viewed as a response of firms to changing economic conditions, similar to (and for the same reasons) the hypothesis advanced in our modeling: that the drawing up (down) of cash balances is to be viewed as a response to recessionary (expansionary) conditions in the economy. Therefore, we posit that an increase in Gross Fixed Assets (GFA) will cause a reduction in the rate of increase of cash balances, and vice versa, and that a similar logic will apply in the case of Total Inventory. Such a negative correlation is indeed obtained, as shown in the table below, validating both the approach and the outcome in the preceding section.

Table 13: Correlation Analysis of Residuals from Regression of \ln (Net Sales) on \ln (Cash Balances) with:

Total Inventory Growth Rate	-0.503625362
Gross Fixed Assets Growth Rate	-0.580268477

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.580268477
R Square	0.336711506
Adjusted R Square	0.297694535
Standard Error	0.071804308
Observations	19

ANOVA

	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	1	0.044494406	0.044494406	8.629873187	0.009197379
Residual	17	0.087649597	0.005155859		
Total	18	0.132144003			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>
Intercept	1.09011761	0.036954077	29.49925169	4.83834E-16	1.012151323	1.168083897
GFA Gr Rt	-0.552372456	0.188031152	-2.93766458	0.009197379	-0.949083511	-0.155661402

Figure 13: Regression of residuals (\ln sales on \ln cash balances) on Growth Rate of Gross Fixed Assets

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.503625362
R Square	0.253638506
Adjusted R Square	0.209734888
Standard Error	0.076168233
Observations	19

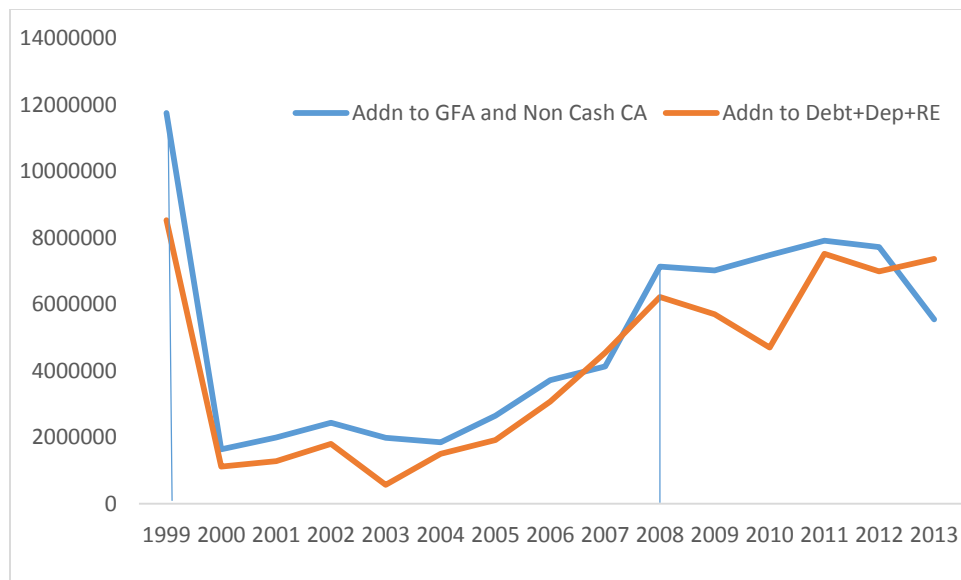
ANOVA					
	df	SS	MS	F	Significance F
Regression	1	0.033516807	0.033516807	5.777166468	0.027923863
Residual	17	0.098627196	0.0058016		
Total	18	0.132144003			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	1.05679701	0.031798514	33.23416381	6.58853E-17	0.98970801	1.123886009
Total Inventory Gr Rt	-0.449092459	0.186843641	-2.403573687	0.027923863	-0.843298083	-0.054886835

Figure 14: Regression of residuals (ln sales on ln cash balances) on Growth Rate of Total Inventory

40. From the point of view of the empirical verification of the model, the chart shown below provides additional validation for the hypothesis under consideration. In the chart below, we have plotted two time series, the one being additions to Gross Fixed Assets and Non Cash Current Assets (or what might be looked at as one possible definition of use of funds) while the other is additions to Depreciation, Retained Earnings and Debt (or what might be looked at as one possible definition of sources of funds). Viewed from this perspective, and given the discussions in the preceding section, one would expect there to be a reasonably high degree of correlation between the two time series. Happily, this turns out to be so, as the correlation between them is 92.3%.

Figure 15: Sources of Funds and Uses of Funds (1999:2013)



Sector-wise Analysis

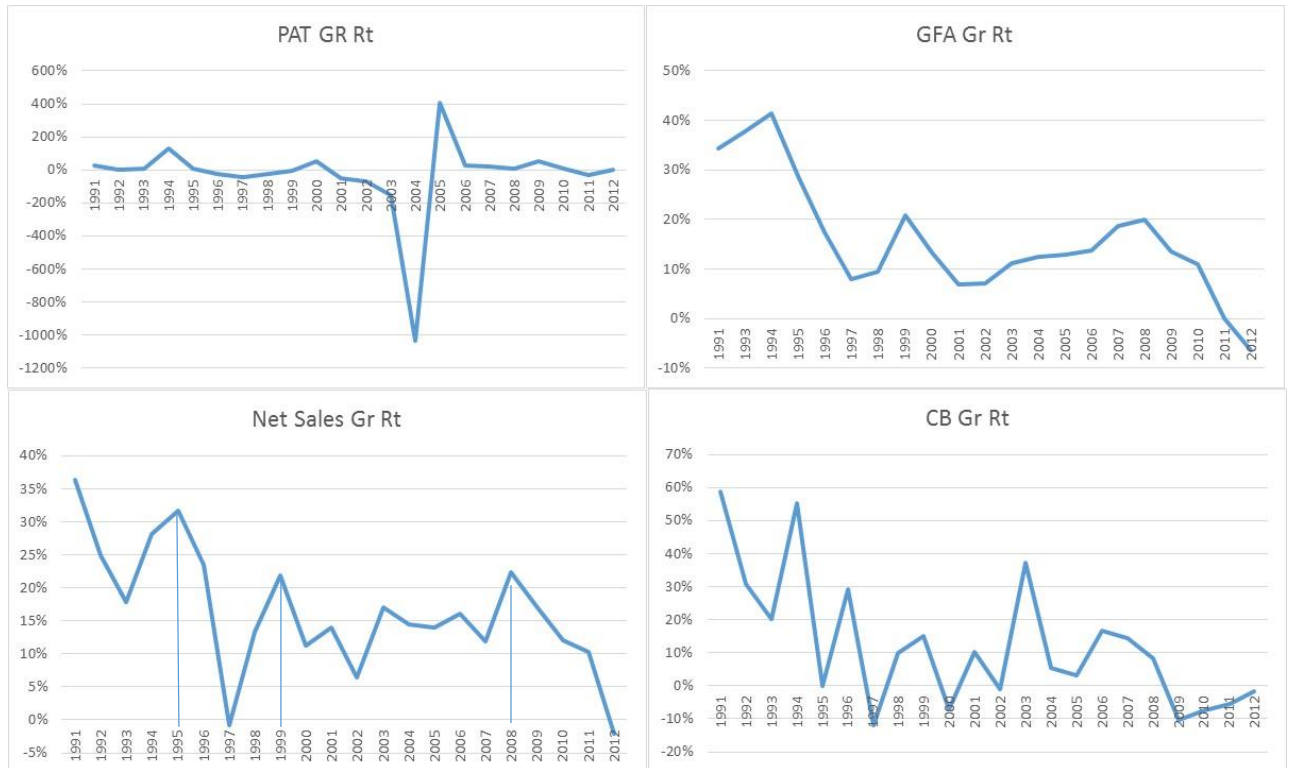
1. In addition to the aggregated data mentioned above, sector-wise data has also been utilized for empirical validation. The same data that has been used in the aggregated sense has also been split up by sector. The following sectors have been analyzed:
 - a. Automobiles
 - b. Cement
 - c. Consumer Goods
 - d. Drugs and Pharmaceuticals
 - e. Food Products

- f. Information Technology
- g. Manufacturing
- h. Metals and Metal Products
- i. Real Estate
- j. Transport Services

2. An attempt has been made to answer two key questions in this section. For the first part: are the turning points observed in the previous section observed in each individual sector as well. The answer to this question, it must be noted, may well not be in the affirmative in the case of each sector. The vagaries of business sentiments, policies, market conditions and many other factors make it well-nigh impossible that this should be the case. That being said, certain broad trends should manifest themselves in each case, and the primary attempt in this section is to see if this is indeed the case.
- Secondly, does the gross fixed assets cycle exhibit procyclicality with the net sales cycle in the case of individual industries as well? In this section, an attempt is made to elicit the answers to these questions.

3. Automobiles:

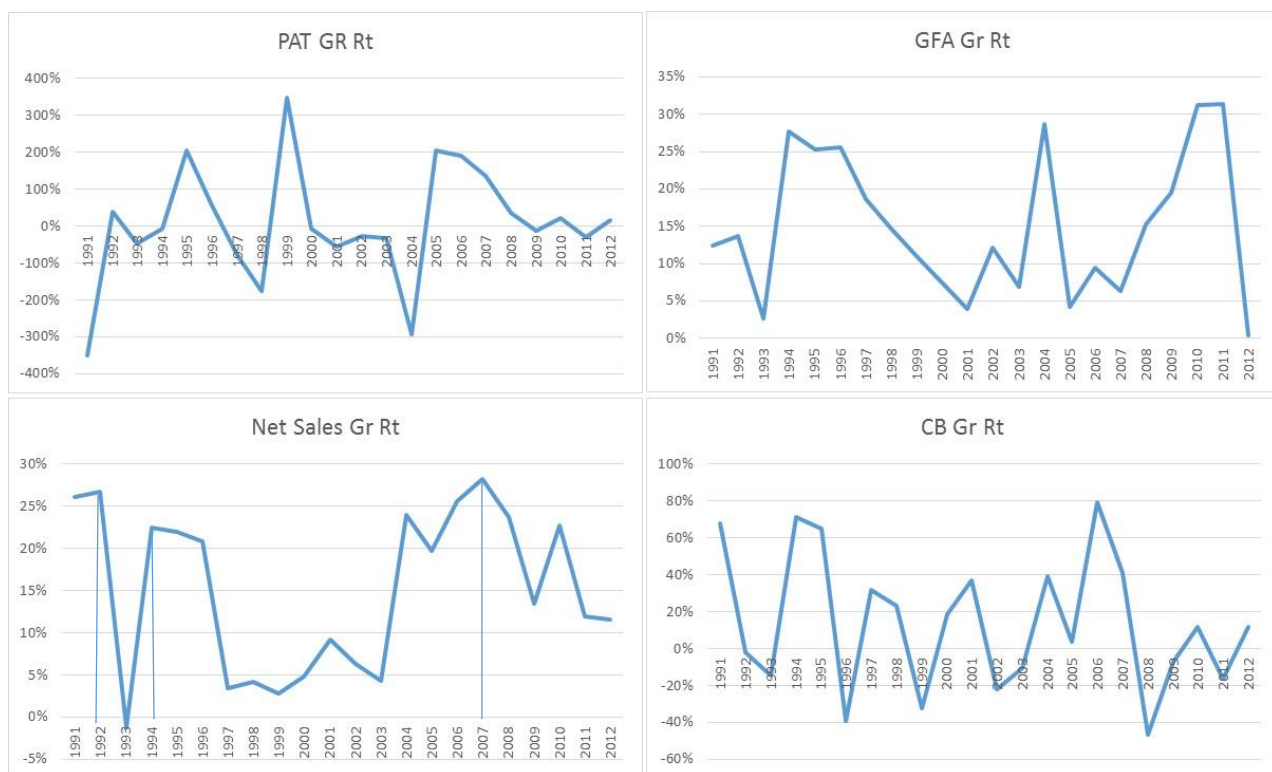
Figure 16: Automobiles (PAT, GFA, Net Sales and Cash Balances Growth Rate)



As can be seen in the chart above (with reference to net sales), the automobile sector experienced a sharp downturn in the year 1996, with a minor downturn being seen around the year 2002 as well. The automobile sector has also seen a severe downturn post 2008, thereby corroborating the three peaks observed in our reference cycle. These three peaks are also seen, for the most part in the Gross Fixed Assets cycle. The contemporaneous correlation between the two series is also a satisfactory 76%.

4. Cement Sector:

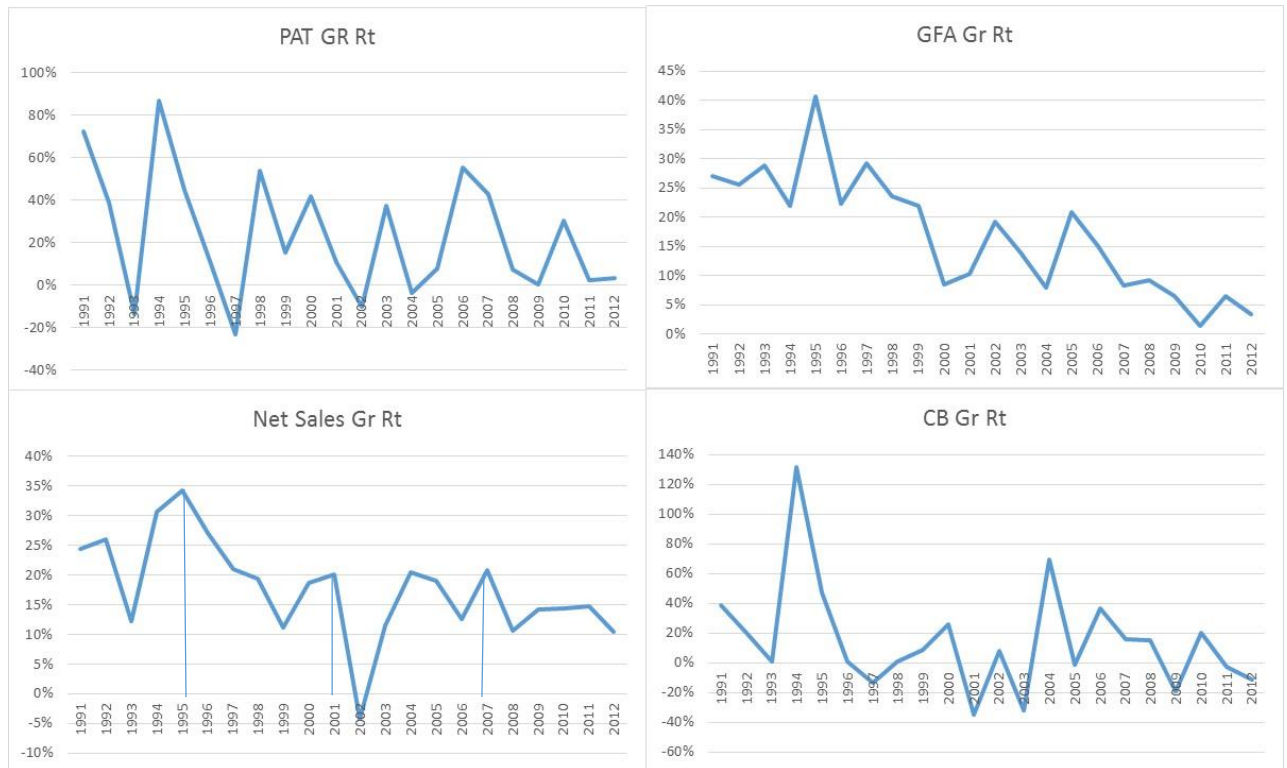
Figure 17: Cement (PAT, GFA, Net Sales and Cash Balances Growth Rate)



In the case of the cement sector, the volatility is rather higher than in other sectors, and the peaks in the case of net sales cycle associated with cement also tend to predate those of the reference cycle. For instance, the peaks observable around the years 1994-95, 2006-07. The volatility observable in the cement net sales cycle also results in the contemporaneous correlation with gross fixed assets declining to 34%.

5. Consumer Goods

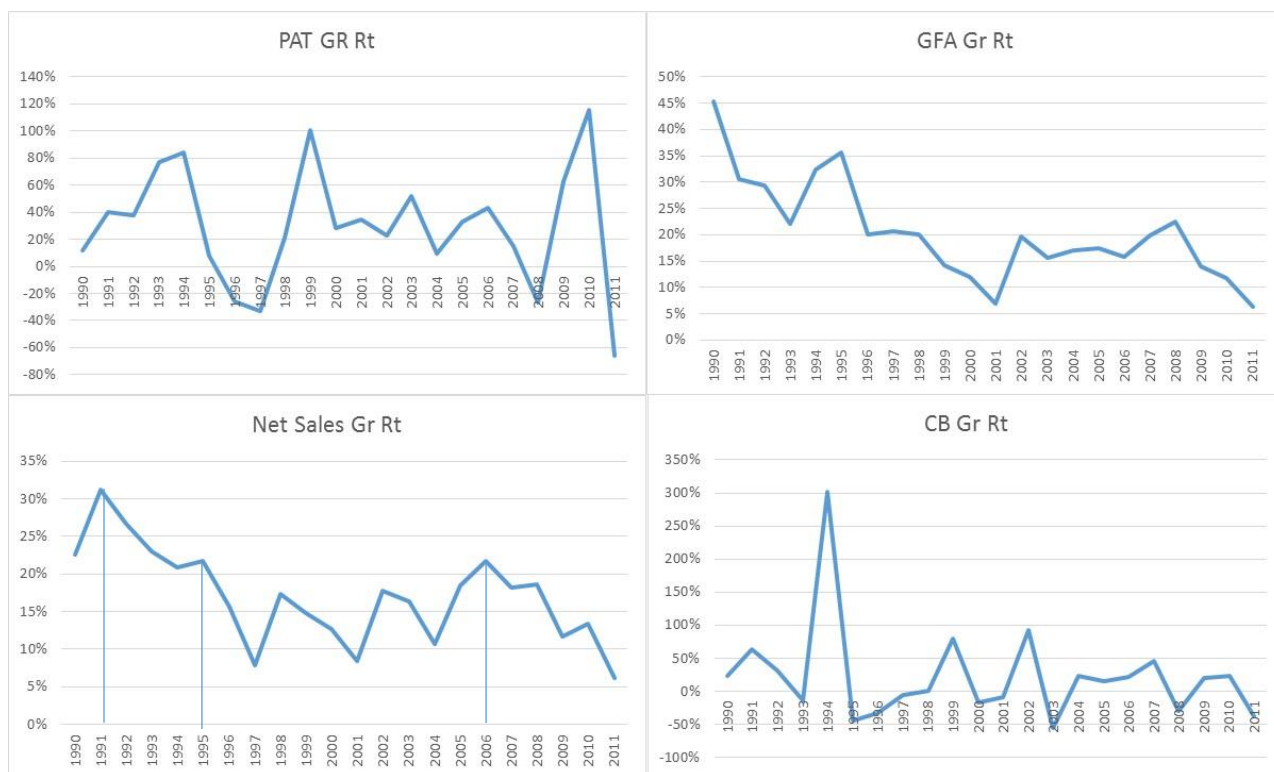
Figure 18: Consumer Goods (PAT, GFA, Net Sales and Cash Balances Growth Rate)



The consumer goods sector net sales cycle highlights the peak of 1996-97, and while there is a dip observed during 1999-2000, a much sharper dip is seen in 2001-02. This is perhaps to be expected, since consumer goods tend to be much more responsive to global economic conditions. The contemporaneous correlation in this case between Net Sales and GFA turns out to be 44%.

