Potential application of industrial housebuilding techniques to the Ugandan construction industry

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List of Abbreviations

LRAC – Long Run Average Cost

SRAC – Short Run Average Cost

OPC – Ordinary Portland Cement

QS – Quantity Surveyor

TC – Total Cost

Q – Output

C – Cost

Abstract

This report is concerned with the application of industrial housebuilding techniques in Uganda. A series of contractors and providers of services to the construction industry are interviewed in the U.K. and Uganda to examine what economic conditions are required for the successful attainment of economies of scale in prefabrication. The Ugandan economy is then analysed for its' suitability, and conclusions are drawn regarding the applicability of prefabrication in Uganda.

Key words

Traditional, housebuilding, Industrial, Prefabrication, Uganda,

Word Count

11,027

Chapter 1

Introduction

What is Prefabrication?

The construction industry has long been criticised for its lack of innovation – specifically in light of the fact that for centuries the manufacturing industry has been making huge strides towards improving efficiency and productivity in its operations, and diversity and innovation in its products – while the construction industry is still by and large steeped in age old practices, and – perhaps stereotypically - characterised by a failure to deliver client value. The reasons for such a difference are myriad and complex; but are broadly based around three major idiosyncrasies of construction (Warszawski 1999);

- Lack of centralised production – i.e. each product is produced in a different location and therefore requires a slightly customised production process with almost exclusive use of most inputs.

- Lack of standardisation; each product is slightly unique. If according to Adam Smith the division of labour is limited by the extent of the market, and the market for each construction product is exceptionally small – there has been virtually no opportunity for construction operations to specialise and improve their productivity.

- Shortage of mass production. A high numerical output is necessary for the adaptation and improvement of the production process.

There has however, been a recognition of the fact that there need not be such major differences between the two industries, that aspects of the manufacturing process can be incorporated into construction (POST 2003); that is to say, the predictability and control of a factory environment, the repetition of work processes, and the advantages offered by large scale production of components, are all benefits which are available to the construction industry. The essence of prefabrication therefore is that insofar as possible, building components should be manufactured in a factory environment, transported to site, and assembled in a well planned and organised fashion.

Obviously the choice of degree of prefabrication will depend on the social and economic conditions as will be discussed shortly. It is widely believed that the economy of prefabrication depends very much on the scale of output – i.e. that as production volume rises, the fixed costs of fabrication will be progressively absorbed by the number of units produced - leading to lower unit costs. In practice however it may be that there are local and regional constraints to the economies of certain production technologies, and therefore average cost might possibly increase over a range of output.

Aims and Objectives of study

The aim of this report is to examine the production conditions in Kampala so as to facilitate a better decision to be made regarding the production choice between industrialised and traditional housebuilding. This will be done by examining the average cost of production at different scales of output and including projections on the effect of time (changing market conditions).

Present construction techniques in Uganda are remarkably uniform; virtually all works consisting of concrete block walls with cast in situ concrete beams, columns, and floors. Thus far most attempts at incorporating prefabrication into Ugandan construction have failed. In contrast there are signs of growing success for such methods in South Asia and important lessons from the West – in particular America. The question then arises; under what circumstances can Ugandan construction make use of such an innovation? This project therefore serves to facilitate the decision making of construction firms regarding the technology to be adopted by uncovering the precise supply-side conditions facing the costs of a housing project in Kampala, so as to enable empirically supported decisions to be made regarding construction techniques. The analysis will consider the conditions requisite for a viable application of industrial housebuilding techniques to large scale housing projects by accounting for the costs of traditional housebuilding projects and analysing the conditions of production, and subsequently producing and comparing Long Run Average Cost Curves for both techniques.

Conceptual Framework

A literature review uncovers the economic theory in terms of the technology and practices of prefabrication and the cost structure of construction firms. Research is then conducted along the supply chain of construction in Kampala to fill gaps in the microeconomic theory such as will allow it to be applied to local conditions. Using the framework uncovered in the literature review the data and theory will be analysed and discussed.

Research method

Housebuilders in Kampala with various levels of fixed costs are interviewed so as to ascertain the relationship between construction costs and output – this enables us to establish what causes limitations to the scale of production in Kampala construction. The interviews are structured to establish what the limitations are at each scale of production. The interviewees are asked about the breakdown of construction costs for a traditional cheap housing project as follows:

- Materials
- Labour
- Equipment, tools and plant
- Site management
- Overheads

Supernormal and subnormal profits are not considered a cost of production and are therefore excluded. Discussions with the interviewee then follow to elaborate on the limitations of each input and the experiences of the construction process at their particular scale of production (see appendix for full interviews). These discussions are used to build on the literature review and construct a LRAC curve for traditional housebuilding, and postulate an LRAC for industrial housebuilding. At the heart of any discussion on the LRAC of production is an understanding of how average cost is affected by scale of production. This relationship will be used to draw the LRAC for traditional housebuilding, and combined with an analysis of the surrounding economic conditions will be used to determine the LRAC of industrial housebuilding. The long run analysis will also consider the effect of industrial organisation – as the industry grows the fragmentation of the industry is likely to change, this will affect the cost of production.

