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Abridged version of the Report on

A Study into the Cyclical Performance of the New Zealand Construction Industry

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Editor's Note: This abridged version has been prepared to publicise the method and key findings of a study performed for CAENZ under the auspices of BRANZ. With apologies to the authors and their sources, most of the source references and many of the graphs have been left out to conform with the ConstructingNZ newsletter size and format. The full report is available from the CAENZ website.

Executive Summary

This study introduces complexity economics and systems thinking as a methodology and approach to understanding why boom and bust cycles exist in the construction industry. System models have been developed to better understand, not predict, the dynamics of the multiple complex interactions, which range from hard economic data to people's irrational behaviour. During the study there has been extensive consultation with a broad cross-section of industry professionals and practitioners.

There is a broad appreciation of how the overall economic climate impacts the construction industry in New Zealand, but there is little uptake of the economic theories about boom and bust cycles by construction practitioners. There is broad agreement that cycles do exist and that they influence decision makers, but the cause of the cycles is uncertain and varies depending on the industry sector and perspective of the observer. Government spending and policy decisions are seen as a major influence for most participants in this study. Also, it is the rate of change, whether in boom or bust conditions, that cause the problem, not the fact that the industry has good years and bad years.

Generally it is accepted that a rapid upward phase of the cycle causes inflated prices and reduced competition due to full-order books; whilst the downward phase leads to competitive cost cutting, reduced margins and pressure on quality. It is this sort of

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negative self-fulfilling prophecy that should be challenged if the industry is to break free of the most negative aspects of boom and bust cycles.

The study concludes that whilst external shocks will always impact the industry, much of the volatility is caused by internal system factors. Better communication within the supply chain, visibility of future orders, long range planning around resources (particularly skilled workers), and reducing delays in the approval and procurement systems can produce considerable improvements in performance and productivity.

The construction industry is an important bellwether and stimulus for the New Zealand economy. As a result, the construction industry is prone to manipulation by policy makers attempting to influence the domestic economy, often to the detriment of the industry itself. This duality of purpose causes increased uncertainty and volatility in the industry.

The key finding of the study is that the complexity and uncertainty that characterises the New Zealand construction industry demands changes to industry structures and strategic thinking that encourage collaborative learning processes.

Introduction

The aim of this study was to establish and communicate a shared understanding of the key drivers in the boom/bust cycles of the construction industry in New Zealand. This shared understanding would allow for interventions and policy making to be more effective and responsive. It would also inform the industry about what it needs to know in terms of quantitative or qualitative data that would help further explain the interplay and interactions between the industry players, the environment, other industries and government.

The study adopted a systems thinking philosophy, for two main reasons: first, systems approaches are seen by many leading thinkers and research organisations as a more effective way to view complex, interconnected real world problems. Secondly, the construction industry is complex and fragmented, with many different bodies and differing objectives – systems thinking strives to understand the key systemic behaviours and relationships rather than finding an optimal solution.

Interpreting existing knowledge

Brief historical perspective of the New Zealand economy

Since its settlement in the early 19th century, New Zealand's economy has been based on its natural resources. Exports, dominated by pastoral products such as wool, meat, and dairy products, were sold predominantly to UK markets. Incomes rose rapidly, surpassed as late as 1960 by only the United States and Switzerland, prompting waves of migration.

The economy was also marked by a high degree of state intervention.

A cradle-to-grave welfare system was implemented, funded by taxation. Controls were imposed on labour and financial markets while state ownership of industrial and commercial activities was prolific. The result of this extreme protectionism was gross inefficiency. The economy's profound structural weakness was exposed following a succession of shocks in the 1970s. The 1973-74 oil shock exerted huge pressure on macroeconomic balances, but more damaging were the accession of the United Kingdom to the European Community and its adoption of the Common Agricultural Policy, which restricted New Zealand's access to its core export market.

Inflation became entrenched and the budget balance moved deep into the red. Increasing recourse was made to international debt markets to finance both the budget and current-account deficits. By 1984, the economy's chronic macroeconomic imbalances had prompted a collapse of confidence in foreign-exchange markets as New Zealand veered close to a Third World-style debt collapse.

The Labour government that came to power in 1984 implemented one of the most radical reform programmes adopted by an Organisation for Economic Co-operation and Development (OECD) nation. The New Zealand dollar was floated in March 1985, leaving its exchange rate to be determined by supply and demand, and the Reserve Bank granted greater autonomy from the government.

The impact of these macroeconomic and structural reforms was profound. The budget balance moved into large and recurring surpluses. Net external debt was eliminated, reversing New Zealand's former position as one of the largest borrowers in international debt markets.

From the late 1990s, the economy has demonstrated considerable resilience, weathering successive shocks buoyed by robust domestic demand. Through internal structural reforms, the economy appeared, until the latest oil price shocks, to have broken its boom-or-bust cycle to transit to a trajectory of stable, sustainable growth. This has important implications for this study.

A 2007 OECD report warned that despite New Zealand having one of the most flexible and resilient economies in the OECD, large external deficit and very low household savings, combined with strong inflation pressures, are causing uncertain growth patterns. Moreover, despite economic growth since the early 1990s labour productivity growth has been lacklustre. The OECD report suggests the large swings in the New Zealand dollar and high interest rates are two of the key factors affecting productivity.

According to Bollard & Hunt (2008) there have been a number of growth periods in New Zealand since the Second World War, some longer than others, suggesting a trend towards more stability.

They suggest that structural reforms and Reserve Bank policy changes are significant factors in the reduction of volatility in the economy. They do warn, however, that the interconnectedness of global economies can mean that external shocks, such as the recent credit squeeze and oil price rises, can easily and rapidly influence New Zealand economic stability.

The Construction industry and the economy

Whilst there have been several growth periods followed by slowdowns in the economy as a whole, Bollard (1992) identified two significant boom periods for the construction industry; the 'Think Big period' from 1977 until 1982 and the 'Construction Boom' from 1984 until 1987. It can be argued that, since 1992, there has been an additional boom cycle, until 2007, caused primarily by house demand and subsequent price rises, albeit with a slight downturn through the late 1990s.

The Think Big Era

The 'Think Big programme' was initiated by the government of the day, who invested around NZ$6 billion per year through several industry departments. Although the investment programmes created thousands of jobs and supported the local production and processing of energy, it did not bring the 'further accelerator effect' (Bollard, 1992) that one might expect from such investment, and left New Zealand with over NZ$28 billion of debt.

The boom cycle in the construction industry was short-lived. The external environment, in the form of the international oil situation, had a very strong effect on this cycle. The 'Think Big Era' influenced future policy makers away from too much government involvement in a market-dominated industry. As a result we have a systemic loop set up of history-influencing economic evolution and future decision making, which in turn induces cyclical behaviour that then impacts policy and influences policy makers. Indeed, it is striking how similar the current economic crisis is to the 1970s crisis. It is all too easy to blame external conditions in these situations instead of acknowledging the influence of the internal dynamics of the economic/political system.