6. Drugs and Pharmaceuticals

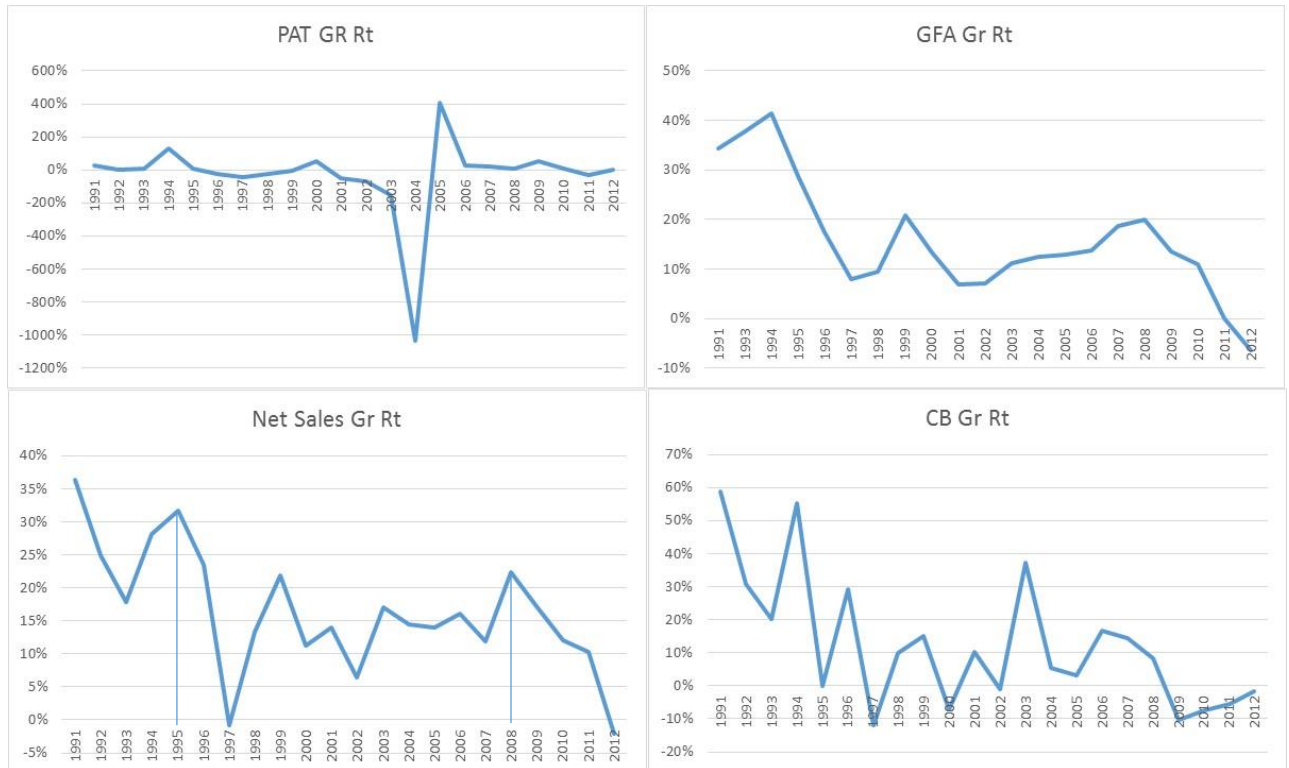
Figure 19: Drugs and Pharmaceuticals (PAT, GFA, Net Sales and Cash Balances Growth Rate)



While the Net Sales cycle in this case exhibits rather more volatility than is seen in the case of the reference cycle, the GFA cycle exhibits the peaks of 1996, 2001 and 2008. In the case of the drugs and pharmaceutical sector, the contemporaneous correlation between net sales and GFA turns out to be 72%.

7. Food Products:

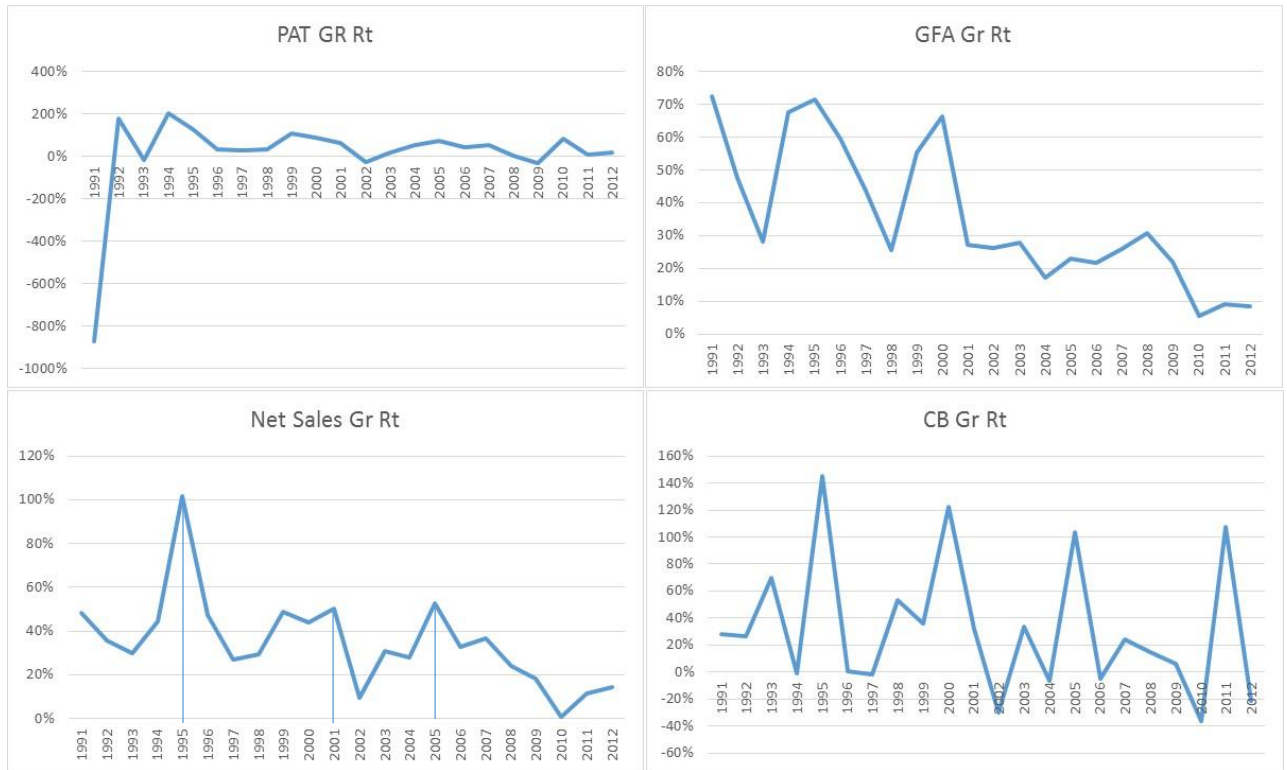
Figure 20: Food Products (PAT, GFA, Net Sales and Cash Balances Growth Rate)



The Food Products sector also indicates the same peaks as the reference cycle, and the contemporaneous correlation in this case turns out to be 80%.

8. Information Technology:

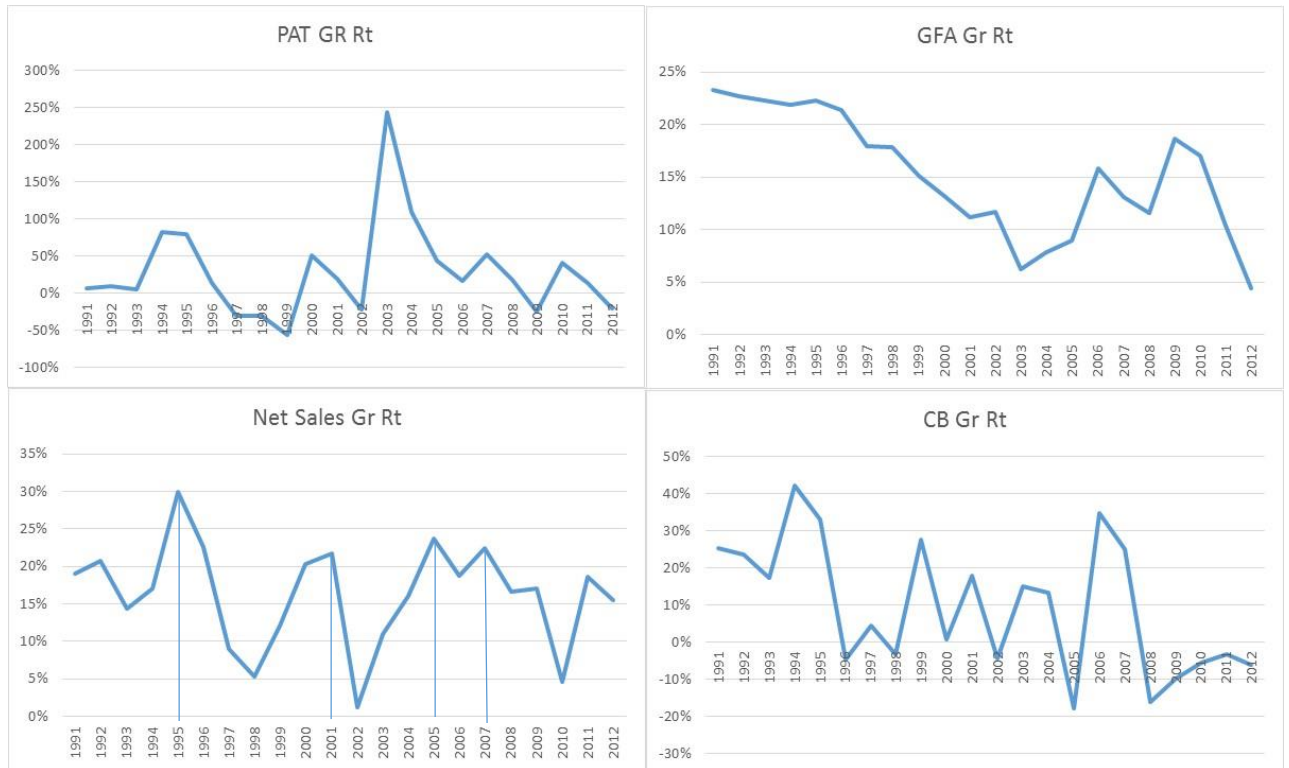
Figure 21: Information Technology (PAT, GFA, Net Sales and Cash Balances Growth Rate)



Given that IT falls in the services sector, looking at the Gross Fixed Assets cycle might be slightly misleading. That being said, the peaks around the period 1996 and 2001 are visible in the net sales cycles. However, it is of interest to note that net sales have been on a downward trend since around 2006.

9. Manufacturing:

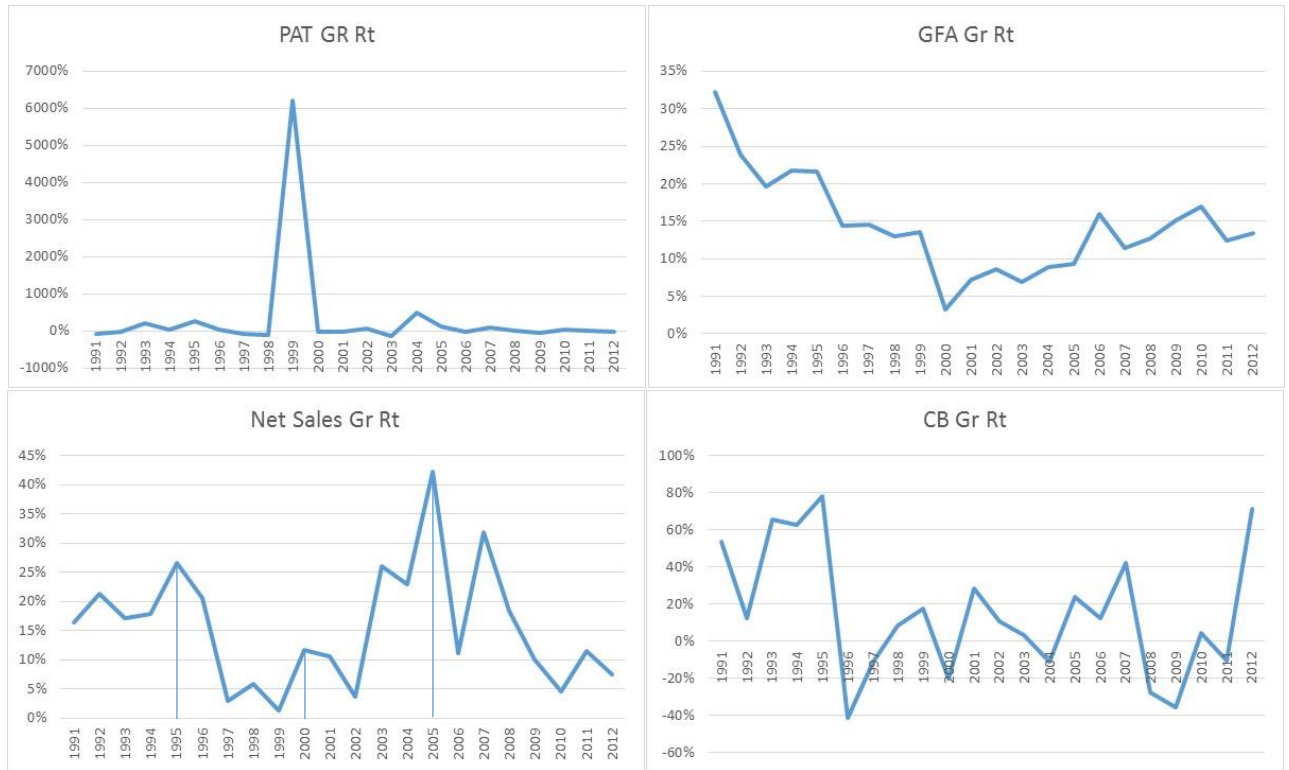
Figure 22 Manufacturing: (PAT, GFA, Net Sales and Cash Balances Growth Rate)



The contemporaneous correlation in the case of the manufacturing sector turns out to be rather low at 15% between the Net Sales and the GFA series, explained in part by the fact that GFA growth rates stayed consistently around 25% for the first five years or so after liberalization. The secular downward trend in the case of GFA growth rates only reversed itself around 2004, and while the peak of 2008 shows up in the case of the GFA growth rate cycle, there has been another secular decline post 2008 as well.

10. Metals and Metal Products

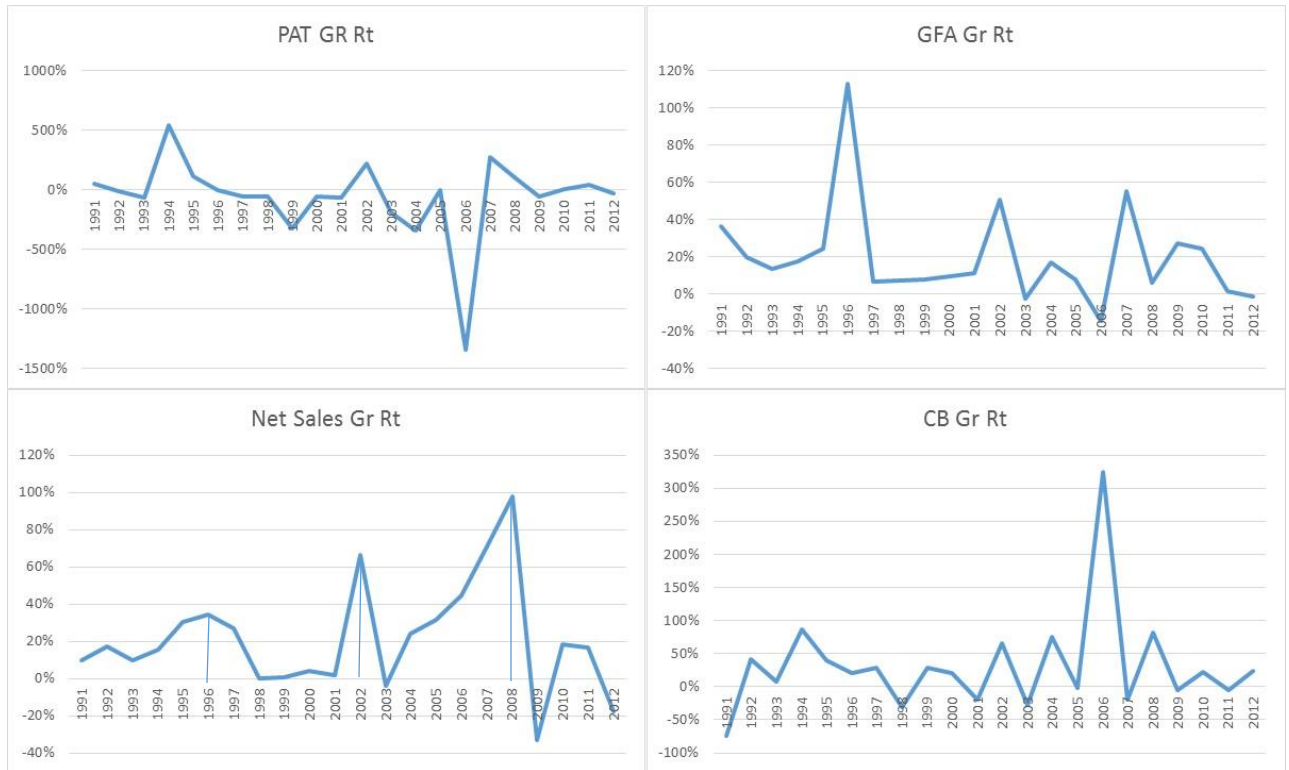
Figure 23: Metals and Metal Products (PAT, GFA, Net Sales and Cash Balances Growth Rate)



The GFA cycle shows a steady capacity addition in the early part of our research period, touching as high a number as 33% in 1991, before coming down to below 5% in the year 2000. Subsequently, there has been an increase, without reaching the highs experienced prior to the turn of the century. For this reason, perhaps, the correlation with the Net Sales cycle is at barely 1% in this case.