Chapter 2 - Prefabrication theory

This chapter will examine the theory behind prefabrication production in terms of the type of output, the industrial organisation, the use of materials, and the production methods - so as to establish what the implications are for the application of such techniques in Kampala.

Buildings can be prefabricated to various extents; Alistair Gibb (Gibb 2001) classifies 4 – degrees of standardisation in building:

- Component manufacture - Practiced in almost all construction projects, this simply defines the incorporation of manufactured doors, windows, and fittings into the building.

- Non-volumetric pre-assembly - The incorporation of assembly components such as walls, slabs and other structural sections.

- Volumetric pre-assembly - Components that enclose usable space but are not complete habitation units, toilet pods and lift shafts for example.

- Modular Building - Similar to volumetric pre-assembly but where the components form the main structural function as well.

Non-volumetric pre-assembly is a fairly versatile method of prefabrication in that certain standard components can be used in a variety of housing projects or building types. This method of prefabrication is therefore suited to an industry where the economy depends on the ability of the product to be used in numerous different projects (Ibid). To a certain extent volumetric and modular sections can also be designed as generic units – but it is more common for these to be custom designed since they place major limitations on the flexibility of the finished building (Ibid). Such a high degree of prefabrication is better suited to conditions where site operations must be kept to a minimum for space or complexity reasons, or to an industry where there is a large degree of specialisation. The various industrial organisation arrangements that are formed to suit the characteristics of the market are now discussed.

The industrial organisation

The industrialisation of construction using concrete requires changes to all three phases of the construction process; design, manufacture, and assembly. The key difference is that in industrialised construction, manufacture is the most critical stage; rather than assembly. Because all three stages are closely linked however, it is important to examine the relationships between them.

There are broadly three relationships between the design and manufacture of precast concrete elements (Warszawski 1999):

1. Architect design based entirely on client preferences

This is a very specific design which is unsuited to small prefabrication industries.

2. Manufacturers design to suit project/client requirements

This represents a reduced need for external design, and greater scope for economies of scale using standard components.

3. Design and manufacture based on industry-wide standardised parameters

This arrangement is ideal for a developing country with a strong central government involvement in the production of mass housing.

There are a few critical drawbacks to the adoption of a total industry wide standard however; firstly the severe shortage of flexibility – the thickness of a traditionally cast floor slab for example, is designed to optimise the use of material and is based on considerations of span, load, and performance. The thickness and weight of the floor slab might affect the height and width of its supporting walls, therefore altering the arrangement of the structure. Standard specification components therefore are not very flexible, nor do they represent the most economical use of materials. The saving however lies in the reduced need for design and assembly effort (Ibid); this is of particular value for the case of housing projects in Kampala (where the prefabrication industry is far from mature) - a set of structural parameters can be determined around which houses are designed to use standard components.

Materials of prefabrication

Broadly there are three structural materials in use in building; concrete, timber, and steel. A steel framed building is a prime example of prefabrication, since steel beams and columns are never formed on-site; they are simply bolted together. More extensive forms of prefabrication using steel are rare, since steel alone is not an ideal material for floors and walls, and is difficult to mould into suitable shapes. Additionally in hot climates steel structures are highly uncomfortable due to their high thermal conductivity (ibid).

Timber is used extensively in North-America and Japan as a component in building small individual homes. Panels and floors are easily constructed out of timber – the major advantages of using timber are weight and workability; timber panels can be relatively easily transported and erected, as well as formed into various sizes and dimensions (CIRIA 1996). Regarding structural strength, an entirely timber structure is seldom suitable for buildings greater than 3/4 storeys however (Ibid). Nations such as Uganda with abundant forestry reserves or large sustainable timber farms are at an advantage regarding supply. The disadvantages of timber construction however are significant – the longevity of timber structures is challenged by local factors such as termites, and heavy rainfall. There are often significant apprehensions among the local population in many countries regarding the structural quality of timber homes (Warszawski 1999).