The Construction Boom

In the mid-1980s the government liberalised the economy and deregulated the financial sector. The subsequent growth of the financial sector coupled with government departmental restructuring increased demand for new office buildings. There were far greater returns on investments in sectors such as construction when the real exchange rate rose. This was a signal to the market to invest in the construction sector, though the key factor that caused the boom was the deregulation policy of the government (Grimmond, 1989).

There then followed a significant downturn in 1987, as stock markets crashed around the world, resulting in rapid retrenchment and over supply of non-residential property in the early 1990s. The estimated amount of 'unnecessary, premature or misdirected construction investment' (Bollard, 1992) was in total over NZ$3 billion. The next two years saw a sharp decline in the number of people employed in the industry.

The Recent Decades

In 1992, the New Zealand Institute of Economic Research forecasted that the contraction of the sector following the two boom periods had taken place and the trough of recession had passed. Despite small fluctuations in 1999 and 2001, there has been a steady growth in the construction sector since 1992 supported by overall building output figures (see Figure 1).

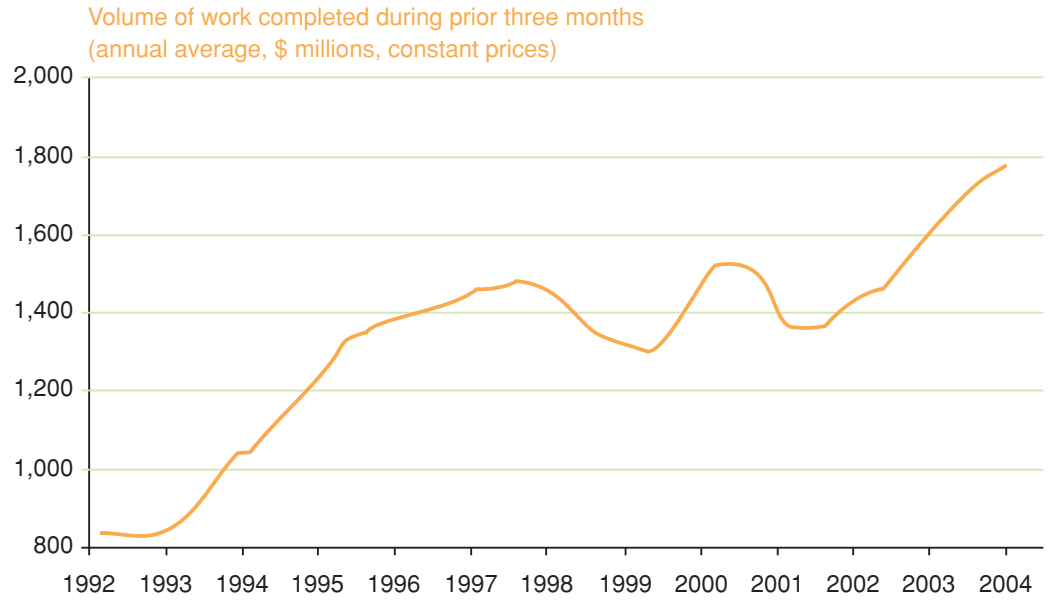


Figure 1: Volume of construction work completed 1992-2004
(Source: Statistics New Zealand)

Evidence from the Reserve Bank (see Figure 2) suggests that construction output closely follows the national GDP cycles, but swings more extremely. In macroeconomics, construction related indices are often used as the economy indicators. Orders for housing, building permits, housing prices and housing starts are all used as key leading indicators of the economy. Also, some indices in the construction industry, such as investment in building, plant construction and orders for engineering output, are key lagging indicators of the economy. In New Zealand at the moment there is a strong correlation between residential construction prices and inflation.

Thus there is a situation where the New Zealand economy is more volatile than its major benchmarking countries and the construction industry is more volatile than other industrial sectors in New Zealand as a whole (Figure 2). The construction industry is more vulnerable to economic fluctuations than other industries so consequently should be acutely aware of the causes and the nature of the cycles in the economy and elsewhere.

Whilst the construction industry represents nearly 5% of the total Gross Domestic Product (GDP) in New Zealand, it influences the economy in other ways. The construction industry in New Zealand has a multiplier effect into other industries. Also, efficiency improvements gained in the construction industry enhance the overall performance of the New Zealand economy, in terms of the national competitiveness.

Construction is often seen as a government economic regulation tool through adjustment of interest rates, public sector expenditure and the system of taxation. Also, government arranges for the construction of infrastructure and other goods regarded as public services, such as roads, water supply or schools. However, government is seen as handicapped by not having adequate methods for assessing the subsequent impact of changes on the industry, on society, or on the environment. Governments are often caught in a difficult position where they are damned if they do make industry interventions and damned if they do not. A clear and consistent strategy regarding infrastructure and policies that influence building and construction would help reduce the impact of cycles, but political cycles tend to work against such aims.

So what is the problem?

Economic cycles are essentially over- and under-shoots of an optimal output level. At a national level this causes waste in the system and loss of productivity due to poor use of resources. For businesses there is added instability and uncertainty in planning, particularly human resources, which causes waste and increased costs.

Purchasers of construction work, including government, constantly seek best value for money and budget certainty from the construction industry. Boom cycles cause inflated prices and reduced competition due to full-order books, whilst recessionary trends lead to competitive cost cutting with a perception of reduced quality. This particularly set of negative outcomes of boom/bust cycles appears to be widely accepted across the construction industry. It is one of those accepted perceptions that can initiate behaviours leading to a self-fulfilling prophecy. Financers of construction lose money – and confidence in the industry – resulting in capital being lost from the industry and a rise in the risk cost of finance.

Business/company managers are distracted from strategic issues in boom and bust phases. On the up phase of the cycle resource issues – spiralling costs, supervision and quality – tend to dominate. On the downward phase of the cycle short-term