11. Real Estate

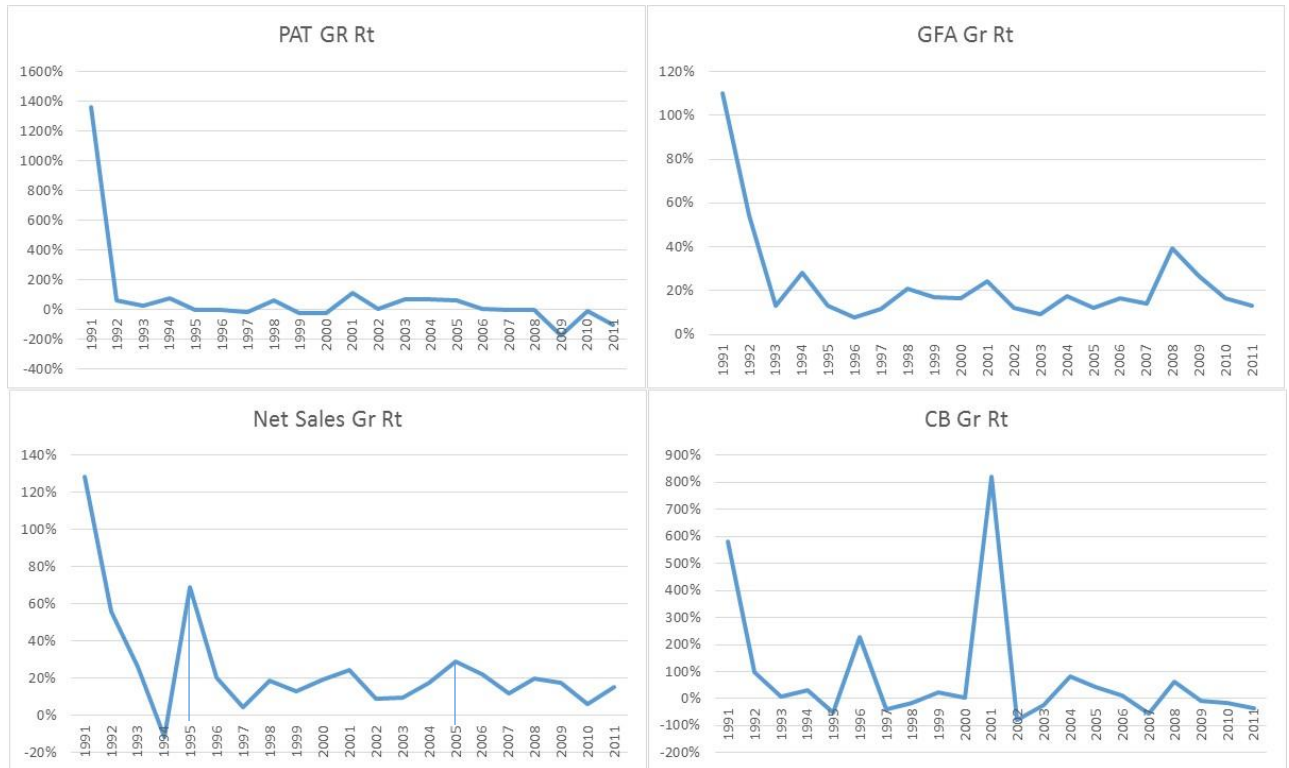
Figure 24: Real Estate (PAT, GFA, Net Sales and Cash Balances Growth Rate)



Perhaps in this sector more than any other are the three peaks of 1996, 2001 and 2007 time periods clearly visible. These peaks are also seen in the Net Sales cycle. The contemporaneous correlation in this case between the gross fixed assets and net sales cycle is 25%.

12. Transport Services:

Figure 25: Transport Services (PAT, GFA, Net Sales and Cash Balances Growth Rate)



In the case of the transport sector, the GFA growth rate was a comparatively stratospheric 110% in 1991, and 54% in 1992. In relation to these numbers, the rest of the series remains comparatively range bound, although it must be noted that the peak of 2008 was relatively high at 39%. The correlation in this case between GFA and Net Sales is 79%.

Three broad conclusions emerge from our sectoral analysis, elaborated upon below:

- a. The three peaks of the reference cycle are observable in most (though not all) sectors. That being said, there is broad evidence that 1996-97, 2000-01 and 2007-08 would seem to be the three peaks observable in the Indian business cycle, both in the reference cycle as well as across sectors.

- b. Almost all sectors show significant addition to their gross fixed assets post the reforms of 1991. These additions, in and of themselves, could be said to have been one of the causes of the boom phase leading up to 1996. As we have posited, due to the inferences drawn from our model in the preceding section, this addition (and the need to subsequently replace) to gross fixed assets in and of itself is the cause for the perpetuation of the business cycle in an Indian context.
- c. Potential divergence of the sectoral GFA cycles: Each sector analyzed above (and all sectors of the economy in general) will have differential rates of technology adoption, technological advancement and replacement. These rates themselves will change over time, as a consequence of their responses to the economic environment, the competition and the policy environment, among others. For this reason, it may well be the case that sectoral GFA cycles may not always overlap each other.

There are two points of note that emerge from this. Firstly, this explains why certain sectors have not exhibited peaks/troughs at exactly the same time as either each other or the reference cycle. Secondly, this also points towards why sectoral GFA cycles will have different peaks and troughs in the future. That being said, however, the point remains that the Net Sales cycle in each case will be fairly well correlated with the respective GFA cycle.

Annual Survey of Industries (ASI) data

Apart from the data sources used in this thesis until the present point, the Annual Survey of Industries data is also a viable alternative to test both our hypotheses about the relationship between fixed capital and net sales as also the dating of the Indian business cycle. As mentioned in the documentation associated with the ASI survey on the Ministry of Statistics and Programme Implementation (MOSPI) website:

“The Annual Survey of Industries (ASI) is the principal source of industrial statistics in India. It provides statistical information to assess and evaluate, objectively and realistically, the changes in the growth, composition and structure of organised manufacturing sector comprising activities related to manufacturing processes, repair services, gas and water supply and cold storage. Industrial sector occupies an important position in the Indian economy and has a pivotal role to play in the rapid and balanced economic development.

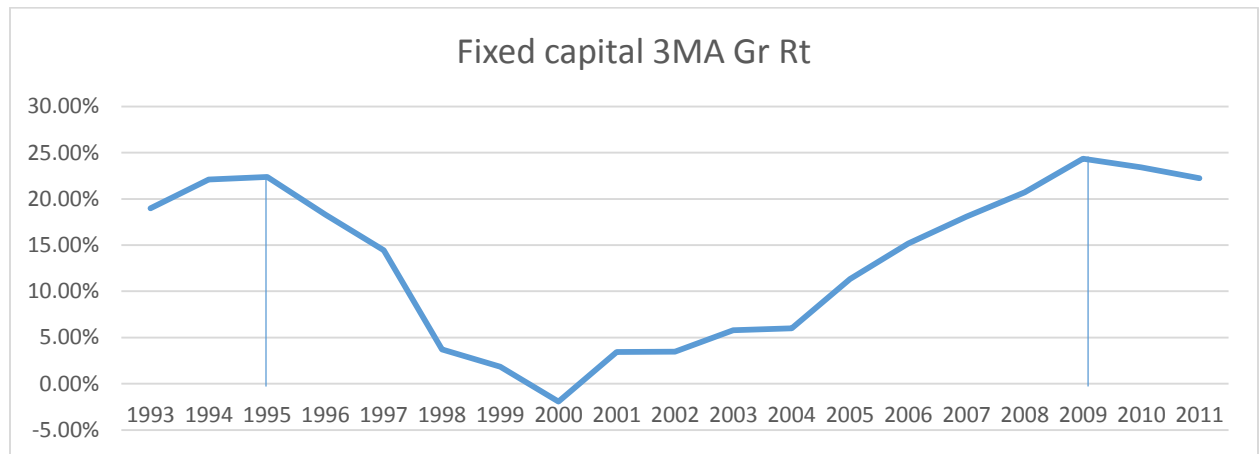
Viewed in this context the collection and dissemination of ASI data, on a regular basis, are of vital importance. The Survey is conducted annually under the statutory provisions of the Collection of Statistics Act 2008, and the Rules framed there-under in 2011, except in the State of Jammu & Kashmir where it is conducted under the State Collection of Statistics Act, 1961 and the rules framed there-under in 1964.”²³

For these reasons, the ASI data will help us corroborate our findings in this thesis. Of the twenty-nine series for which analysis has been done, some select series have been shown and analyzed below. Nominal data has been used, since the same results are obtained in terms of

the shape of the business cycle when appropriately deflated. As with the CMIE data, growth rates have been calculated for 3 period moving averages.

a) Fixed Capital:

Figure 26: Fixed Capital (3 Period MA) Growth Rate



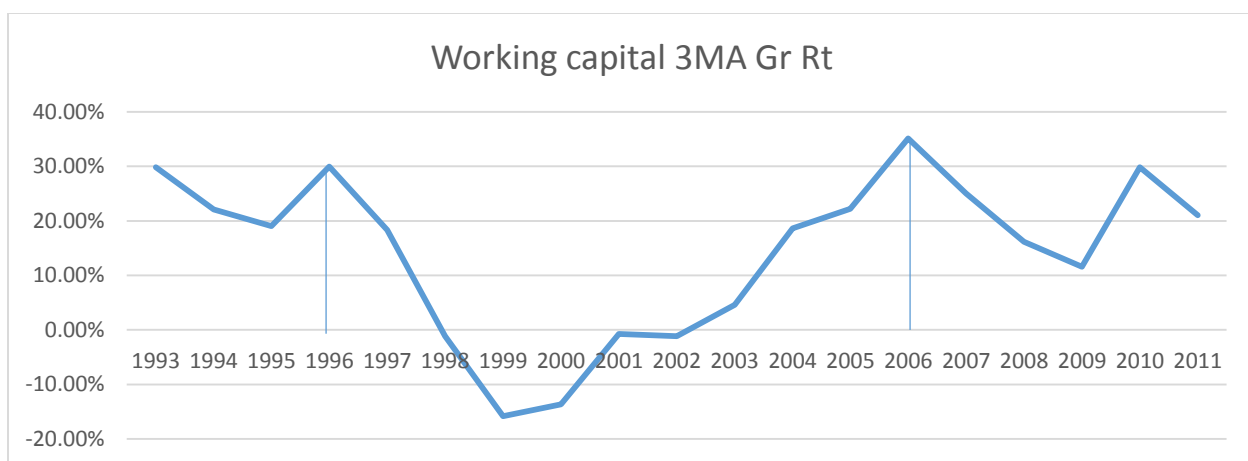
As can be seen from the graph, the peak of 1995-96 is clearly visible, as is the peak of 2009-10.

The contemporaneous correlation of this series with Net Income from the ASI series is 68.7%.

(The contemporaneous correlation between Net Income derived from ASI data and Net Sales derived from CMIE data is 46.6%).

b) Working Capital:

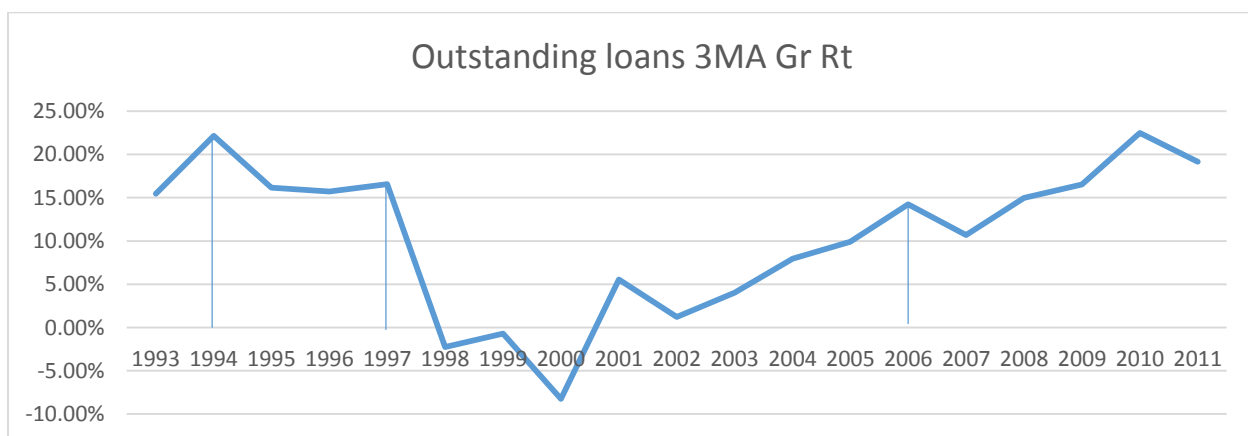
Figure 27: Working Capital (3 Period MA) Growth Rate



Interestingly, in the case of the working capital cycle, the peak is observed around the year 2006, rather than later.

c) Outstanding Loans

Figure 28: Outstanding Loans (3 Period MA) Growth Rate

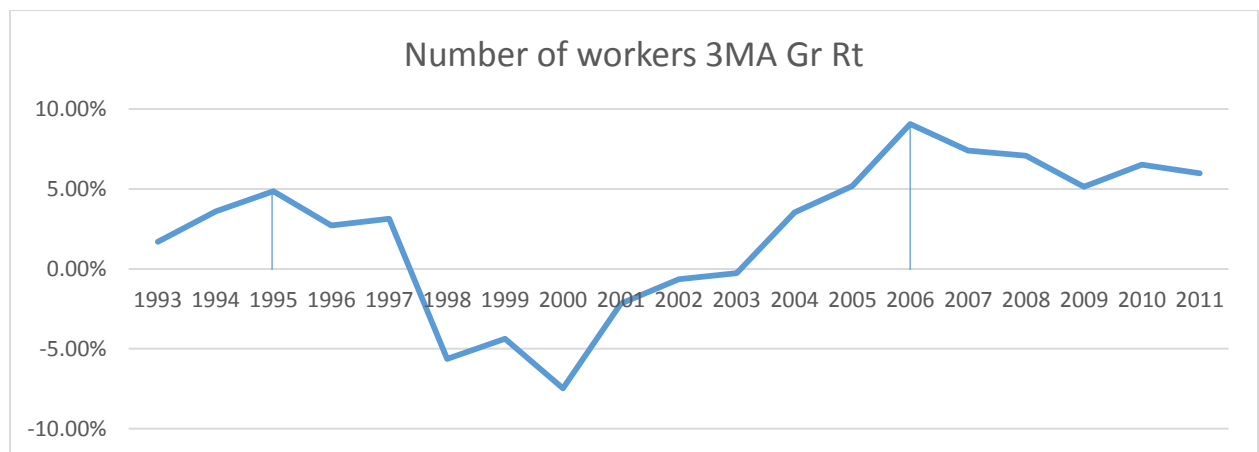


Further corroboration for our hypothesis in the previous section is also to be found upon inspection of the Outstanding Loans data – a peak in loans outstanding is observed up until 1996, after which there is a precipitous decline up until the year 2000, post

which, as would be expected, there is a rise in loans outstanding once again.

d) Number of Workers:

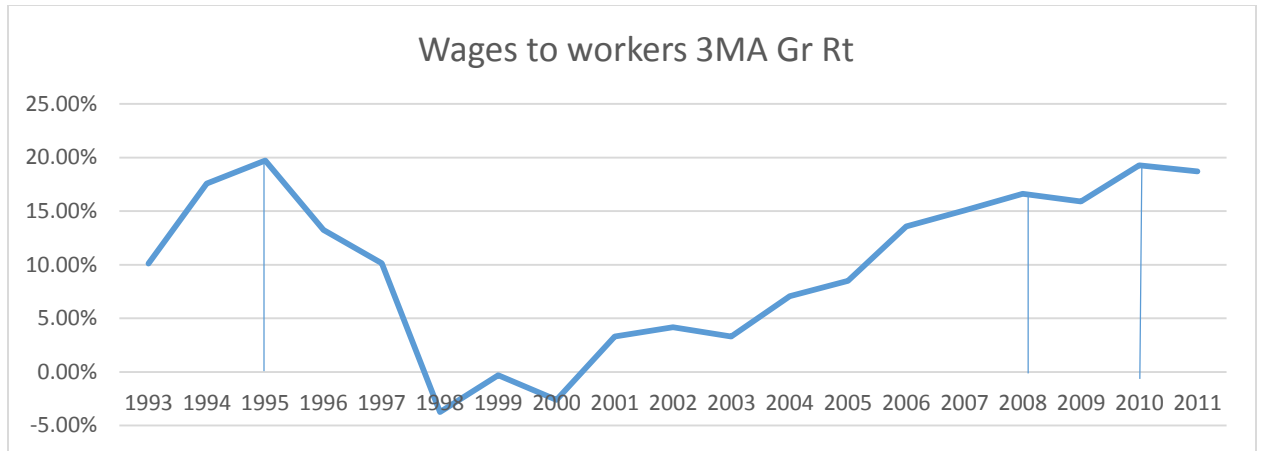
Figure 29: No. of Workers (3 Period MA) Growth Rate



Interestingly, (and as might be expected) the Indian business cycle also impacts employment data, with the growth rate of the number of workers employed as per ASI records showing a decline post 1996, up until around 2001, post which there is a strong recovery up until 2006, which is where the cycle experiences another downturn.

e) Wages to Workers:

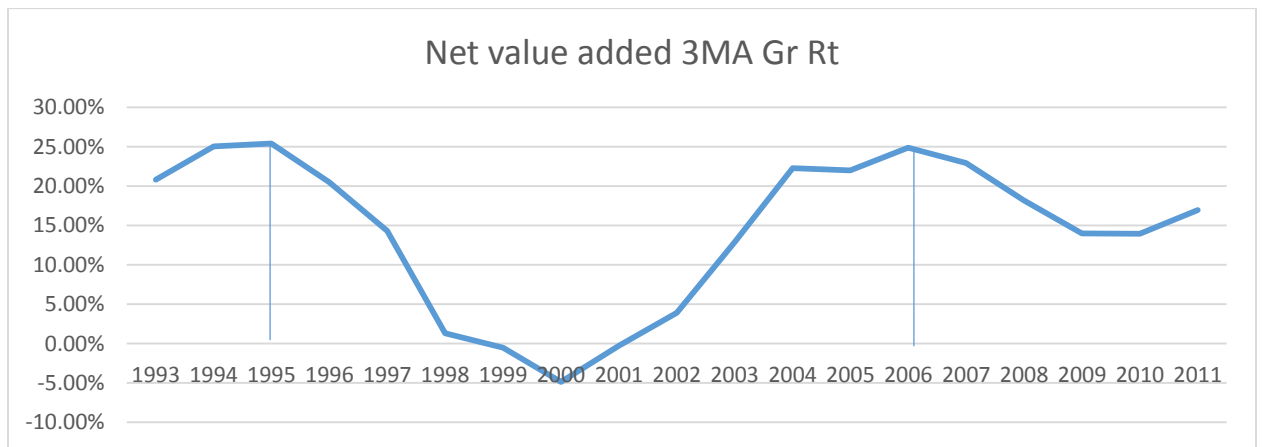
Figure 30 Wages to Workers (3 Period MA) Growth Rate



Additional validation is provided by the growth rates seen in wages given to workers, which also declined sharply around 1996, and only started to recover post 2000.