Concrete is used in abundance largely because of its strength and workability. It is often cast into floor slabs for multi-storey buildings, although it is also used to form walls, staircases and other sections which are simply lifted into place by crane (Ibid).
Also concrete has been used as a hybrid form of prefabrication for many decades in what is known as 'brick and block;' Long concrete beams are formed and placed such that standard building blocks can be slotted in-between forming a complete floor/roof (Mwamila et al 1999).
Because of its versatility, durability, and availability in Uganda, concrete will be chosen as the material for analysis for this research.

Concrete in prefabrication

The major components of concrete are cement, aggregates, reinforcement steel, and water. Various combinations and arrangements of these materials are used to attain specified performance characteristics. For example, the production of a floor slab is dependent upon the imposed load, desired span, and depth limitations. In warehouses and other such spaces it is possible to use T-shaped reinforced prestressed beams up to 1200mm in depth to serve spans of up to 30m (Warszawski 1999). In conventional housebuilding however, it is sufficient to use ordinary prestressed hollow core slabs for spans up to 20m, and solid slabs for spans of up to 7m(Ibid). The advantage of using prestressed slabs lies in the additional strength which allows for a saving of materials and a thinner slab. It is satisfactory to use Ordinary Portland Cement for the production of most precast components, since it attains a 28-day strength of between 20 and 40MPa depending on the mix(Ibid). Large spans where the strength may need to be 50 or 60 MPa may require the use of high strength Portland cement, it is unlikely however that these will be necessary in small houses – which are the subject of this paper.

Ordinary Portland cement (available locally in Uganda) of specification C42.5 displays a 2-day strength of 19.8 MPa, and a 28-day strength of 49.1 MPa. A slightly cheaper Pozzolanic cement of specification C32.5 displays a 2-day strength of 10.2 MPa, a 7-day strength of 20.6 MPa, and a 28-day strength of 35.2 MPa (Appendix 1)

Reinforcement steel is required in the form of rebars, or prestressing wires. Rebars are required to attain a tensile yield strength of between 200 and 400 MPa for most precasting; prestressing wires however are required to attain a strength of up to 1700MPa (Warszawski 1999).

The materials used in prefabrication are therefore similar to those used in traditional construction – traditional construction being based around concrete blocks for walls and cast-in-situ concrete for flooring. The only difference is that prestressed slabs may be slightly more economical with the use of concrete (Ibid).

The production of such slabs is fairly simple, requiring only molds (which can be made from timber or steel), cement mixing equipment, and lifting equipment (overhead cranes). Casting can be mechanised where it proves to be beneficial - a casting machine as used by Bison U.K. at the Iver plant is estimated to cost £120,000 and is capable of producing 60,000m^2 of prestressed hollow core slab annually(Appendix 2). Such a system may prove to be advantageous at very high outputs, or if labour becomes very expensive. In the U.K. this purchase cost equals the annual wage of approximately 4 labourers. In Uganda this would equal the cost of well over 150 labourers. Maintenance and depreciation considerations notwithstanding, it is much more practical that pouring, compacting and levelling will be conducted using a more labour intensive technique with the help of simple tools in Uganda. The minimum degree of mechanisation for such production includes the use of overhead lifting cranes, forklifts, and concrete mixers (Appendix 2).

Chapter 3 - Housebuilding costs

The purpose of this section is to highlight the microeconomic theory of housebuilding and subsequently ascertain a framework of research. The cost structure and considerations of the traditional housebuilding firm and the industrialised firm will be discussed, followed by a presentation of the theory behind the derivation of Average Cost Curves.

Hillebrandt (Hillebrandt 2000) classifies construction costs into variable, fixed, and postponable costs. Variable costs being those which vary with the level of output, fixed costs being those which must be met for the company to stay afloat regardless of workload, and postponable costs being those which must be met only in the very long run. The following assessment of each factor of production will consider the production of large scale single storey housing projects of more than 50 units.

Traditional construction firm

Variable costs:

Materials

The quantities of materials used in housebuilding will vary proportionately with output since each unit is identical. What may vary disproportionately is the price of materials – large scale purchases are likely to attract scale discounts thereby reducing the unit cost of materials (Ibid).

Site labour

It is preferred in many countries that labour is found using labour only subcontractors who locate, assess, and appoint labourers on behalf of the main contractor. In the U.K. the apparent transactional cost associated with this procedure is partially justified by lower national insurance contributions overall. Largely however it appears that main contractors are prepared to pay slightly higher wages to subcontracted labour in exchange for the flexibility it offers them in periods of discontinuous work. The absolute cost of labour is largely subject to wider economic conditions. A contractor is most likely to increase his supply of labour in times of economic growth when the price of labour is also likely to be rising thereby increasing the unit cost of labour. The supply of labour however, is the other major factor. Generally site labour in traditional construction accounts for approximately one-third of the cost of construction (Ibid). Obviously this is under the assumption of traditional construction in developed nations – developing countries are likely to employ slightly more labour intensive techniques for their works.