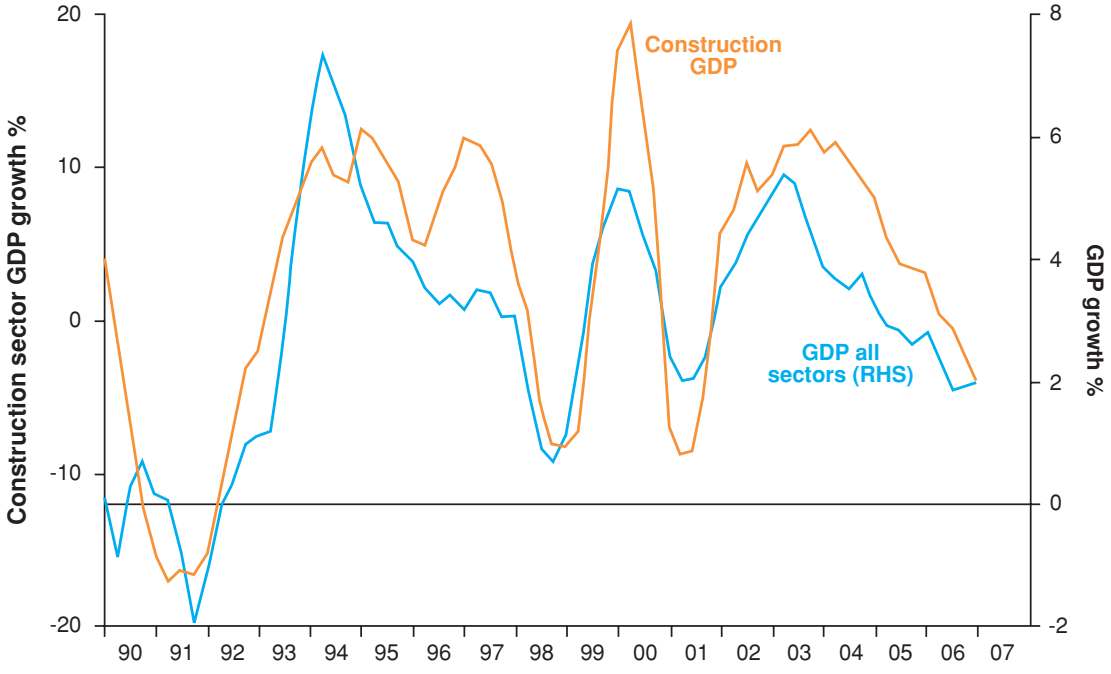


Figure 2: Construction GDP growth compared to national GDP growth (Source: Reserve Bank NZ)

work load issues, cash flow and redundancies tend to take attention away from future planning. Clearly, management will always have distractions from strategic initiatives, but it is the pace of growth or decline that particularly challenges management.

Labour planning, especially retention of trained staff, is particularly difficult in New Zealand with near full employment and net migration effects. The New Zealand construction industry has had a labour turnover rate of over 20% on average over the past 20 years. These figures are considerably higher than other engineering sectors, such as manufacturing at 8% and electronics at 4%, (CIPD, 2007). This in turn raises recruitment and training costs, though it is difficult to attribute all of this to boom and bust cycles.

Employees do face redundancy and uncertain futures as construction demand grows, peaks and falls, which in turn can have a significant impact on the wider economy and social well-being. In 2006, the construction industry directly employed 170,000 people, or about 8% of the total workforce. At least the same numbers again are employed on off-site work in the supply chain.

Whilst the majority of participants in this study considered boom and bust cycles detrimental to business, there are some perceived benefits. Price increases, mainly due to supply and demand, during boom periods provide improved margins even though related input prices mitigate profits. On the downward phase businesses saw opportunities to stream-line operations, shed unproductive labour and generally become leaner.

History suggests that the construction industry is vulnerable to imbalances in the supply and demand relationship. Government interventions with multiple objectives and conflicting aims can produce unintended consequences that exacerbate these imbalances. Moreover, when a tipping point is reached, the re-balance can take place suddenly, resulting in the construction sector (system) over-shooting or under delivering.

What constitutes the construction industry?

It order to understand the behaviour of the construction industry in New Zealand, it is first necessary to describe its boundary, structure and purpose. Unfortunately, there is not a readily accepted definition of the construction industry or where its boundary lies. Some writers consider it as involving only site activity, whilst others include the planning and design functions and even extend it to cover the manufacturing and supply of material and components, finance of projects and management of existing construction items (Myers, 2004).

Government uses definitions for the purpose of taxation and statistics. The New Zealand Standard Industrial Classifications (1993), classifies the construction industry into two general divisions, construction and construction trade services, consisting of 7 groups and 21 classes.

Commercial organisations have different approaches. The management consultancy Deloitte define the segments of the construction industry by the major activities (Deloitte, 2006). Other consultants use supply chain definitions to look at value-added activities. The basic idea of a supply chain approach is to formulate a logical network of related organisations by activities, information and resources that are involved in moving a product or service from supplier to customer. In this sense, energy, mining and logging industries are at the very beginning of the supply chain of the construction industry. Different tiers of suppliers are involved to provide necessary materials to construction companies. Finance, consultancies and other service organisations also play significant value-adding roles. Using the construction supply chain approach involves many different organisations and stakeholders. Furthermore, professional and trade bodies use their own definitions based on their membership interests and needs.

Clearly there are numerous techniques, approaches and taxonomies that could be used to define the construction industry and no one method can claim dominance. However, by taking a holistic, inclusive approach, a systems model of the construction industry can provide insights and a taxonomy that is meaningful from all perspectives (see Figure 3).

There are three major parts of the system model – the industry, the suppliers and the clients. Elements of the system model are connected by the logical consequences of construction processes. Economics, value chain and supply chain approaches, as well as government documents, have been taken into consideration.

Economic cycle theory

Periodic fluctuations in the economy have always attracted the attention of leading economists. The classic theories developed from the various schools are summarised here as key propositions:

1. Economic fluctuations exist with irregular intervals and are becoming fading phenomena in many countries.
2. Recessions are market adjustments to discordances in the economy that result from a failure of society to coordinate and are exacerbated by lags in the system.
3. Due to globalisation, economic cycles are more interconnected with, and relative to, other economies.
4. Cyclical fluctuations in the economy can be controlled or postponed by governments using Keynesian-type interventions.

Perhaps, not surprisingly, there is no real agreement from economists on what causes economic cycles or their frequency. Indeed some argue that the reason why cycles are not regular is that the cycles do not exist and that fluctuations

are caused by unpredicted shocks that do not ever repeat in the future. However, there are some common themes or drivers that seem to influence the system we are interested in:

- the efficiency of resource allocation;
- demand change economics;
- supply change economics;
- technology change and disruption;
- market competition and free trade;
- labour supply and movement;
- wages and how these relate to other factors such as inflation;
- taxation both local and national;
- economies of scale;
- capability of government to control markets;
- price inflation or deflation (stickiness to real change);
- investment failure;
- productivity changes;
- asymmetrical information;
- monetary and fiscal policies;
- externality effects; and
- unforeseen shocks.

However, how these factors relate to and influence each other is uncertain and extremely complex, if not impossible in any meaningful way, to model.

Complexity economics

There are two recognised major shortcomings of economists' analysis of business cycles: firstly, the theories are based on static patterns with historical data. The dynamism of a real economic system is often ignored or over simplified due to data availability and model restraints. The second major issue is the oversimplification of human behaviour in the modelling.

By taking a systems approach it is clear we are dealing with a complex adaptive system whose behaviour is dynamic and non-linear. Firstly, interdependence among various industry players can create multiple types of mutually-dependent behaviour. As a result, industries and firms can become stuck in undesirable steady-states that may include skewed policies or inferior technology choices. Secondly, the consequences of policies will depend critically on the nature of the interdependences. In particular, the effects of different policies may be highly nonlinear, rendering history a poor guide to evaluating future policy effectiveness.