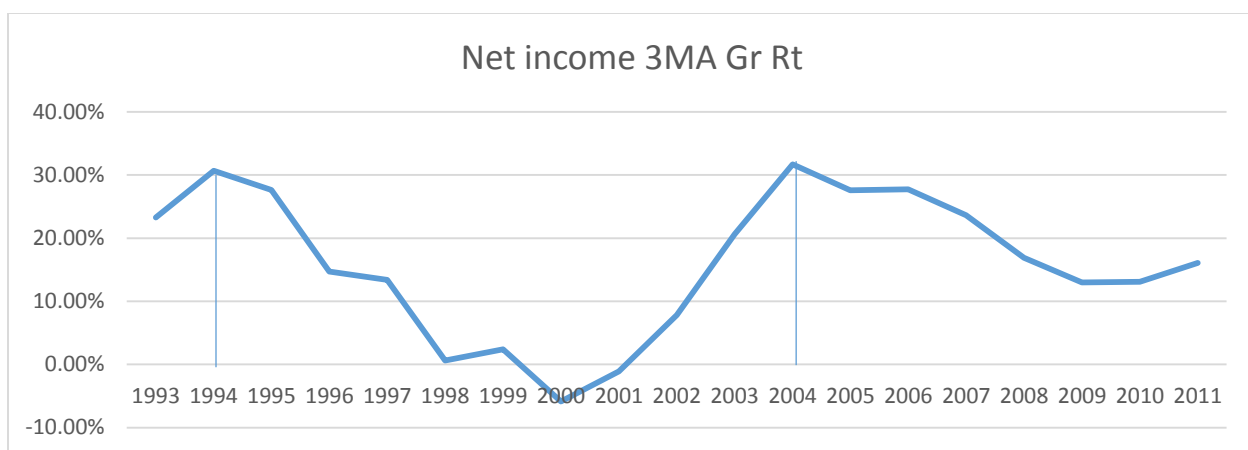
f) Net Value Added

Figure 31: Net Value Added (3 Period MA) Growth Rate



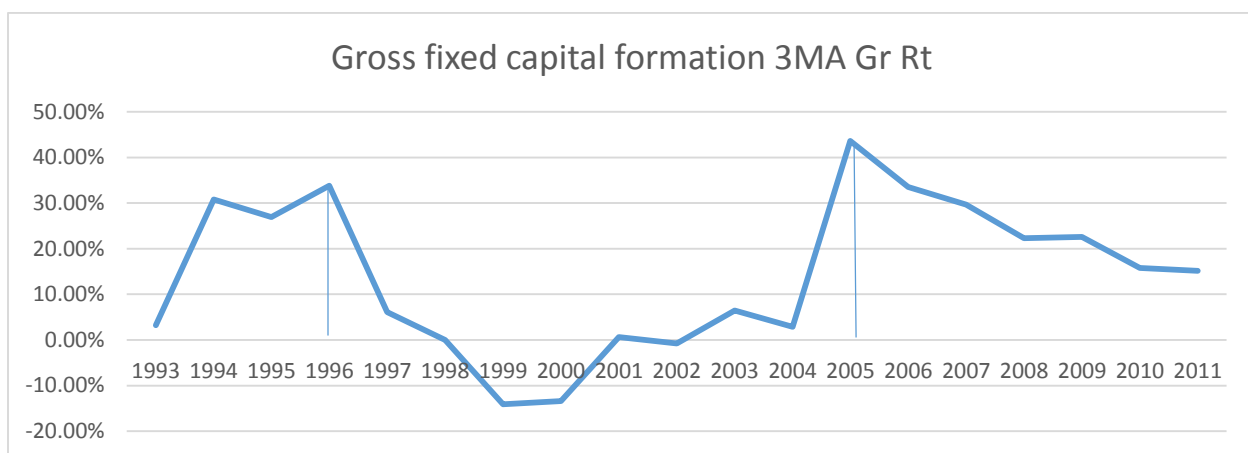
g) Net Income

Figure 32: Net Income (3 Period MA) Growth Rate



h) Gross Fixed Capital Formation

Figure 33: Gross Fixed Capital Formation (3 Period MA) Growth Rate



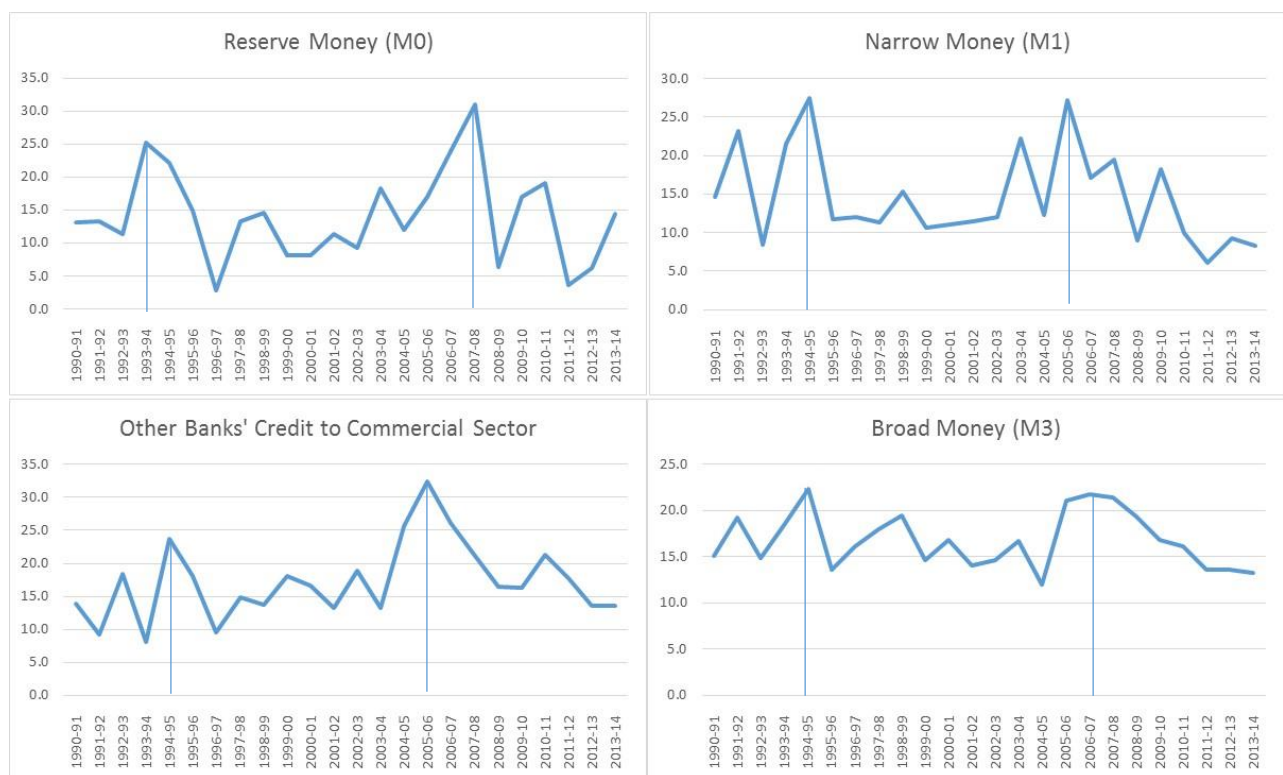
The four series above also provide the same information as has already been adduced earlier – the Indian business cycle certainly experienced a peak around the year 1996, and subsequently in the year 2007, with some series showing evidence of a peak around 2001 as well. Of interest is the Gross Fixed Capital Formation series, which indicates that the peak for this particular cycle was attained in the year 2005, post which it has been

experiencing a steady decline. While the rate of addition has been positive, it has been declining year on year.

In the next section, we turn our attention to three parts of the economy that we haven't covered in detail this far: do government borrowing, monetary data and stock market data exhibit the same turning points as our reference cycle?

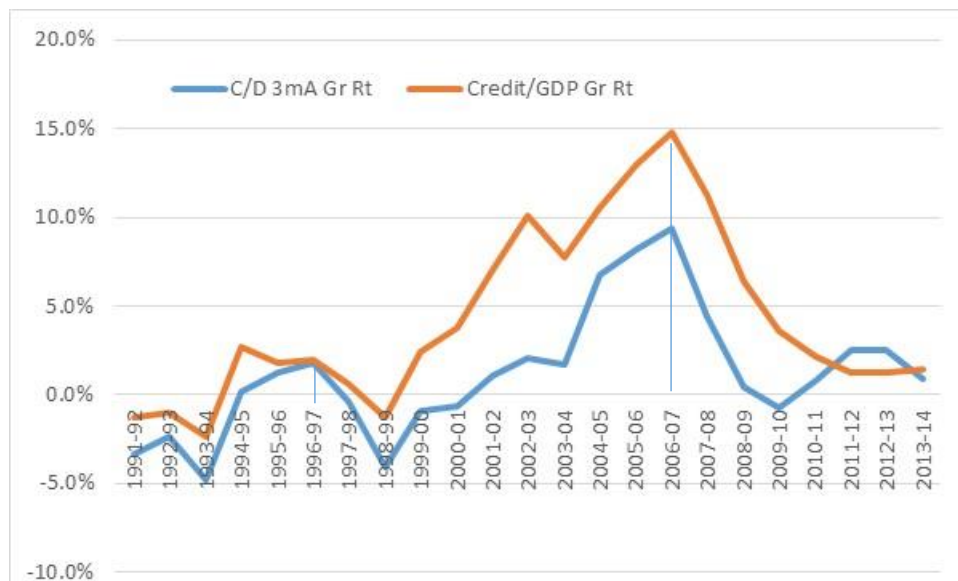
Monetary Data

Figure 34: Reserve Money, Narrow Money, Other Banks' Credit to Commercial Sector and Broad Money Growth Rates (1990-91 to 2013-14)



The four charts above show growth rates for each of the variables mentioned in the respective charts (in clockwise fashion, beginning from the top left: Reserve Money, Narrow Money, Banks Credit to the Commercial Sector and Broad Money). In each of these charts, the peak of 1996 is clearly visible, as is the lead-up to the peak of the 2007 cycle.

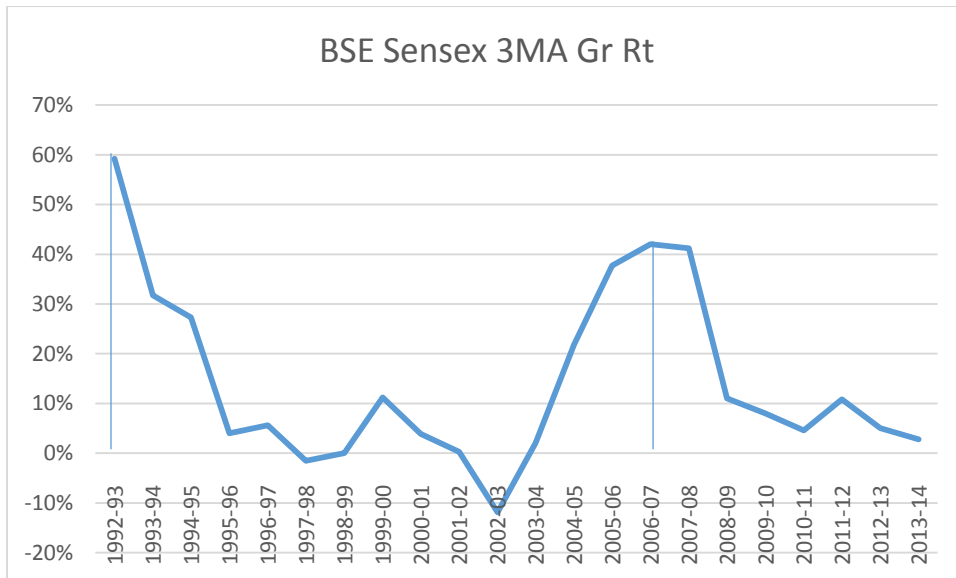
Figure 35 Credit/Aggregate Deposit Ratios, Credit/GDP Ratio (3 Period MA) Growth Rates



In the chart above (Figure 26), we have plotted 3 period moving average growth rates of the Credit to Aggregate Deposit ratios, as also the Credit to GDP Growth Rates. Both series strongly indicate a steady buildup of credit prior to the recession of 2008, dwarfing, in fact, the buildup in both of these ratios seen during 1996/97. That being said, it is certainly the case that the three peaks of the Indian business cycle are all too visible here as well.

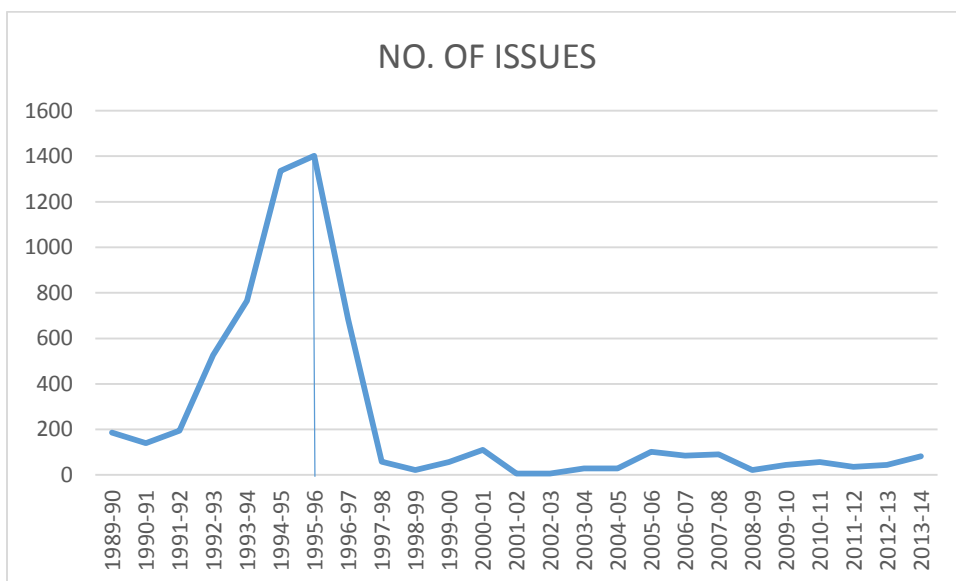
Stock Market Data

Figure 36: BSE Sensex (3 Period MA) Growth Rate (1993-93 to 2013-14)



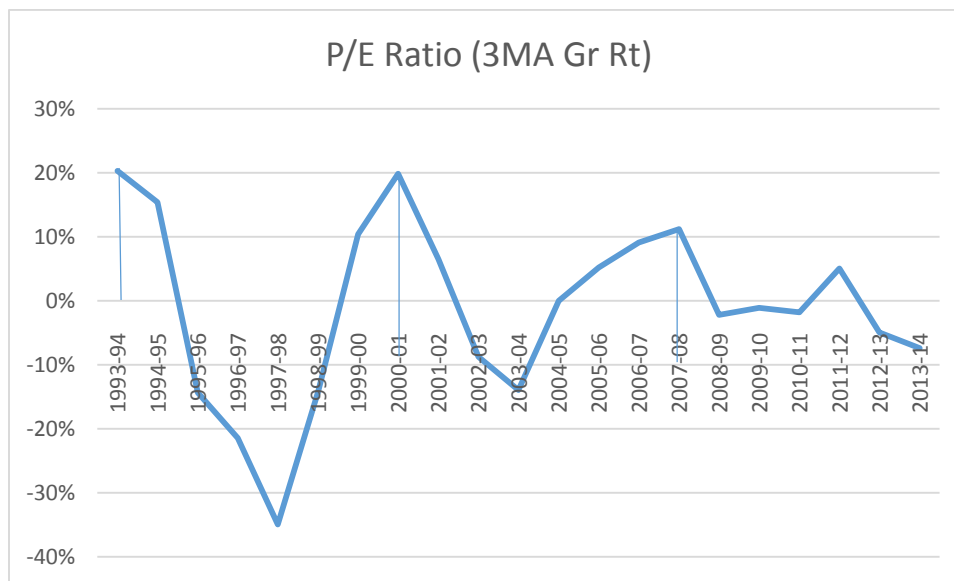
Annual returns from the BSE Sensex indicate that it would (as expected) perform well as a leading indicator, given the peak observable in 1994 and 2007. However, it is perhaps more instructive, from the point of view of our thesis, to inspect the following chart:

Figure 37: No. of Issues, Capital Markets



As the data indicates, the total number of Initial Public Offerings, Follow On Public Offerings and Offer For Sales reached a peak around 1996, which is when firms in India rushed, as it were, to raise capital for deployment into their respective industries. As has been mentioned before, it is this “fillip” to capital, an in particular, fixed capital, that has led to both the instigation as well as the perpetuation of the business cycle in India post 1991.

Figure 38 P/E Ratio (3 Period MA) Growth Rate

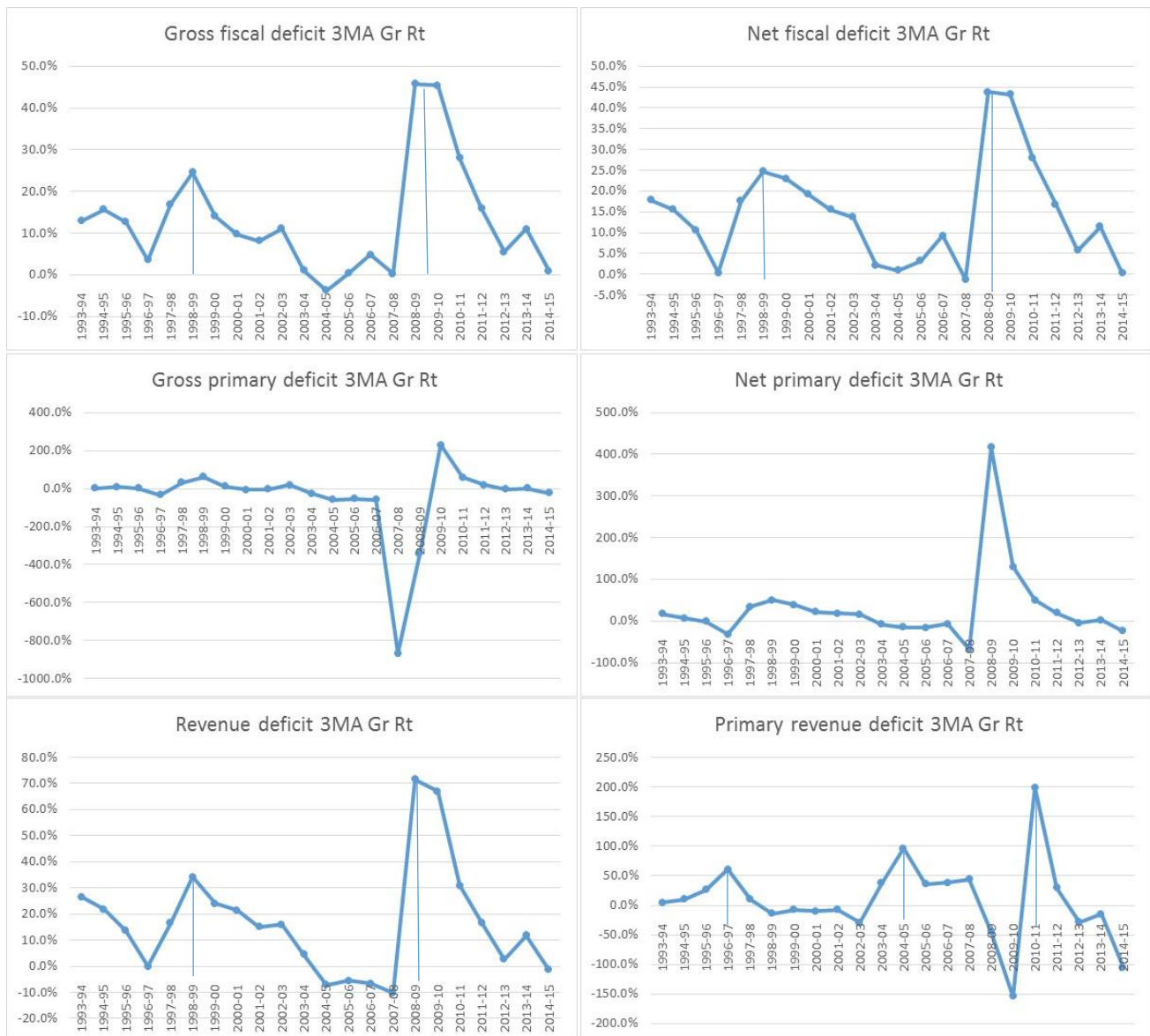


The P/E ratio cycle for the BSE Sensex also shows a peak in the years 1994-95, 2000-01 and 2007-08, as expected.

Government Borrowings

Conventional economic theory indicates that government borrowing should *respond* to the reference cycle; in other words, the government borrowing cycle will typically be a lagged cycle in relation to the reference cycle. This hypothesis is borne out in the following charts, in which the peaks of the respective cycles are observed to occur a year after the peaks observed in the reference cycle.

Figure 39: Gross Fiscal Deficit, Net Fiscal Deficit, Gross Primary Deficit, Net Primary Deficit (3 Period MA) Growth Rate



The charts associated with the fiscal deficit and the revenue deficit clearly indicate that the peaks occur, as noted earlier, about a year after the peaks observed in the reference cycle.

Monthly Time Series Data with the HP Filter

In this section, we attempt to analyze data with monthly frequency, in order to further establish that the peaks of the business cycle do indeed occur at or around the time periods that would be suggested by our modeling in the previous section. The data is sourced from the Business Beacon service from CMIE²⁴, and in order to work with data with monthly frequency, we shall in this case make use of the Hodrick Prescott filter (hereinafter referred to as the HP filter).

In contrast to conventional attempts at dealing with time series of monthly (or higher) frequencies, which rely on decomposing a time series into its components (trend and cyclical), we instead make use of an algorithm that will, so to speak, smoothen the original time series.

There are various filters that may be used for such purposes, and of the ones available, we have chosen to make use of the HP filter. Choosing a filter is as much a matter of art as it is of objectivity, for there are various advantages and disadvantages associated with each. Broadly speaking, however, the requirements of a good filter have been put forth in succinct fashion by (Baxter, Measuring business cycles: approximate band-pass filters for economic time series 1999) and are paraphrased below:

- A) The filter should extract a specified range of periodicities
- B) An introduction of phase shifts should be avoided (the timing relationships between frequencies should not be affected)
- C) The chosen method should be as closely approximated to the ideal band pass filter as possible
- D) Stationarity of the series must be ensured
- E) The components must be unrelated to the length of the sample period

F) The method be operational

In our opinion, the HP filter meets most, if not all, of these requirements. There are, however, some lacunae in the application of this filter, which will be discussed shortly.

For a time series, which may be represented thus:

$$y_t = \tau_t + c_t, t = 1, 2, \dots, T$$

The HP filter is a way to disassociate the cyclical component (the latter in the equation above) from the trend component by means of the following minimization problem:

$$\text{Min}_{\{\tau_t\}_{t=1}^T} \left[\sum_{t=1}^T (y_t - \tau_t)^2 + \lambda \sum_{t=2}^{T-1} (\nabla^2 \tau_{t+1})^2 \right]$$

λ in this case is the “penalty” parameter. The former term in the equation above “punishes” the variance seen in the cyclical component, while the second term “attaches”, by means of the penalty parameter, a penalizing value to the pack of smoothness, such as there may be, in the trend component. Another way of understanding the intuition behind the equation above is to realize that the HP filter arrives at the cyclical component by the extent to which the trend component keeps up with the original time series. What remains then becomes the cyclical component.

The HP filter has become over time one of the most popular filters in the field of business cycles, primarily because it meets most, if not all, of the six criteria mentioned above, but also because of its simplicity and relatively widespread usage.

However, as has been mentioned above, there are some problems with the HP filter as well. In what follows, we make a brief mention of some of the problems, and our reasons for continuing to make use of the HP filter in face of these problems.

While there are plenty of filters available, the HP filter has remained perhaps one of the most popular, for reasons cited above. However, a persistent problem with the HP filter, and a rather well documented one, is to do with the estimation of the cyclical component of the most recent time periods (Baxter 1995), (Guay 1996)

“The Hodrick–Prescott filter is often applied to individual economic time series as an initial step in real business cycle analyses. The filter generates cyclical components, which are then subjected to further analysis. Although the view is implicitly taken that actual time series are made up of the sum of growth and cyclical components, little attention is paid to either the structures of or relationship between those components. In particular, the HP filter was not developed to optimally estimate specific unobserved components, but rather is presented as an intuitively plausible transformation.

Whether or why this should be so is not our concern. In Section 2 we note that, whatever the intention, the HP filter does optimally estimate a particular components decomposition, and one might take the view that, inadvertently or otherwise, that is precisely the decomposition that is being estimated when the filter is applied. As we have noted, a number of previous authors have analyzed HP from this viewpoint. However, the optimality conclusion strictly applies to infinitely long time series, or from a practical viewpoint to the midpoints of series of typical length. It does not apply at or close to series endpoints.”²⁵

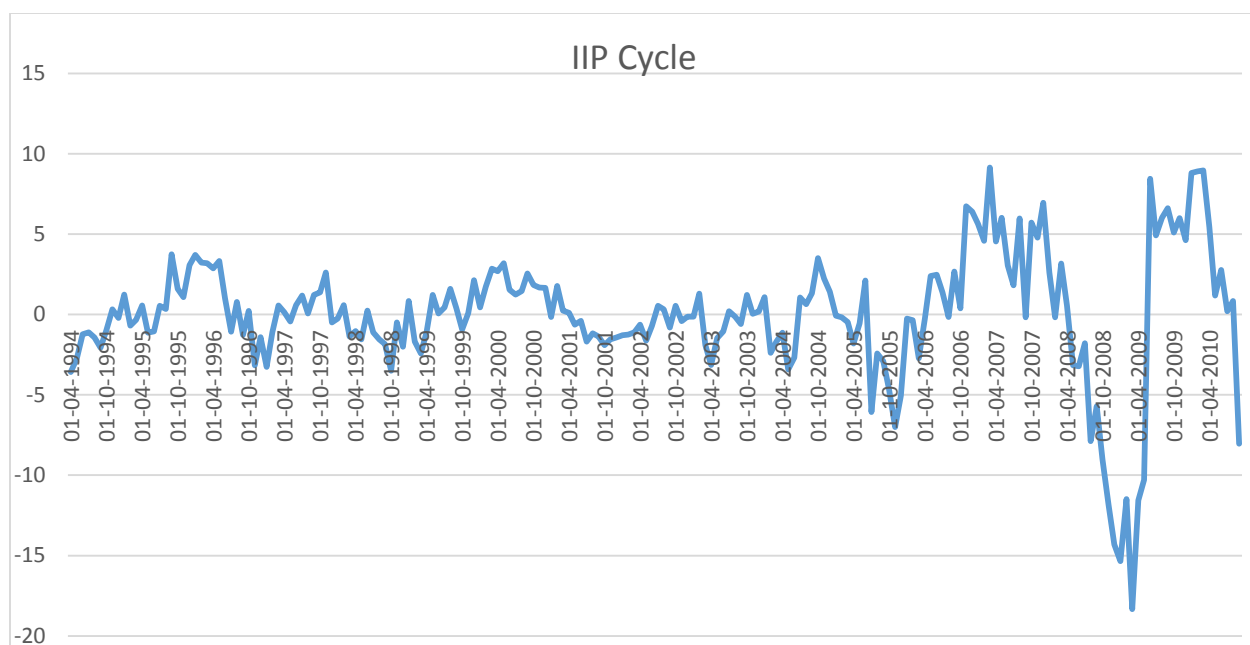
However, the criticism (although warranted) does not apply in our case, because as the authors of the citation above themselves point out, this limitation of the HP filter makes itself evident, in the first instance, only for time series of rather limited length, and in the second instance, only towards the “end-points” of the series. The more recent the data, the more problematic the usage of the Hodrick-Prescott filter. Since our usage of the Hodrick-Prescott filter is for the purpose of dating business cycles as opposed to making policy prescriptions in the near future, and since the length of the data series is comfortably longer than 120 observations (at the bare minimum), the problems cited above need not apply herein.²

In what follows, monthly time series data from Business Beacon, CMIE has been de-trended using the HP filter, and perturbations around the trend have been portrayed as the cycle that emerges. This exercise has been carried out for the following time series, and the attempt is to ascertain if the same turning points are visible in these cases as well.

a) IIP

Figure 40: IIP Data, Detrended

² In addition, a separate appendix also lists an analysis done using the bandpass filter for all the series shown here. The bandpass filter de-trended results are superimposed on the HP filter analysis for ease of reference. Please note that for all monthly data, a value of 14,400 for the smoothing parameter has been used.

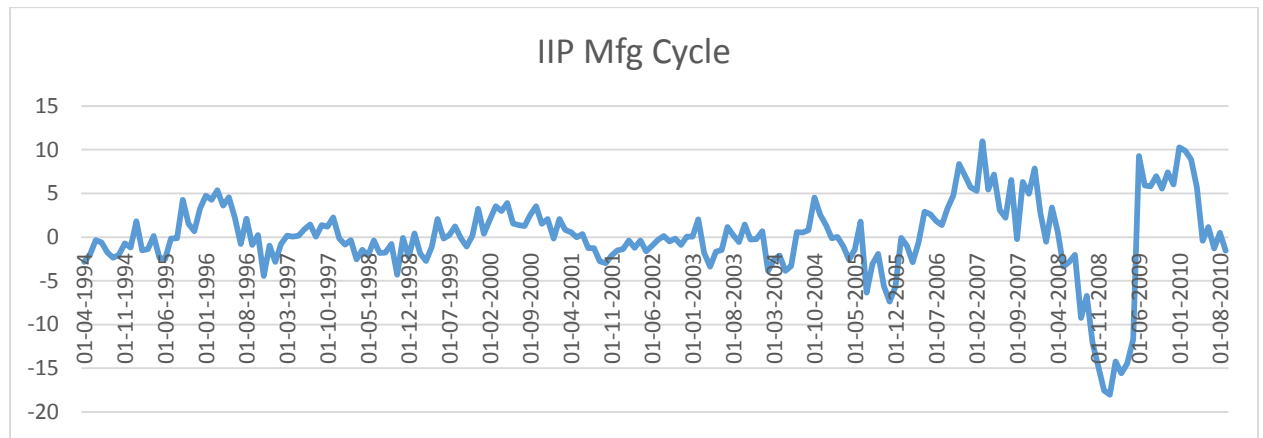


As can be seen, the number of peaks increase dramatically in such an analysis. While the (by now) conventional peaks of 1995-96, 2000-01 and 2007-08 are observable, peaks also emerge in this case in the years 1997-98, 2004-05 and 2009-10. A rather more minute study of the business cycle indicates that these peaks are 'relative' recoveries, relative to events that predate these peaks (such as for example a small uptick around the year 2004 in the economy, given the expectation of a stable government). However, these peaks do not emerge in our analysis of annual data. This in itself is suggestive of the fact that these peaks are relatively minor recoveries. The corroboration that is obtained with regard to our annual level analysis is important, for the *absence* of these peaks would have been far more damaging than the *presence* of other peaks. These trends, as will be clear from the subsequent charts, remain in the case of the other data

series as well. Where pertinent, an additional explanation is given for the subsequent charts.