Research (Sterman, 2000) has also shown that people have a very difficult time mentally processing systems with complex feedback, with delays of varying lengths. Indeed, one of the most significant implications of this research is that the only way to mitigate the cycles is to change the structure of the system itself, for example by:

- Reducing the time delays in the system by avoiding over regulation, reducing consent approval times and speeding up the design and procurement process for large projects.
- Having a more modular flexibility, such as developing smaller interrelated projects rather than large inflexible ones and designing using standard modular components.
- Getting more forward and accurate visibility on customer orders. This approach has been quite successful when implemented in the highways sector.
- Increasing the transparency of how much capacity is actually available in the industry versus how much is utilised in existing

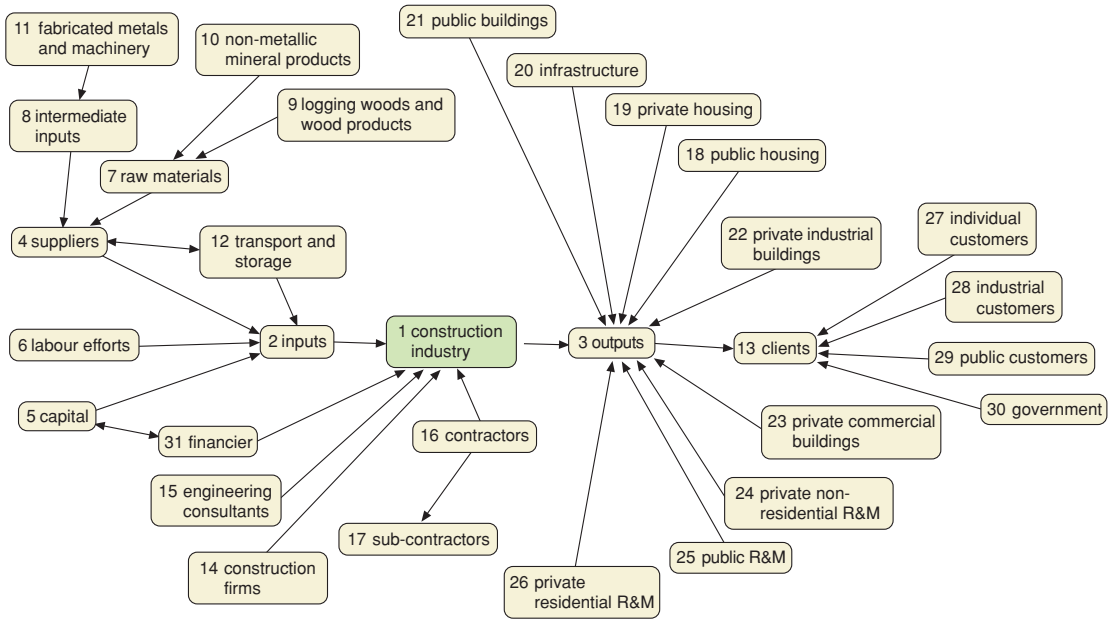


Figure 3: A model of the construction industry inflows and outflows

construction.

- Understanding the impact of the flexibility that exists within the construction industry through staff working more or less time, shifting temporarily into other sectors, and going overseas.

Interconnection of cycles and influencing factors

There appear to be numerous cycles impacting the construction industry; some of small amplitude and period, others resembling long period waves. The challenge is to understand how these interrelate and when peaks concur.

Systems theory suggests that the interfaces or boundary between the sub-systems are important, and are likely to be where key issues emerge and where communication is weakest.

Product lifecycle (PLC) of construction products

Product lifecycles are widely used as a strategic technique to help capture a deeper understanding of the product demand and evolution over time. In outline the lifecycle of a product or service commonly follows key identifiable phases:

- The *beginning*, signalled by innovation and introduction to the market.
- The *growth phase*, typified by rapid development, high profitability and emergence of new competition.
- The *maturity phase*, which occurs as the growth slows and the market becomes more stable, often associated with competitor consolidation.
- Finally the *decline*, caused by market shrinking and company failure, with weak competitors exiting the market. Sometimes innovation and product modification can reinvigorate the market before it goes into decline, which extends the life of the product or service.

The construction industry has two additional and distinct sub-phases within a normal lifecycle curve. The first can be described as the project lifecycle, which starts from initiating a construction plan and ends at handing it over to the users. A large proportion of the construction industry is involved in this cycle. All interested parties are gathered and organised together to deliver the construction product to meet a specific market or client demand.

The second lifecycle can be described as repairing and maintenance (R&M). This phase usually starts well beyond the normal project completion phase and continues throughout the rest of the lifespan of the construction product, rising to a peak as the product reaches the end of its utility.

In summary, the product cycles in the construction industry may be affected by the demands for new construction products and the demands for the R&M of existing products, with a complex lagged relationship between the two.

Local microeconomic cycles

Due to the characteristics of the construction industry, the local economy can influence the construction industry significantly. The construction industry relies heavily on the local economy for providing labour and markets. If the local market is booming, there will be more capital investment, which stimulates the construction industry. Also, the construction multiplier effect means that a booming construction industry can have a very positive influence on the local economy. This mutual dependency can formulate a cycle that is out of step with the overall economy but still dependent on it.

Agricultural cycles

Agricultural cycles might be the most well-known cycles in human history. The idea is based on the growth and harvest of a crop. A lunar cycle could accurately describe the cycle. In longer terms, agriculture, as primary products, is affected by environment changes, such as periodic natural disasters. This would cause fluctuations of outputs.

Construction industries are closely related to the agriculture industry in many aspects, particularly in New Zealand, because:

1. Agricultural fluctuations affect the overall macroeconomic situation.
2. Many construction products directly serve the agriculture industries.
3. Agricultural fluctuations exert huge impacts on peoples' expectations.
4. People are generally optimistic at the beginning of an agricultural cycle (usually springtime) and willing to spend more, whereas people become more pessimistic towards the end of a cycle (harvest and onset of winter) and tend to be more prudent.

Related Industrial cycles

As mentioned earlier, the construction industry is closely related to other industrial and commercial sectors, in that they are major clients and supply most of the materials and products used in the construction industry. If fluctuations occur in either the supply or the demand side of the supply chain, the construction industry will be affected. Inventory cycles or bull-whip effects are likely when there is stock holding in the supply chain such as steel, cement, bricks, etc. Indeed the internal structure of the industry and its supply chain could be a major generator of boom and bust cycles, and certainly likely to make any cycles more pronounced.

Indices/financial market cycles

Stock market indices clearly impact the market value of those companies that are publicly listed on stock exchanges and also those that invest heavily in the market. The companies issuing public shares tend to become the weatherglass of the industry. Their values determine the overall industry investment attractiveness.

Additionally, different indices influence mid- and long-term confidence greatly. A booming market makes people confident, or even overconfident, when investing in fixed assets, such as housing and buildings, which would inject additional financial stimulus into the construction industry.

Political cycles

According to Keynes, a totally free market might not be as desirable as a market with a certain degree of regulation and control. The Keynesian approach is widely adopted by governments, which become an increasingly important regulator and controller of the free market. Beyond conventional monetary and fiscal policies, in terms of interest and tax rates, additional market measures can be introduced such as infrastructure building, public purchasing, PPPs (Public Private Partnerships) and PFIs (Private Finance Initiatives).