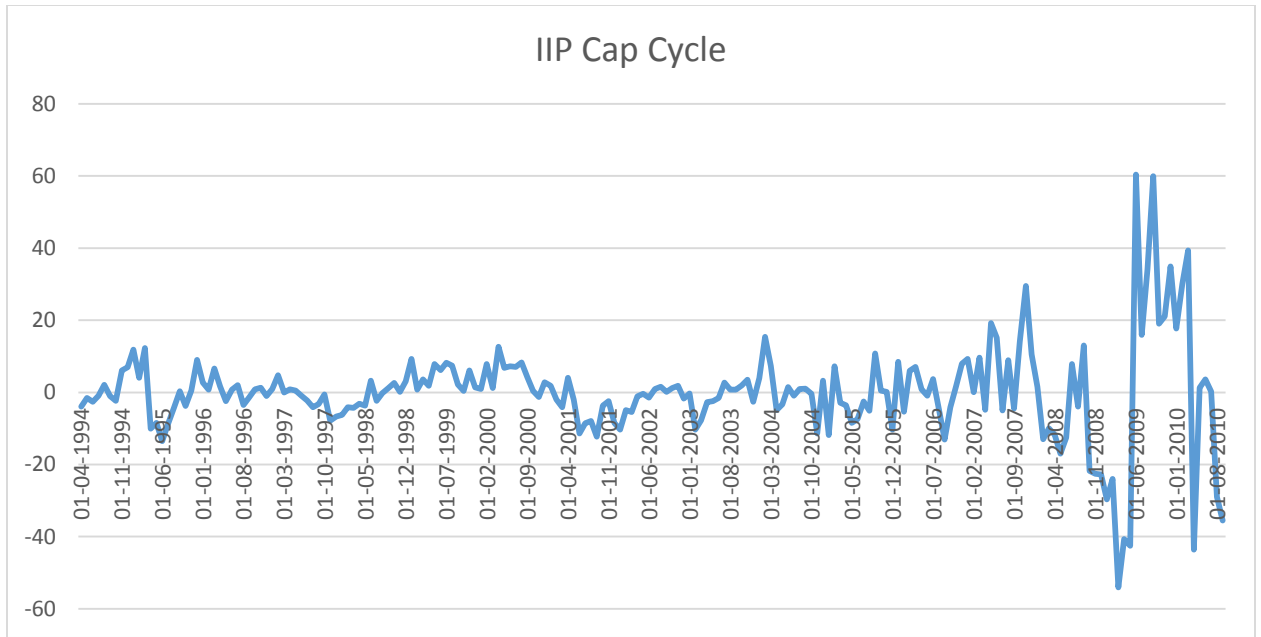
b) IIP Manufacturing

Figure 41: IIP Manufacturing , Detrended



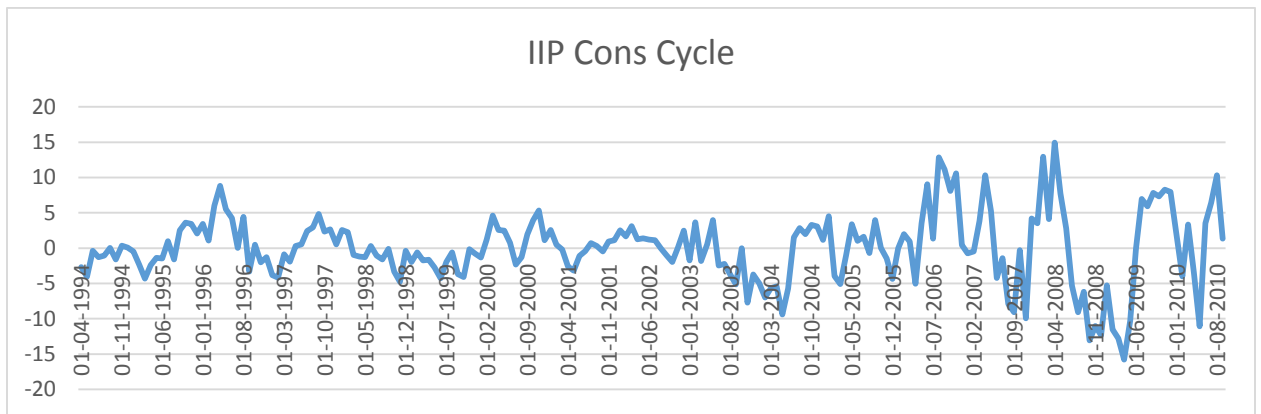
c) IIP Capital Goods

Figure 42: IIP Capital Goods , Detrended



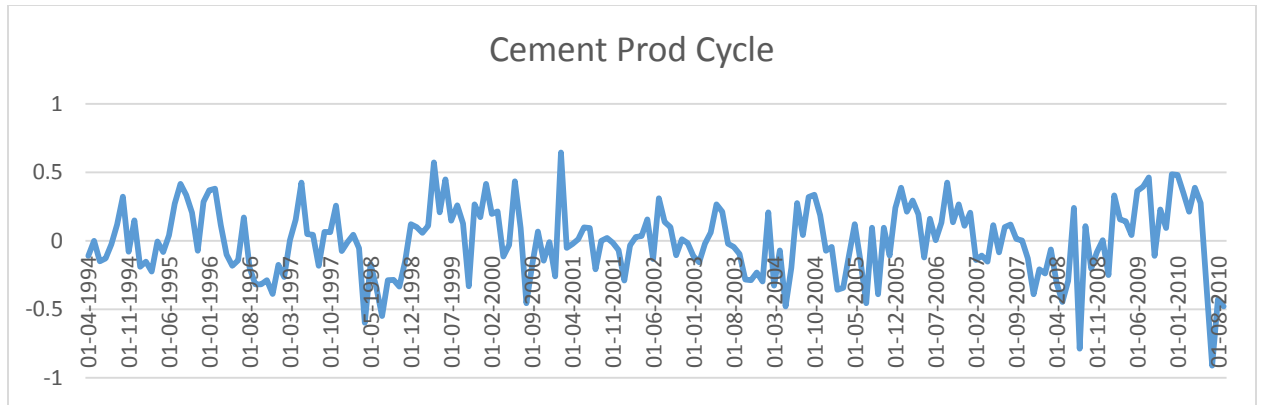
d) IIP Construction

Figure 43: IIP Construction, , Detrended



e) Cement Production (mt)

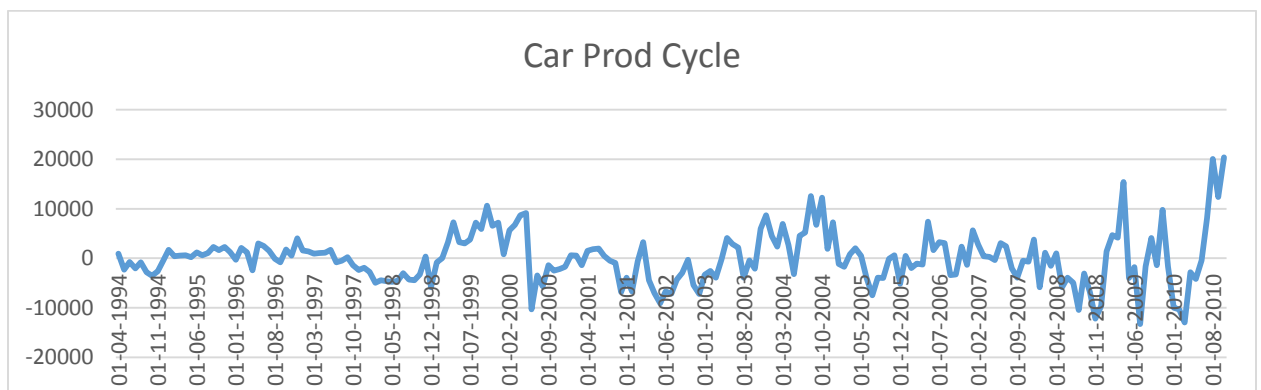
Figure 44: Cement Production, Detrended



As is clear from the chart above, cement production is a far more volatile cycle than the others analyzed thus far, clearly far more sensitive to short term economic perturbations than others. This is hardly surprising; demand for cement is likely to be far more responsive to local, short term economic conditions. As has been mentioned earlier, the absence of our reference cycle peaks would be a cause for concern, not the presence of other peaks.

f) Car Production

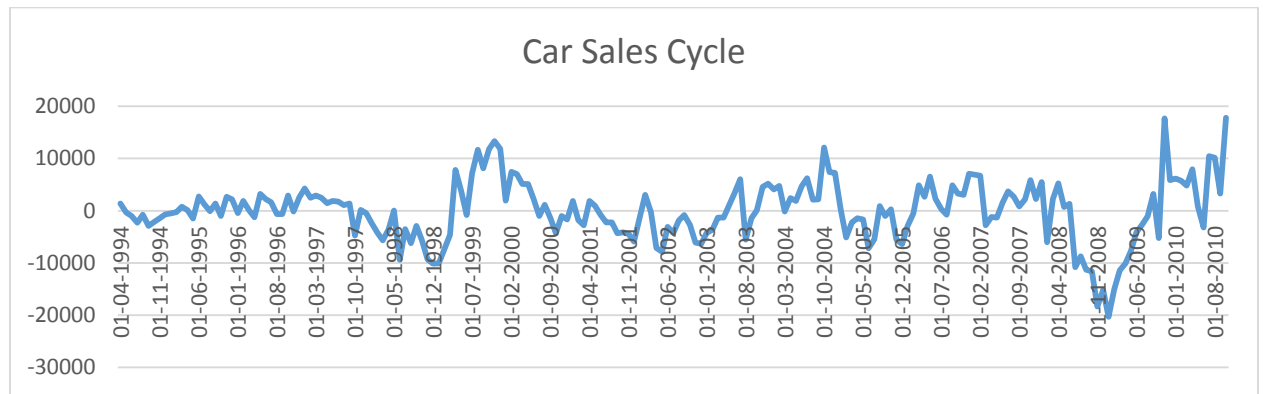
Figure 45: Car Production, Detrended



The point of note in this case (a point we have already noted before in the case of data related to the automobile sector data drawn from the CMIE database) is that the first true peak to occur is visible around 1999. This is so because of the launch of many automobile manufacturing firms around this time.

g) Car Sales

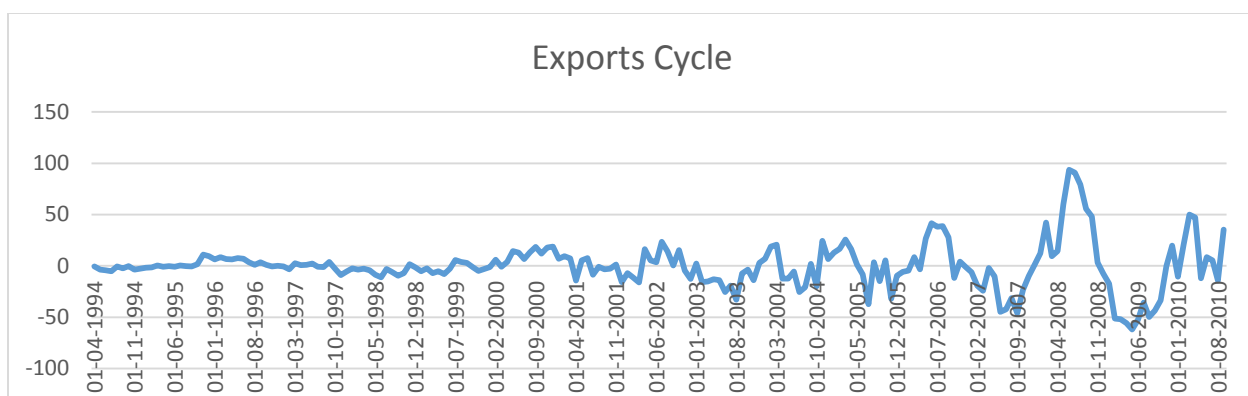
Figure 46: Car Sales, Detrended



The same peaks that are observable in the car production cycle are to be seen here as well, which one would expect to be almost tautological. The other point of note is the severe downturn in car sales in the aftermath of the onset of the Great Recession globally.

h) Exports

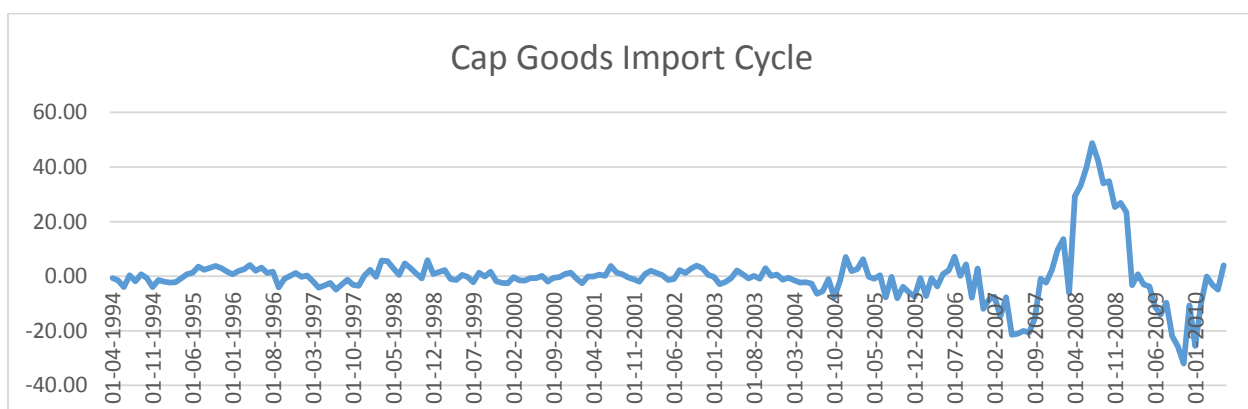
Figure 47: Exports, Detrended



The Indian business cycle immediately after the economic reforms of 1991 seems to have not given rise to a concomitant increase in exports. In fact, relative to trend, the sharpest rise seems to have occurred prior to the onset of the Great Recession on a global scale. Unfortunately, the data seems to indicate that that onset was followed almost immediately by a slump, driven no doubt by depressed global demand.

i) Capital Goods Import Cycle

Figure 48: Capital Goods Import , Detrended



A rather similar story seems to have played out in the case of the capital goods import cycle, as can be seen from the chart above.

Chapter 5: Concluding Remarks

The attempt in this thesis, then, has been to establish three interlinked aspects pertaining to business cycles in India.

For the first part, a systematic review of the literature pertaining both to Indian business cycles and the theory of business cycles in general has revealed the fact that replacement cycles as a theory for generating and more importantly, perpetuating business cycles has been grossly under-studied, and particularly so in the Indian case.

Second, our theoretical modeling, described in Section 2, reveals the existence of a cycle that emerges in a theoretical economy as a consequence of the need to replace fixed capital after a certain period of time, along with assumptions about the behavioral response that industrialists are likely to make in response to changing business cycle conditions making as regards the drawing up or down of cash balances. Not only does such a cycle emerge, it also perpetuates, and settles into a rhythmic, unvarying and undying pattern over the course of many years. This business cycle, although generated due to the need to replace fixed capital, is observed when one studies the GDP of the theoretical economy.

Third, empirical evidence from the Indian economy after the period 1991 strongly suggests that the need to replace fixed capital in the case of listed Indian firms (addition to gross block) also generates a cycle which bears close synchronicity with the overall business cycle for the Indian economy. While we have not attempted to establish evidence of causation on part of the

former where the latter is concerned, the theoretical modeling in Section 2 lends credence to the view that this is strongly possible.

In what follows, we discuss some features of the Indian economy that provide greater nuance to our thesis. We also discuss potential sources of data that cannot be used just yet, but might provide greater credence to our hypothesis in the years to come. Policy prescriptions that suggest themselves, along with further areas of research, are also discussed.

Evidence regarding the existence of replacement cycles, and the fact that their peaks and troughs mirror that of the Indian business cycle has already been supplied in Section 3. Of greater interest, perhaps, is the realization of the fact that the manufacturing sector in India is still only one-fifth, or at best one-fourth of the overall Indian economy. As India's manufacturing sector matures over time, and as the share of manufacturing in the Indian economy rises, it is inevitable that the linkage between replacement cycles, particularly in the manufacturing sector, and the overall business cycle will only strengthen. In other words, in terms of material predictions, our hypothesis is only likely to strengthen over time.

Three other long term trends that are likely to manifest themselves in the Indian economy that will positively impact the predictability quotient of our hypothesis are: formal financial channels being deployed to a larger extent, a successful implementation of the Goods and Services Tax and a limitation on the extent to which subsidies are able to direct pricing decisions in the economy. In other words, as India liberalizes further and deeper, the linkage between replacement cycles and business cycles is likely to get stronger for India. Also, as India's

international linkages increase with an increase in globalization, international influences on India's domestic business cycle will only increase (A. P. Shah 2009)

In addition to the above, it is also the case that the government agencies are making efforts to make more data available, and make data available quicker. While monthly estimates of output (GDP) are still some years in to the future, better and more holistic measure of consumer price indices, more thorough measures of output and of employment will make the process of estimating both the trend and perturbations around the trend far easier. Most important of all, however, is the fact that the Reserve Bank of India has recently started collecting data about the Order Books, Inventory and Capacity Utilization Survey (OBICUS). While data is currently available for the fourth quarter of 2011-12 and onwards, this data series will in the future be of great help in establishing both the presence of a replacement cycle as well as its potential impact on the Indian economy.

This thesis has been largely positive in terms of its approach. However, certain normative prescriptions make themselves apparent, and are duly noted here. However, it is important to note that careful research on these is warranted.

Broadly speaking, three policy prescriptions suggest themselves:

First, the thesis suggests that business cycles are, in a definite sense, inevitable. To speak of "conquering the business cycles", therefore, is fallacious. As long as there is a manufacturing sector of a reasonable size in an economy, and in so far as it runs in more or less capitalistic fashion, a business cycle is going to be present in that economy. While we cannot say any more

than this regarding its impact, its amplitude or its frequency, this thesis does present one normative conclusion: “ridding” an economy of the business cycles is not possible.

Second, absent government interventions, the impact of the business cycles, insofar as they have been due to replacement cycles, are only going to accentuate for more industrialized economies. In other words, specifically in the case of India, business cycles are a feature of its economy in the current instance, and are likely to be so in the foreseeable future.

Third, more research is warranted as regards the question of whether policy makers should focus on reducing the deleterious impacts of the business cycle. In other words, while there is no doubt about whether business cycles are going to be around, there remains unanswered the question of whether one should be doing anything regarding the impact of the cycles (and what impact, in turn, might those actions themselves have, both on the cycle and the economy).

Finally, we examine ways in which the modeling in this thesis could plausibly be made to approximate reality more closely. There are three modifications that suggest themselves in this regard.

Firstly, one could build in an assumption of varying capacity utilization: firms might tend to use their fixed assets more intensively during expansionary phases of the business cycle, and might similarly tend to keep fixed capital idle during recessionary phases.

Secondly, we might be able to assume a variable rate of profit. This variable rate of profit might make the cycle vary rather more in terms of amplitude, by invoking the famous Keynesian assumption of ‘animal spirits’.

Thirdly, we might assume that technology doesn't remain constant over the life of the model and improves (presumably for the better). Each of these assumptions might well serve to make the model more appropriately reflect reality, but we feel confident that results obtained from such models will only reinforce our findings, and not contradict them.

¹ Burns and Mitchell, *Measuring Business Cycles*

² Alvin Hansen, in *Business Cycles and National Income*, refers to Lord Lauderdale, who in 1804 published a book titled '*An Inquiry into the Nature and Origin of Public Wealth*'. Hansen suggests that Lord Lauderdale anticipated the development of concepts such as forced saving, income distribution and effects of fiscal policy

³ The rest of this section, it needs to be emphasized, does not follow a necessarily chronological order.

⁴ The Debt Deflation Theory of Great Depressions, by Irving Fisher, *Econometrica* Vol. 1, No. 4 (Oct., 1933), pp. 337-357

⁵ *BUSINESS CYCLES: A Theoretical, Historical and Statistical Analysis of the Capitalist Process* pp 157

⁶ The Monetary Theory of the Trade Cycle and Its Statistical Test, R.G. Hawtrey, *Quarterly Journal of Economics*, May 1927

⁷ Theory and Measurement: Causality Issues in Milton Friedman's Monetary Economics, by J. Daniel Hammond

⁸ Econometric Policy Evaluation: A Critique, by Robert Lucas, published in *Theory, Policy, Institutions: Papers from the Carnegie-Rochester Conference Series on Public Policy*

⁹ "Sticky Price Manifesto" by N. Gregory Mankiw and Lawrence Summers

¹⁰ Hereafter referred to as the GT

¹¹ Interactions between the Multiplier Analysis and the Principle of Acceleration by Paul A. Samuelson in *The Review of Economics and Statistics* Vol. 21, No. 2 (May, 1939), pp. 75-78

¹² *ibid*

¹³ *Das Kapital*, Volume II, Karl Marx

¹⁴ Johan Einarsen, *Reinvestment Cycles and Their Manifestation in the Norwegian Shipping Industry* (Oslo, University of Economics, 1938); "Reinvestment Cycles," *Review of Economic Statistics*, February 1938; and "Replacement in the Shipping Industry," *Review of Economic Statistics*, November 1946

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- ¹⁵ Walter Isard, "A Neglected Cycle: The Transport-Building Cycle," Review of Economic Statistics, November 1942; "Transport Development and Building Cycles," Quarterly Journal of Economics, November 1942, and "The Transport-Building Cycle in Urban Development: Chicago," Review of Economic Statistics, November 1943.
- ¹⁶ Capital in Transportation, Communications, and Public Utilities: Its Formation and Financing (Ch.: Long Cycles), by Melville J. Ulmer, NBER 1960
- ¹⁷ Hicks, J. R., (1942), 'Maintaining Capital Intact: A Further Suggestion', Economica, May 1942, pp. 174-179.
- ¹⁸ Hill, Peter "Capital Stocks, Capital Services and Depreciation" OECD Working Papers, 1998
- ¹⁹ ibid
- ²⁰ ibid
- ²¹ Although it needs to be mentioned that in our attempts to validate our modeling from an empirical viewpoint, we trace out cycles in individual sectors of the economy
- ²² Patnaik, I. and Sharma R., 2002, Business Cycles in the Indian Economy, Margins 35 (1), 71-79
- ²³ ASI Documentation, MOSPI (http://mospi.nic.in/mospi_new/upload/asi/ASI_main.htm?status=1&menu_id=88)
- ²⁴ <http://www.mayin.org/cycle.in/tracking.html#sa>
- ²⁵ On suboptimality of the Hodrick–Prescott filter at time series endpoints Emi Mise, Tae-Hwan Kim, Paul Newbold

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Appendix: Granger Causality Results: All series are 3MA, lag of one 'order'.

** - Significant at the 10% level

*** - Significant at the 5% level

Overall (All Sectors)**

```
> grangertest(netsales3ma~gfa3ma, order=1, data=gcdatal)
Granger causality test

Model 1: netsales3ma ~ Lags(netsales3ma, 1:1) + Lags(gfa3ma, 1:1)
Model 2: netsales3ma ~ Lags(netsales3ma, 1:1)
  Res.Df Df      F  Pr(>F)
1      16
2      17 -1 4.4841 0.05022 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
> |
```

Automobiles, Banks, Cement

```
> grangertest(autons~autogfa, order=1, data=gcdataset)
Granger causality test

Model 1: autons ~ Lags(autons, 1:1) + Lags(autogfa, 1:1)
Model 2: autons ~ Lags(autons, 1:1)
      Res.Df Df      F Pr(>F)
1         17
2         18 -1 0.1029 0.7523
> grangertest(bkns~bkgfa, order=1, data=gcdataset)
Granger causality test

Model 1: bkns ~ Lags(bkns, 1:1) + Lags(bkgfa, 1:1)
Model 2: bkns ~ Lags(bkns, 1:1)
      Res.Df Df      F Pr(>F)
1         17
2         18 -1 0.3313 0.5724
> grangertest(cementns~cementgfa, order=1, data=gcdataset)
Granger causality test

Model 1: cementns ~ Lags(cementns, 1:1) + Lags(cementgfa, 1:1)
Model 2: cementns ~ Lags(cementns, 1:1)
      Res.Df Df      F Pr(>F)
1         17
2         18 -1 8e-04 0.9779
```

Chemicals and Chemical Products, Communication Services***, Consumer Goods

```

> grangertest(cacpns~cacpgfa, order=1, data=gcdataset)
Granger causality test

Model 1: cacpns ~ Lags(cacpns, 1:1) + Lags(cacpgfa, 1:1)
Model 2: cacpns ~ Lags(cacpns, 1:1)
      Res.Df Df       F Pr(>F)
1         17
2         18 -1 0.6602 0.4277
> grangertest(csns~csgfa, order=1, data=gcdataset)
Granger causality test

Model 1: csns ~ Lags(csns, 1:1) + Lags(csgfa, 1:1)
Model 2: csns ~ Lags(csns, 1:1)
      Res.Df Df       F   Pr(>F)
1         17
2         18 -1 13.891 0.001676 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
> grangertest(cgns~cggfa, order=1, data=gcdataset)
Granger causality test

Model 1: cgns ~ Lags(cgns, 1:1) + Lags(cggfa, 1:1)
Model 2: cgns ~ Lags(cgns, 1:1)
      Res.Df Df       F Pr(>F)
1         17
2         18 -1 0.6252 0.44

```

Coal Oil and Natural Gas, Drugs and Pharmaceuticals**, Food Products***

```

> grangertest(coangns~coanggfa, order=1, data=gcdataset)
Granger causality test

Model 1: coangns ~ Lags(coangns, 1:1) + Lags(coanggfa, 1:1)
Model 2: coangns ~ Lags(coangns, 1:1)
      Res.Df Df       F Pr(>F)
1         17
2         18 -1 0.0034 0.9542
> grangertest(dapns~dapgfa, order=1, data=gcdataset)
Granger causality test

Model 1: dapns ~ Lags(dapns, 1:1) + Lags(dapgfa, 1:1)
Model 2: dapns ~ Lags(dapns, 1:1)
      Res.Df Df       F Pr(>F)
1         17
2         18 -1 3.5164 0.07805 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
> grangertest(fpns~fpgfa, order=1, data=gcdataset)
Granger causality test

Model 1: fpns ~ Lags(fpns, 1:1) + Lags(fpgfa, 1:1)
Model 2: fpns ~ Lags(fpns, 1:1)
      Res.Df Df       F Pr(>F)
1         17
2         18 -1 5.6378 0.02962 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

IT, Manufacturing, Minerals and Mineral Products

```

> grangertest(itns~itgfa, order=1, data=gcdataset)
Granger causality test

Model 1: itns ~ Lags(itns, 1:1) + Lags(itgfa, 1:1)
Model 2: itns ~ Lags(itns, 1:1)
      Res.Df Df      F Pr(>F)
1         17
2         18 -1 0.5649 0.4626
> grangertest(mfgns~mfggfa, order=1, data=gcdataset)
Granger causality test

Model 1: mfgns ~ Lags(mfgns, 1:1) + Lags(mfggfa, 1:1)
Model 2: mfgns ~ Lags(mfgns, 1:1)
      Res.Df Df      F Pr(>F)
1         17
2         18 -1 0.0133 0.9095
> grangertest(mampns~mampgfa, order=1, data=gcdataset)
Granger causality test

Model 1: mampns ~ Lags(mampns, 1:1) + Lags(mampgfa, 1:1)
Model 2: mampns ~ Lags(mampns, 1:1)
      Res.Df Df      F Pr(>F)
1         17
2         18 -1 0.1179 0.7356

```

Mining, Real Estate, Retail Trade***

```

> grangertest(minns~mingfa, order=1, data=gsdatasect)
Granger causality test

Model 1: minns ~ Lags(minns, 1:1) + Lags(mingfa, 1:1)
Model 2: minns ~ Lags(minns, 1:1)
      Res.Df Df       F Pr(>F)
1         17
2         18 -1 0.1019 0.7535
> grangertest(rens~regfa, order=1, data=gsdatasect)
Granger causality test

Model 1: rens ~ Lags(rens, 1:1) + Lags(regfa, 1:1)
Model 2: rens ~ Lags(rens, 1:1)
      Res.Df Df       F Pr(>F)
1         17
2         18 -1 0.5725 0.4596
> grangertest(retradns~retradgfa, order=1, data=gsdatasect)
Granger causality test

Model 1: retradns ~ Lags(retradns, 1:1) + Lags(retradgfa, 1:1)
Model 2: retradns ~ Lags(retradns, 1:1)
      Res.Df Df       F   Pr(>F)
1         17
2         18 -1 14.247 0.001512 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