If a government changes, or even the leader of a party changes, many of the policies change or lose focus and the construction industry will then be impacted. As most OECD countries, including New Zealand, have a maximum term before general elections are held, there is an inbuilt cyclical disturbance that significantly impacts and influences any cycles in the construction industry.

Social/cultural/psychological cycles

In economic terms, people are important on both the supply and demand sides of an economy system. However, people are also unpredictable agents of society itself and sociologists observe patterns such as our propensity to herd, which has been credited as the cause of many stock market bubbles and crashes.

There are established social and cultural factors influencing peoples' behaviour, which can in turn influence purchasing and investment patterns, employment trends and even population. Different generations have different social behaviours and perceptions and expectations appear critical to the understanding of peoples' behaviour and their role in cyclical trends.

Development pattern cycles

Construction is relatively capital-intensive. In OECD countries, 15% to 26% of the total GDP is invested as fixed capital and construction takes up half of that amount. In other words, up to 7% to 13% of GDP may be spent in construction investment.

New Zealand's percentage of GDP spent on construction has historically been low compared to other OECD countries, particularly in infrastructure. By implication, New Zealand is a highly developed country or has been under-investing in key infrastructure for a number of years.

Investment in construction by Governments, particularly in infrastructure, tends to be cyclical. This is partially due to governments realising that they have underinvested and then playing catch up with large programmes of expenditure. This often coincides with political cycles and Keynesian policies as discussed earlier.

Environment cycles (Forrester Cycles)

Environmental issues have become more and more crucial in making long-term decisions. Global warming and climate change is already impacting both positively and negatively on individual firms in the construction industry, and the aggregate effect of this is unclear. Also, with the increased impact of natural disasters, there are new challenges and opportunities for the construction industry. In this sense, the construction industry is already experiencing the effects of environment change, but the nature and duration of the fluctuation is uncertain.

Summary of key influencing cycles and stakeholders

The key stakeholder groups have been mapped onto the different cycles to show their level of influence as shown in Figure 4. The magnitude indicates the impact of the cycle and the time implies how long it would take to impact the construction industry.

In practice the whole system can be interacting, causing considerable turbulence, so that one additional shock, unless very large, can get lost in the confusion. Ironically, a large shock in the system can provide a degree of perceived clarity. The challenge from a systems perspective is to seek the key drivers or patterns in the system.

Conclusion of the review of existing knowledge

There is some evidence that there has been underinvestment in New Zealand construction and infrastructure over a number of years, yet this does not necessarily mean that it has or will induce cyclical behaviour. Most systems, including the construction industry, tend to have self-balancing forces and behaviours which limit peaks and troughs.

However, sometimes situations can cause positive, self-reinforcing loops to occur that create run-away exponential growth or decline. Dot.com boom and sub-prime collapse are examples of each, and these are nearly always caused by behaviours driven by greed or fear. Both can be damaging to economies and industries and need to be better understood.

There does appear to be a lack of good quality information that is shared and clearly understood across the industry. Systems dynamics theory suggest that any delays in information that causes a delay in reaction to sub-optimal performance will tend to cause oscillations in output. One of the best ways to avoid cyclical behaviour is to have timely information and, where possible, have lead indicators.

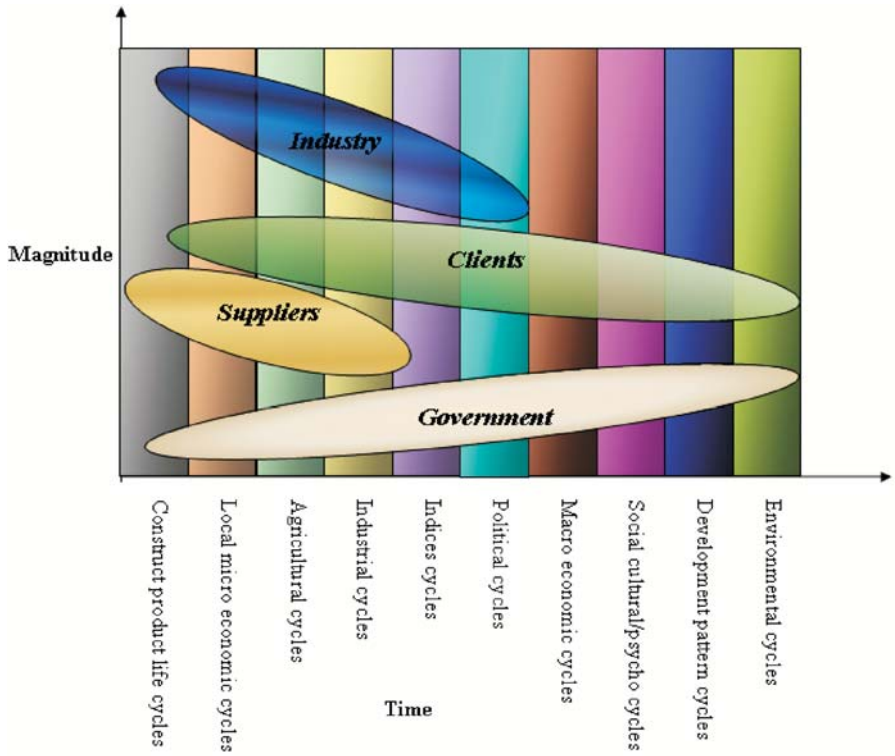


Figure 4: Different cycles related to key stakeholder groups

Participative phase

Engagement was sought with key stakeholder groups to try to understand the system behaviour and key indicators that are required to better predict and understand the whole construction cyclical system. This was achieved through a series of interviews and workshops and generally followed a soft systems approach. The lists of organisations participating in the interviews and workshops are shown on page 14.

This part of the study was essentially an action research project; a participative process that seeks to understand through a series of interactions and testing with the stakeholders and subject matter. The key element of the action research phase of this study consisted of 14 face-to-face interviews with senior executives from a range of stakeholder organisations.

The conceptual development of the qualitative research process was based on Grounded Theory, a research method in which the theory is developed from the data, rather than the converse Blockley et al, 1991). It is therefore an inductive approach, and its direction moves from the specific to the more general. Data collection and analysis were consciously combined, and initial data analysis used to shape continuing data collection.

The study employed a piece of qualitative analysis software called Decision Explorer, to map the connections between the codes or concepts and to analysis the presence of loops and key nodes.

Personal Construct Theory was used to underpin the hypothesis that experience and perception heavily influence the decision-making process of senior managers regarding key issues such as how to react to good or bad news. Concept mapping (Eden, 1994) was also used to analyse and understand some of the interactions and emerging issues from the case studies in the interviews.

In practice all of the techniques were used together as they complement each other and are intended to give a rich picture of the evidence and data, whilst at the same time search for new and original meaning.

Interviews

A semi-structured interview approach was used where the researcher and interviewee worked from a predetermined set of questions. The questions acted only as a guide and were not intended to restrict the direction and depth of the interaction. The questions were sent to interviewees beforehand.

Workshops

Half-day workshops were held in Auckland and Wellington to elicit feedback from key industry representatives. A presentation was made of preliminary findings to the participants and then a discussion was initiated and recorded about the problem definition, usefulness, ability to influence decision makers and future focus for the study. The list of organisations participating in the workshops appears at the end of this document.

Defining the system boundary

One of the first and hardest tasks was to define the boundary of the system under consideration. This was done after the interviews and

clarification of the problem under consideration. What is important here is what is inside the boundary (things we must consider), outside the boundary (potential influences we need to be aware of), and what is excluded from the study (those things that are beyond our scope and control for the sake of the model). These delineations are important and the variables shown in Table 1 below have arisen from the interviews and workshops.

Outputs from one phase to the next

It became clear that there are three distinct sub-systems that interrelate in the New Zealand construction industry system: private house building, infrastructure/public sector building and commercial building. There are other ways of arranging the system, but this evolved as the most natural structure:

1. Private house building – dominated by smaller players, customer orientated, reacts quite quickly to market forces, has little shared information and is quite volatile in comparison to the other sectors. The cycles seem to be shorter and more pronounced. Key issues are population, particularly immigration, availability of skilled workers, and the level of government intervention (central and local) and regulation.
2. Infrastructure and public sector buildings – dominated by government spending on large one-off projects, relatively knowledgeable clients, players in this sector tend to be larger. Generally better sharing of information mainly due to government involvement. Long lead times in planning, which appears to cause longer, flatter, more predictable cycles, can, however, become out of phase with the economic cycles. This can have an impact on funding and security of long-term contracts. Issues are continuity and availability of workforce.
3. Commercial buildings – which partially straddles both sectors above – is characterised by higher than average margins associated with innovation and entrepreneurship, volatility due to relatively low barriers to entry, close connection to macro-economic trends, a mixture of clients with varying degrees of knowledge, high expectations and quick return required on investments.

The interconnectivity of the issues in each sector was represented in three concept maps, showing the mental construct of each sector. This was a first step towards developing system dynamic models (SDM) for the three construction industry sectors.

Intermediate Causal maps

In the next step, intermediate causal maps were constructed for each of the three sectors (private house building, infrastructure and public, and commercial construction). The factors affecting each sector were inter-related to look at causal links to try and provide an understanding of how the full SDM would be constructed. It was important that the logic and key loops were identified, both +ve reinforcing and –ve balancing loops. Thus, the dynamic interactions and feedback loops were beginning to get established. However, at this stage we were not trying to establish the nature of the variable relationship, but only whether one would tend to increase or decrease the other variables.

The causal maps are shown in the unabridged Report.

System Dynamics Models

The system dynamic modelling approach used

Inside the boundary	Outside the boundary	Excluded
GDP	Population	Internal trade
Building sector starts	Technological change	Industrial suppliers
Infrastructure spend	Tax rates	Product cycles
Infrastructure maintenance	Oil prices	Local economies
Inflation rate	Exchange rates	Agriculture cycles
Interest rate	Market cycles	
Employment	Political cycles	
Unemployment	Macro cycles	
Investment	Local cycles (Auckland)	
Housing stock	Clients	
Building sector cycles	Government procurement	
Commercial sector cycles	Environmental Issues	
Infrastructure/civil	Government regulation	
Industrial cycles	Gov. spend decisions	
	Gov. immigration policy	

Table 1: Defining the boundaries

in this study was the Vensim model (Sterman, 2000). The model expresses how the system behaves and they can be animated – mathematically simulated – so that their evolution and their behaviour can be observed. This provides an immediate method of generating hypotheses that can be tested against the real world system in subsequent studies. One of the useful properties of a system dynamics model is that it provides an immediate test for behaviours that are at variance with general observations. It should be stressed that the models in this exercise are only approximations and that a number of assumptions about the relationships between variables have been estimated, due to lack of correlated data. Wherever possible the relationship variables have been estimated from data or from accepted theory. Fully tested and validated models are beyond the scope of the study.

Generally these are not predictive models but aim to give insights into the system behaviour that would have been difficult to foresee. The key elements of the models are stocks – represented by squares, flows represented by valves, and variables and arrows indicating the direction of the flow. Whilst we describe the basic elements of each of the models, the full discussion of those elements and all three models are shown in the full report. The only model shown in this abridged version is that of the Infrastructure and Public Construction sector.

The model for the private house building sector

The system dynamic model of the private house building sector is composed of interconnected subsystems, including the industry sector, inflation, population, market demand & national account). Different systems are connected by the tangible flows, such as material and money exchanges, and intangible flows, i.e. confidence fluctuations.

The principal variables considered included:

- the construction industry structure;
- inflation;
- population and its effect on demand;
- market demand, and
- the overall economy.

Implications from the dynamic modelling of the private housing market:

1. The inflation rate shapes the overall system.

   When changing the basic inflation rate, turbulent oscillations can be observed in most parts of the model.

2. Setting the house price high does not necessarily guarantee a steady growth.

   Initial house price is a key variable to control the housing system. Increasing the initial house price and the fluctuation in the overall system is significant. At a certain price tipping point, the system goes into an exponential decline, even before the end of the simulation process.

3. The housing market cannot grow indefinitely.

   The curve of the housing sector's revenue has a trend to regress beyond a certain range, no matter how the other variables are manipulated.

4. Being too responsive to market change may not be helpful in managing fluctuations.

   If the decision delay in making prices is shortened, the fluctuations become very significant.

The system dynamic model for infrastructure and public buildings sector

This model simulates the public building sector from four aspects, including the construction industry, the government, other industries and the people in New Zealand. The resulting model is shown on page 15 (all models are presented in the full report).

Implications from modelling the infrastructure and public construction sector:

1. An increase in expected government spending has a great impact on both construction industry and the macro economy.

   Given that other variables remain unchanged, the spending tendency variable, which is an expectation variable, for government spending changes from current levels to a higher level, the GDP and construction industry's revenue rise accordingly. When the spending tendency is much higher, significant disturbances and fluctuations occur. At very high rates the trend is for the economy to go into decline.

2. The delay in public projects is a cause of fluctuations.

   Given other variables unchanged, if the decision delays (in whatever form) are increased, greater fluctuations will appear in the revenues of construction industry. Conversely, quicker decision making smooths the fluctuations.

3. Retaining people in New Zealand is crucial.

   When the leaving ratio of people increases, the revenue of the construction industry drops and fluctuations appear across the system. Or, more likely, as the population increases the industry may become more stable with increased revenues.

4. Controlling costs of public buildings is a good way to smooth cycles.

   When initial unit costs for public projects are raised, the disturbances in the system tend to be more turbulent.

5. A policy of not selecting the lowest tender price for public construction projects, particularly in the downward part of the cycle, can help the industry smooth the fluctuations and increase the revenues in the long run.

When the mark-up is raised, significant turbulences during the starting period of the revenue curve are smoothed. In a longer term, the overall revenue of the industry increases. Moreover, the GDP income and national wealth reserve increases accordingly.