Telecom***, Transport Services***

```

> grangertest(telecomns~telecomgfa, order=1, data=gsdatasect)
Granger causality test

Model 1: telecomns ~ Lags(telecomns, 1:1) + Lags(telecomgfa, 1:1)
Model 2: telecomns ~ Lags(telecomns, 1:1)
      Res.Df Df      F    Pr(>F)
1         17
2         18 -1 13.426 0.001922 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
> grangertest(transpns~transpgfa, order=1, data=gsdatasect)
Granger causality test

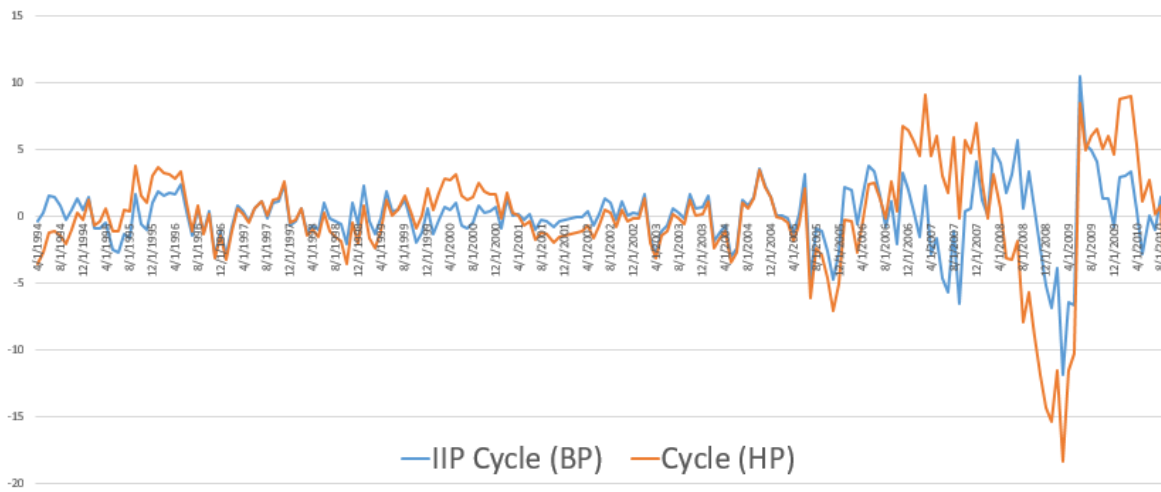
Model 1: transpns ~ Lags(transpns, 1:1) + Lags(transpgfa, 1:1)
Model 2: transpns ~ Lags(transpns, 1:1)
      Res.Df Df      F    Pr(>F)
1         17
2         18 -1 18.002 0.0005485 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

Appendix II: Bandpass Filter Analysis

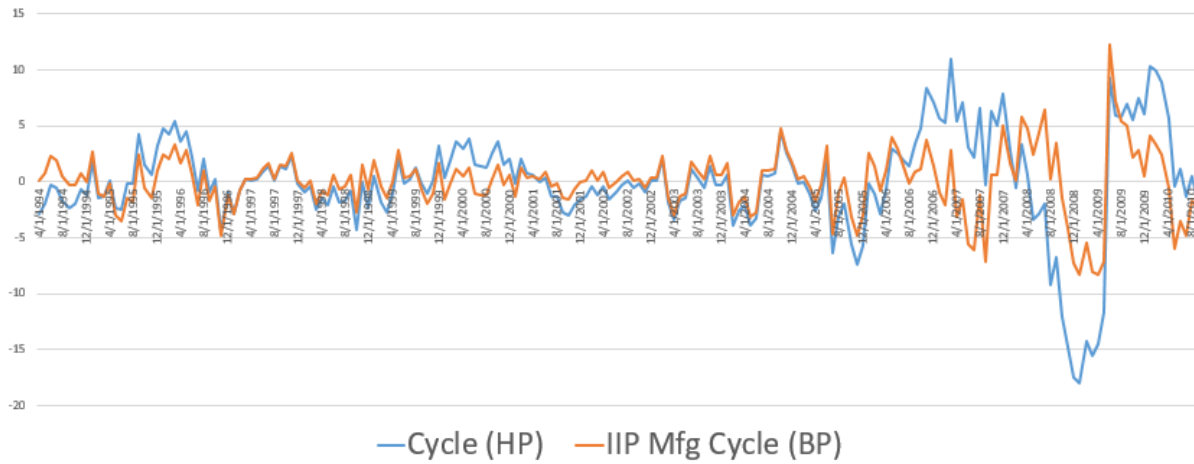
Note: figures in parenthesis indicate correlation between the two filters.

IIP Cycle (65.98%)

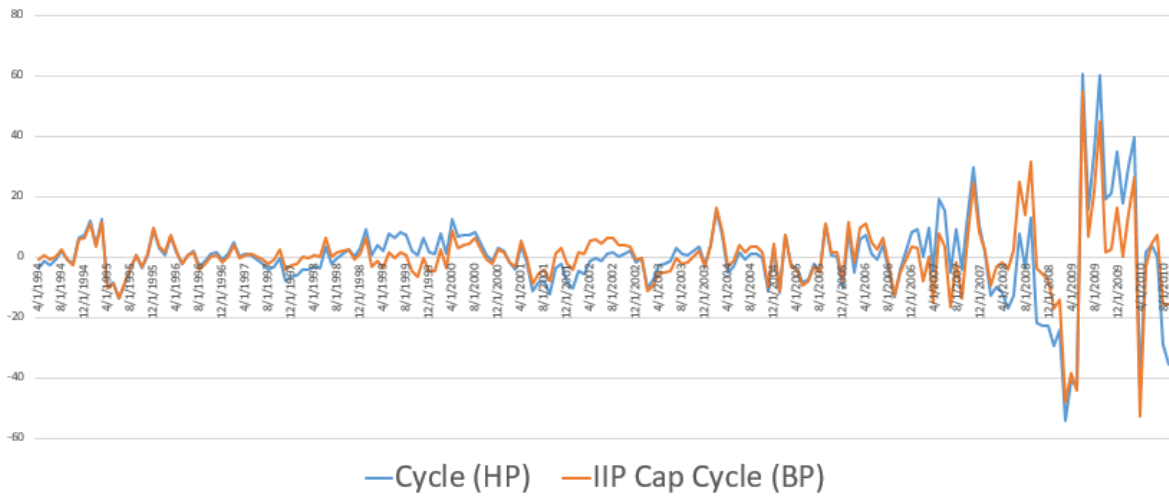


2

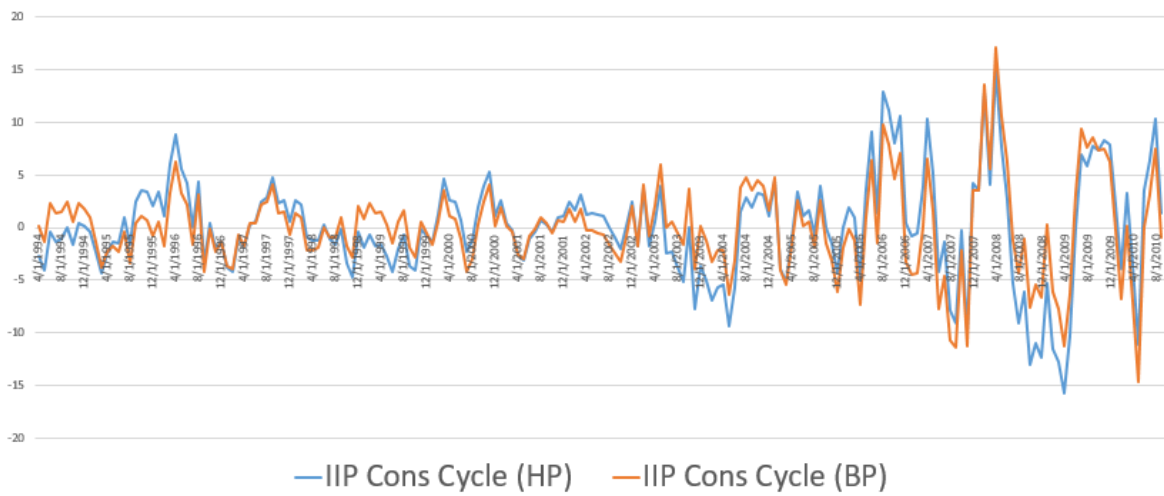
IIP Manufacturing Cycle (64.97%)



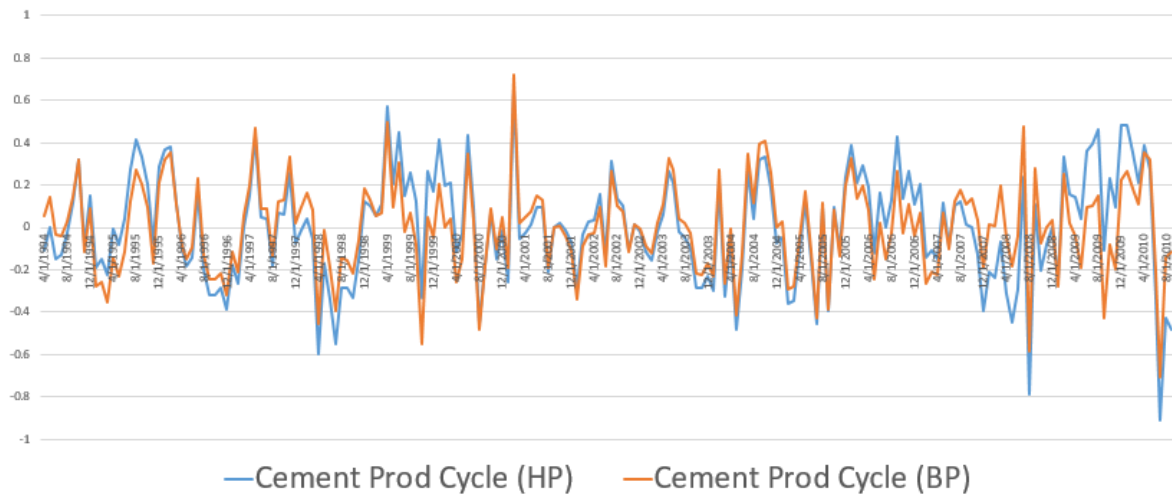
IIP Capital Goods Cycle (87.81%)



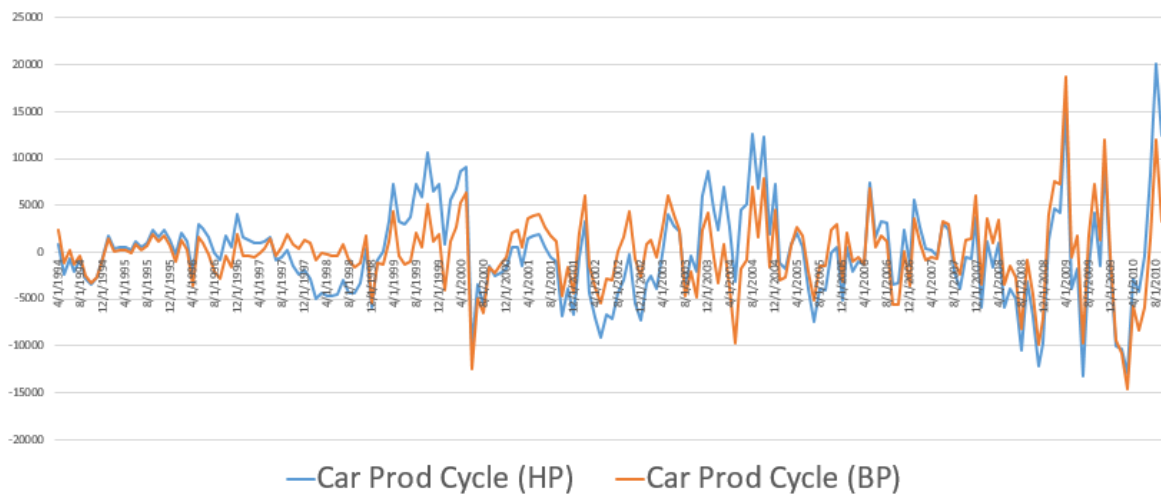
IIP Construction Cycle (87.76%)



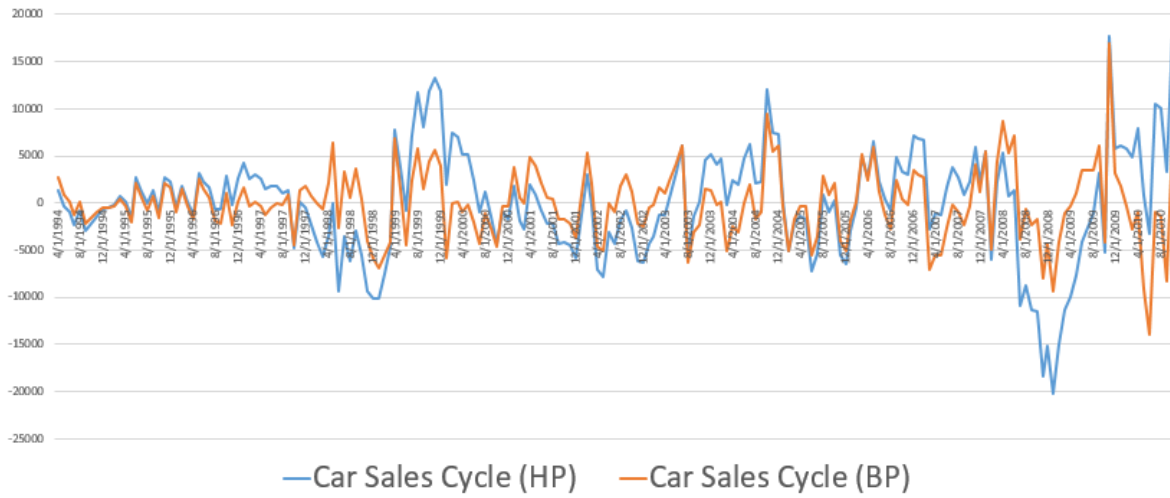
Cement Production Cycle (86.92%)



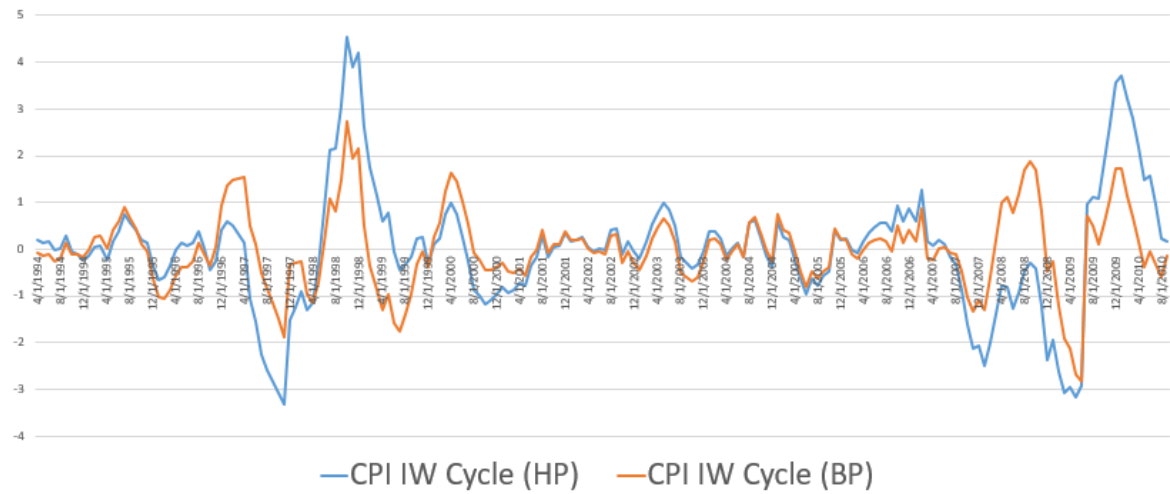
Car Production Cycle (80.46%)



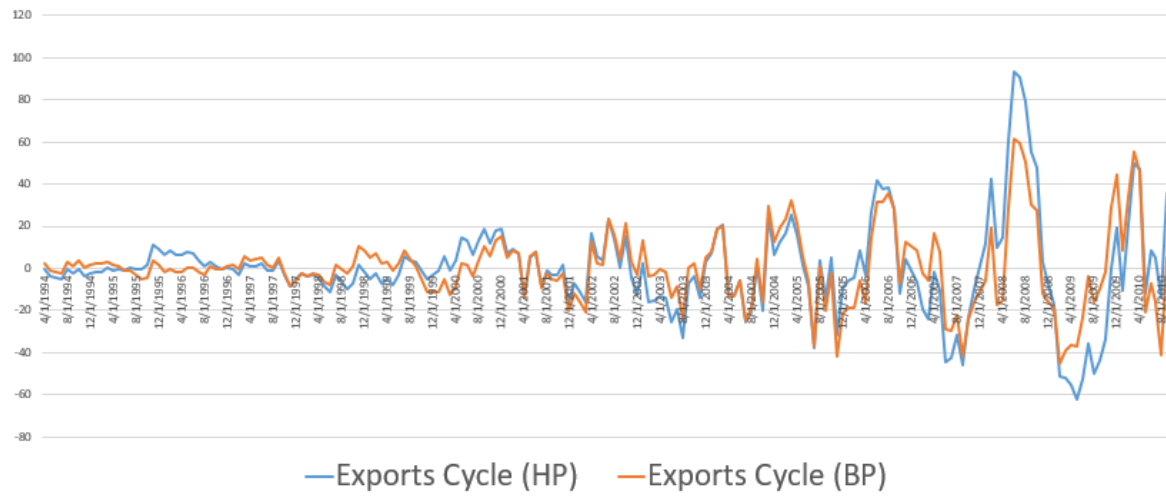
Car Sales Cycle (62.19%)



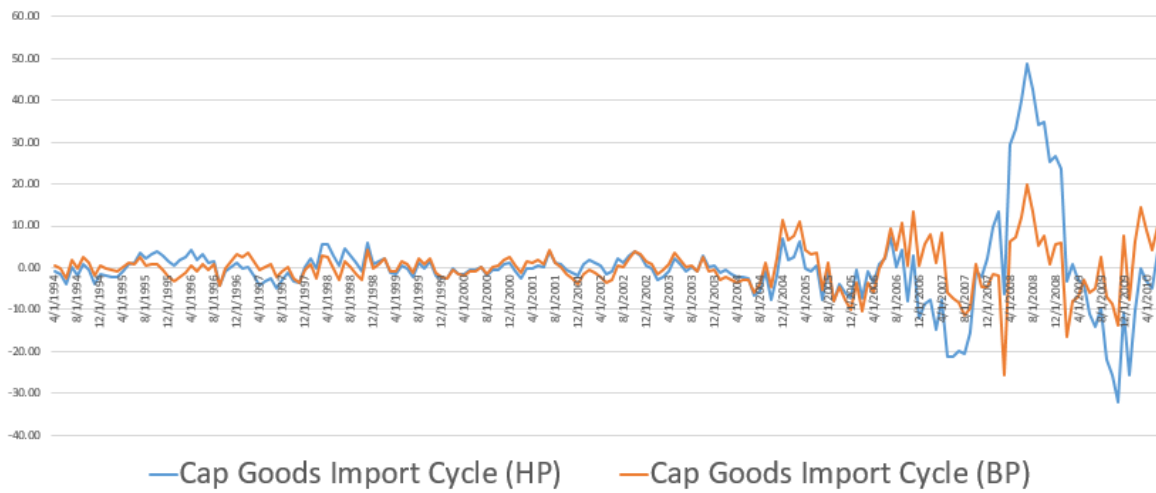
CPI (IW) Cycle (68.81%)



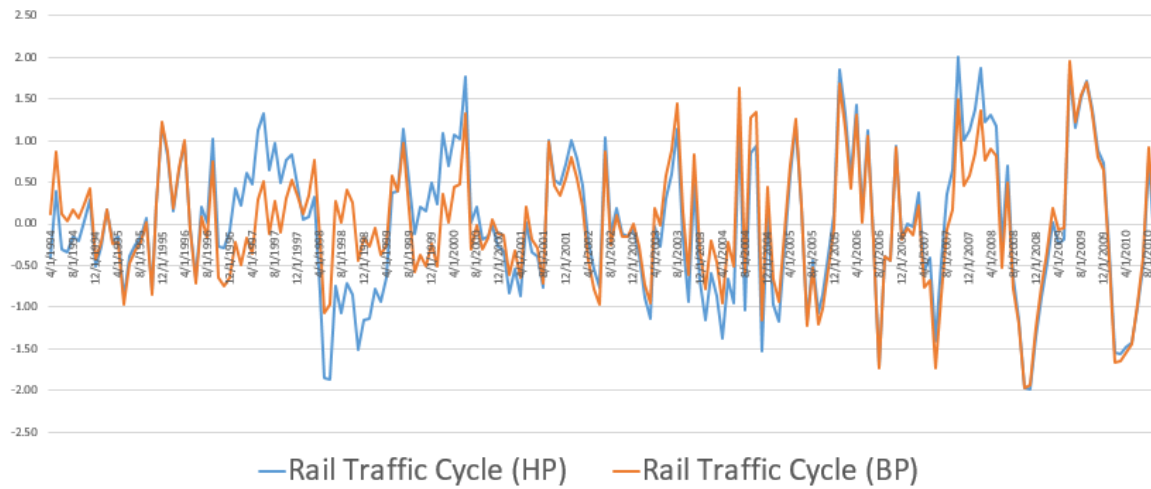
Exports Cycle (85.03%)



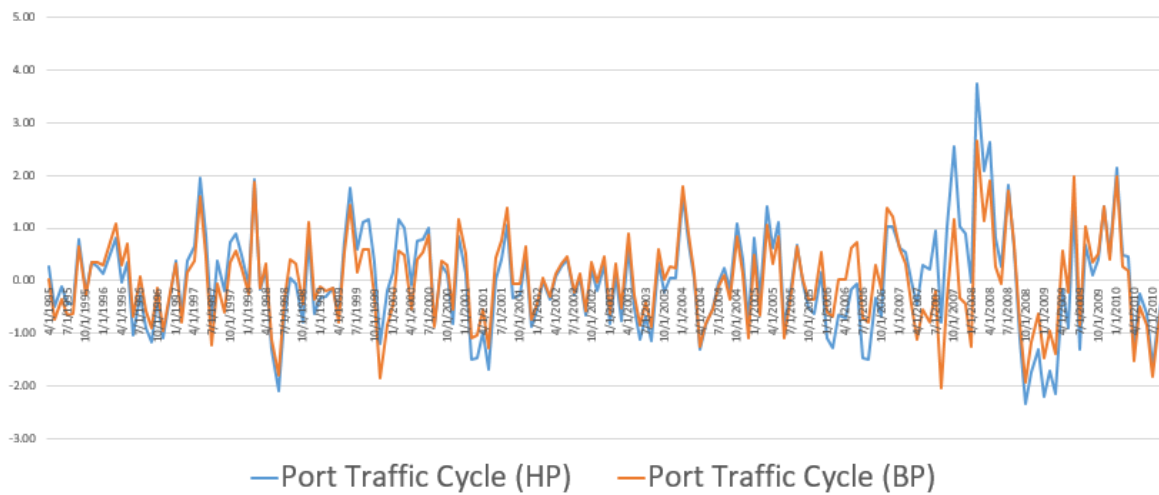
Capital Goods Import Cycle (59.37%)



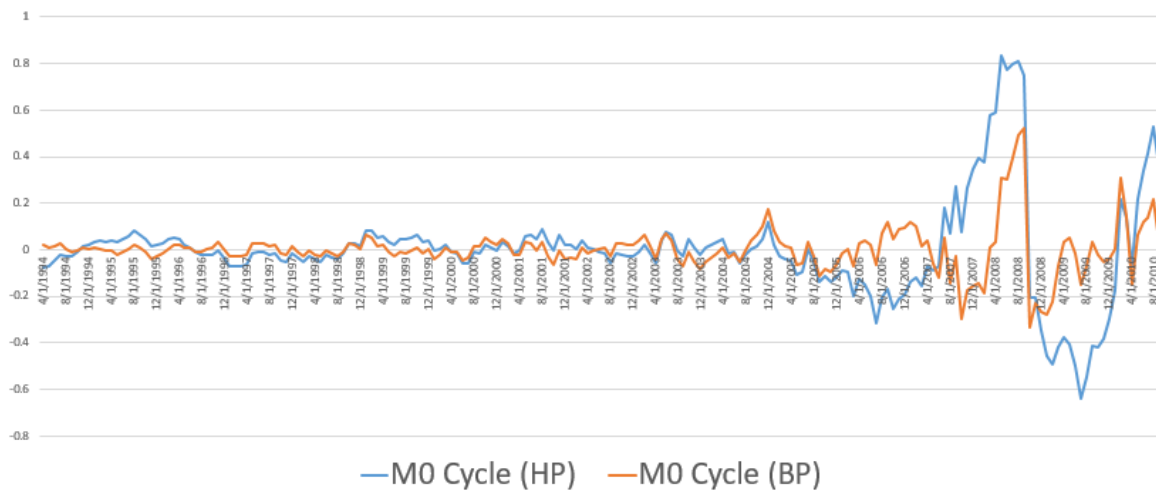
Rail Traffic Cycle (89.3%)



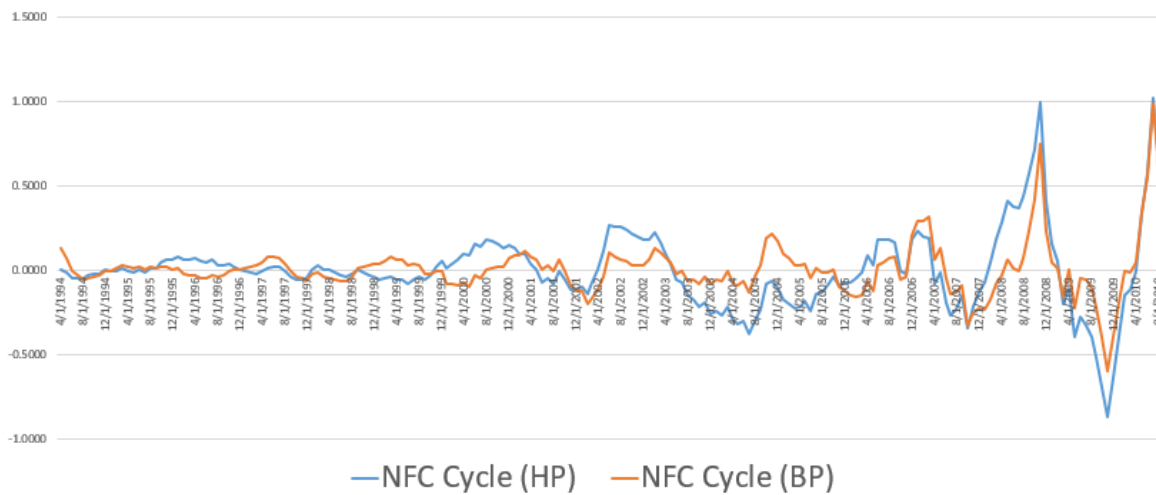
Port Traffic Cycle (88.14%)



M0 Cycle (56.4%)



Non Food Credit Cycle (78.4%)



Commercial Bank Credit Cycle (75.53%)