6. Inflation rate shapes the boom/bust symptoms.

   When the inflation rate stays low, i.e. in the current range between 1.8%-3% per year, the fluctuations appear in the initial part of the revenue curve. When the inflation rate increases, the whole revenue curve oscillates. If the inflation rate reaches a very high level, say 20% per year, the revenue curve shows very chaotic fluctuation behaviour.

The model for the commercial building sector

The system dynamic model for the commercial building sector is primarily composed of three subsystems, including the industry sector, the financial environment (costs and inflation), and the macro economy system (population and the national account). The aim of this industry sector is to meet the demand from other industries by providing construction products and services.

Implications from the modelling of the commercial sector:

1. Delivery rate is crucial for managing boom/bust cycles.

   Delivery rate is measured by the delivery time. A shorter time indicates a higher deliver rate. When the delivery time is short, fluctuations will be quite concentrated at the initial part of the revenue curve. This might be merely an inherent overshoot of the system model itself, which has no implication to reality. When the delivery time is prolonged, significant fluctuations appear and the interval of fluctuations increases as well.

2. Cost is a key factor influencing the boom/bust cycle.

   When other variables are fixed, the increase of initial costs of the unit costs for commercial buildings will amplify the fluctuations, in terms of scale and duration.

3. The influence of interest rate is not as significant as expected.

   When the interest rate is varied, the revenue curve of the construction industry barely moves (this could, however, be due to a modelling anomaly).

4. Continuing to attract more people to New Zealand may smooth the fluctuations.

   When the variables related to population are changed, for example, increasing the constant level of immigration, the building demand curve is smoothed. This is similar to the effect in the private housing market model.

5. The overall commercial building demand will reach an equilibrium point.

   The simulation shows no matter how the variables change, a final steady state of the commercial building sector should be reached. This is unusual in such a SD model.

6. People's perspective is important.

   People's perspective on the future of the economy is largely determined by the time delay function. This can change the revenues of the construction industry quite dramatically.

The challenge then is to combine the system maps (or SDMs) and findings into a set of key drivers that represent the complexity of the interrelatedness of the different cycles within the whole system. The usefulness will be partially dependent on the availability of good data to input into the model, which itself appears to be a common issue for the industry, but also how understandable it is. As mentioned in the report, most people have great difficulty in integrating more than two or three dynamic variables.

Summary & Recommendations

The economic system is probably one of the most complex systems ever developed by humans. Boom-bust cycles are the emergent property from that complex adaptive system and are generally unwanted as they create waste in the system. It is unlikely that there is a reliable predictive tool for the construction industry in New Zealand to manage these cycles. However, this study has demonstrated that a systems approach is a helpful way to understand and model the root behaviours and patterns that emerge from complex systems, such as the New Zealand construction industry.

Summary of the key points

- The construction sector is an important contributor to the New Zealand economy. The health of the industry is a bellwether of the state of the New Zealand economy.
- Much of the construction industry boom/bust effects are caused by internal system structure rather than external shocks.
- The industry in its totality is characterised by complex and often ill-defined supply chain relationships. These are wider and more dynamic than most in the industry recognise or understand.
- This uncertainty, often fuelled by misconceptions and shocks to the supply chain, can lead to a 'bullwhip effect', leading to undesired outcomes.
- There are multiple levels of interdependencies of stakeholders in the industry, including government.
- The housing industry dynamics are more independent of the construction industry overall than other sectors.
- The so-called 'reinforcing loops' dominate all sectors of the industry, but are more prevalent

in the domestic housing sector.

- These loops can cause highly non-linear behaviour, rendering history a poor predictor.
- Things will need to be done differently if the industry wishes to ensure its long-tern profitability and sustainability.
- The analysis undertaken in this study suggests a way forward that embraces shared learning and greater collaborative working.

Key Recommendations

The key motivation for action should be based on the finding that much of the construction industry boom bust effect in New Zealand is actually caused by the industry's own internal system structure and behaviour rather than external shocks.

This means that the way forward requires the industry and policy makers to adopt new thinking that:

- Recognises how co-dependencies and industry dynamics drive behaviours and profitability.
- Utilises systems thinking to understand the perceptions and related behavioural aspects that create damaging self-reinforcing loops and bullwhip effects.
- Establishes sector level indicators of conditions that encourage boom bust type cycles rather than using broad economic data.
- Adopts structures and cultures that reinforce communication and information sharing throughout the industry, particularly across industry sectors.
- Encourages long-term strategic thinking instead of short-term profit seeking and speculation.

The systemic behaviours behind the drivers of boom/bust cycles are well ingrained in the culture of society and will be slow as well as difficult to change. However, in the short-term the construction industry could smooth the peaks and troughs of the cycles to a large extent by adopting some or all of the recommendations below:

1. Government and large organisations should minimise delays in their procurement processes and make the progress of construction projects forward thinking and transparent to the rest of the supply chain.
2. Delays in initiating Government approved and funded projects should be reduced. Procuring faster, smaller projects rather than rolling projects together would help the industry as a whole, despite the advantages to individual stakeholders.
3. Setting up a construction industry alliance to share information across the entire supply chain and to champion the change in thinking described above.
    a. A similar approach to that of TransitNZ could be adopted, which appears to work well in providing efficiencies and continuity of work in the highway sector.
    b. It is recognised however, that there exists a plethora of industry associations, professional bodies and interest groups. A new group or body could easily get lost amongst the other initiatives. The new alliance must not look after individual member interests, but rather be charged with looking after the health of the industry as a whole.
    c. Whilst government should be a key stakeholder in such an alliance it must be owned by the whole industry and directed by a small yet representative group. Recommendations from the alliance should be acted upon by industry and government bodies at the highest level.
    d. At a practical level government should provide significant funding for the alliance set up and functioning with matched funding from industry contributions,
    e. Government and industry sectors will need to supply good quality, regular information about workloads, prices, delays, etc. Some funding may be necessary to initially set up these information and monitoring systems.
4. The simple fixed price competitive tender model (which the probity rules of some government agencies demand) does not fit with maintaining a holistic view of the industry and should be replaced with a value-added contractual approach. Fixed-price competitive tenders are only really appropriate for higher volume contracting where there are standard designs and many competitors, for example the housing market.
5. Retaining and training skilled and semi-skilled workers is critical to controlling the worst effect of the fluctuations. Employment conditions need to become more attractive and internationally competitive.
6. Government should refrain from using construction as a blunt economic tool to control inflation and unemployment without fully understanding the systemic implications and dynamic affects it may induce.
7. Application of good cost estimating and cost control throughout the industry with particular attention given to inflationary rises and methods for accounting for this.
8. The commercial building sector appears to quickly reach a tipping point due to over investment, which produces very turbulent conditions across the industry as a result. Some form of self-regulation needs to be exercised in this sector to avoid inexperienced, speculative investors over stimulating the whole industry. The result is a rapid loss of capital from the industry which then takes years to return.
9. Simple systems simulation software should

be developed as an education toolkit and freely distributed to training departments, professional bodies and universities. (There are numerous software products available that could be bought cheaply and adapted to a New Zealand context).

10. Inflation is clearly a key factor in shaping the underlying construction system but more research into this relationship is important. Also, requiring more research is what impacts people's decisions about the economy that then shapes their behaviours despite contradictory evidence.

References

Blockley, D, Turner B and Pidgeon, N, 1991. "The use of grounded theory for conceptual analysis in knowledge elicitation", *International Journal of Man-Machine Studies*, 35(2): 151-173.

Bollard, A E and Hunt, C, 2008. *Coping with Shocks – a New Zealand Perspective*, address to the Canterbury Employers' Chamber of Commerce, January 2008.

Bollard, A E, 1992. *The Impact of Economic Changes on the Construction Sector*, The New Zealand Institute of Economic Research (NZIER), Wellington

CIPD, 2007. *Annual Survey Report 2007*, Chartered Institute of Personnel Directors, UK

Deloitte, 2006. *2005-2015 Construction Demand/Capacity Study*, Full Report. O. o. G. Commerce.

Eden, C, 1994. "Cognitive mapping and problem structuring for systems dynamics model building", *Systems Dynamics Review*.

Grimmond, D, 1989. *Investment, Growth and Public Policy*, Working Paper 89/27, Institute of Economic Research, New Zealand

Kelly, G A, 1955. *The Psychology of Personal Constructs*, Norton, New York.

Myers, D, 2004. *Construction Economics – A New Approach*, Spon Press, New York.

OECD, April 2007. *Economic Surveys: New Zealand*, Organisation for Economic Co-operation and Development.

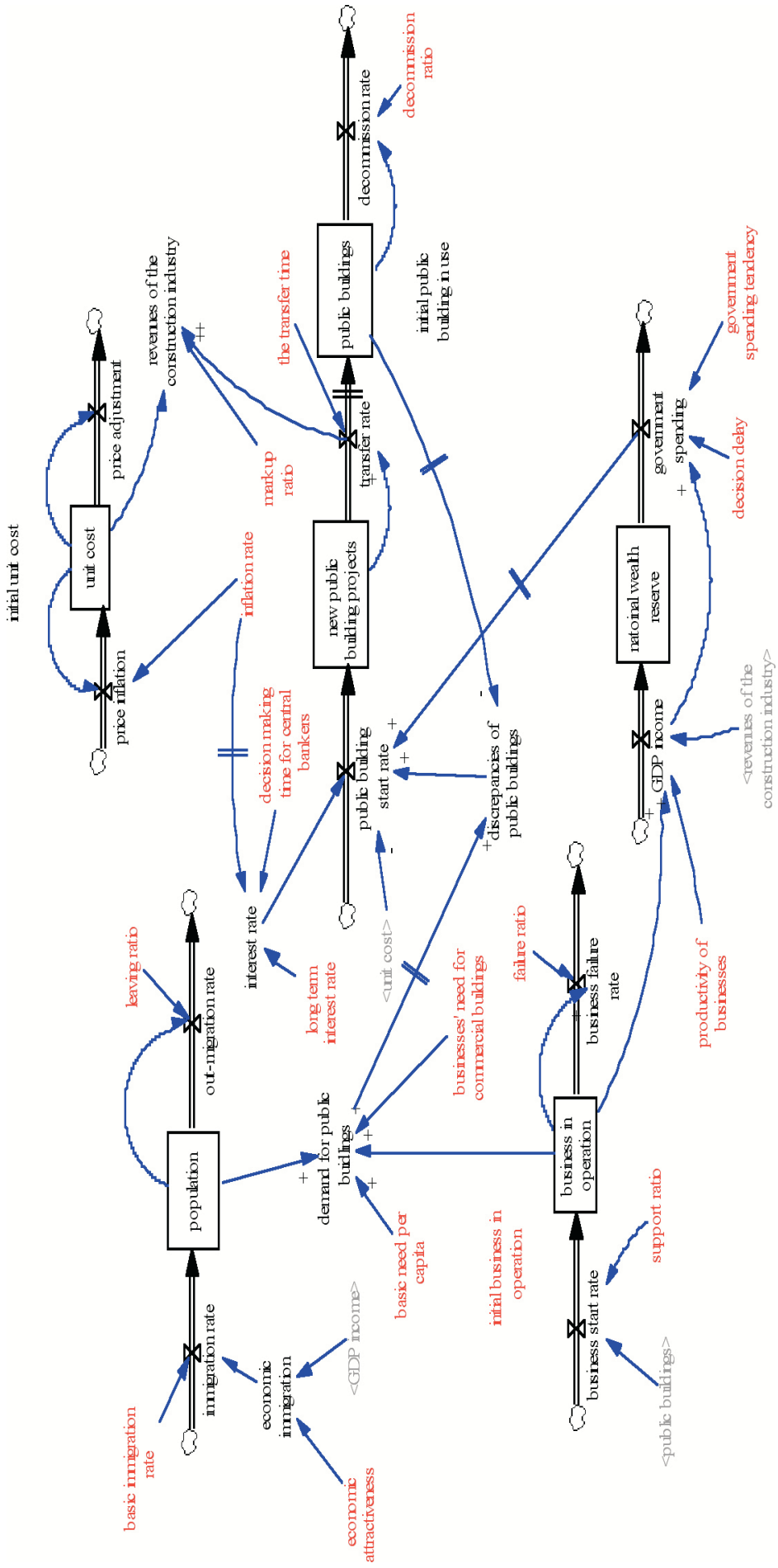
Sterman, J D, 2000. *Business Dynamics: Systems Thinking and Modelling for a Complex World*, Irwin McGraw-Hill, Boston.

Interviewee's Affiliation	Description
Construction Clients Group	An industry association
CAENZ	New Zealand Centre for Advanced Engineering
Opus	Consultants engaged in asset management and infrastructure design
Arrow International	Commercial design & build company
ACENZ	Association of Consulting Engineers New Zealand
Stonewood Homes	A leading house designer and builder
Amalgamated Workers Union (North)	The main construction industry union representative
Primesite Homes	A leading house designer and builder
Roading NZ	A highway industry association
NZStrong	A leading structural designer and contractor
Fletcher Construction	A leading civil engineering contractor
Fulton Hogan	A leading contractor
Canterbury University	Department of Civil Engineering
Gibson Consultants	A specialist consultant
Master Builders Federation	An industry association

Table 2: Interviewees' affiliation

Roading NZ	Registered Master Building Federation
BCITO	Wellington City Council
Property Institute	BRANZ
Building Research	Mainzeal
Arrow International	Subcontractors Federation
Beca	Winstone Wallboards Ltd.
Goodmans	HERA
Association Wall & Ceiling Industries Inc.	Project Roofing
Designers Institute of NZ	

Table 3: Organisations taking part in the interviews



Sample Model: System dynamic model for infrastructure and public construction
(all models are presented in the full report)

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