Site management

As output increases there is an inevitable requirement to manage the process more efficiently, the introduction of middle management becomes necessary to relay information through the chain of command - particularly in conditions (developing countries) where operatives are unreliable and need extensive supervision. It must be considered however that the introduction of competent management is likely to greatly improve the efficiency of production. Additionally management input is very indivisible; a single site manager may be necessary for anything up to x units of output, after which two managers may be adequate for anything up to perhaps 3x units. After a certain point however, it will be necessary to appoint project managers in addition to site managers. There will be an increasingly convoluted managerial structure adding to costs significantly and often offsetting the economies of scale (Ibid).

Site plant and equipment

In a typical housebuilding project there is a need to prepare foundations, mix cement and transport materials. There are certain economies of scale that can be achieved with the use of larger more efficient diggers and cement mixers, and larger lorries. Each of which may result in slightly higher maintenance costs. A large fleet of owned lorries for example may necessitate the need for a large depot, or an in-house maintenance division – although this may not be the case if the equipment is rented. Specific conditions notwithstanding, the cost of plant and equipment on site will increase in proportion to scale (Ibid).

Tender costs

These generally rise slightly less than proportionately with the size of contract, and proportionately with the number of contracts tendered for. Small firms are able to outsource the costs of estimating to independent self employed quantity surveyors, and larger firms may find it cheaper to employ full time quantity surveyors if the number of tenders required is high. Additionally for a large or growing firm an internal QS may be useful for monitoring costs throughout the project (Ibid).

Fixed costs:

Head office staff

In small firms this consists simply of the entrepreneur and possibly one or two assistants. All additional work is outsourced or subcontracted. As a company grows it will find itself increasingly in a position to save costs by having more full time staff (Ibid).

Buildings and equipment maintenance

The rent of office space is important but many small contractors are able to operate from their homes. In general the fixed costs of a small contracting firm are simply the living costs of the entrepreneur. Larger companies will require permanent offices and will subsequently be charged with building maintenance and tax costs. Plant and equipment can often be outsourced to independent suppliers so as to save on maintenance costs and liability issues. This depends on the ability of the industry to cater for such flexibility (Ibid).

The long run average cost of a construction firm depends on the ability of the economy to facilitate economies of scale. If there is a shortage in the supply of any particular input, the growth in demand of this input will raise prices resulting in negative marginal profits (Ive et al 2000).

Industrialised construction

An industrialised construction firm will need to bear the additional costs of the casting site, the casting machinery, and the specialist staff who are more likely to be employed permanently. This adds to the cost of maintenance and overall administration. In consequence however, the industrialised firm may find that at higher outputs (once the benefit is able to outweigh the investment), the product is cheaper or more efficient. The Long run average cost of an industrial construction technique depends on the ability of the firm to benefit from large scale production (Hillebrandt 2000). The number of skilled staff required in industrial housebuilding is significantly lower than that of traditional housebuilding techniques (Appendix 9). Finlay Currie of Wave Homes U.K. however, points out that the administration and management of the prefabrication process depends upon very specialist skill and experience - particularly in the interaction of design, assembly and manufacture, whether the work portions are outsourced or conducted in-house. He additionally states that due to the high cost of management, prefabrication is seldom cheaper in England; rather it sustains itself by providing higher quality products. This however, is as a result of the demand for luxury homes, rather than cheap mass housing.

Determination of the Long Run Average Cost Curve

The Production Function

The production function in its simplest form expresses output as a function of Capital and Labour:

$Y = f(K,L)$

This can be expressed graphically using the isoquants:

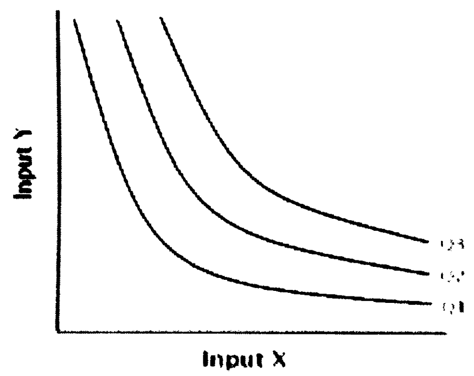

Figure 1 - Isoquant Graph

Here each line represents the possible combinations of labour and capital required to meet a certain level of output (Earl 1995).

An isocost line (shown in red below) represents the relative prices of capital and labour(i.e. input Y and input X), the optimal combination of inputs can then be read off the chart to obtain a cost of production at any given output.

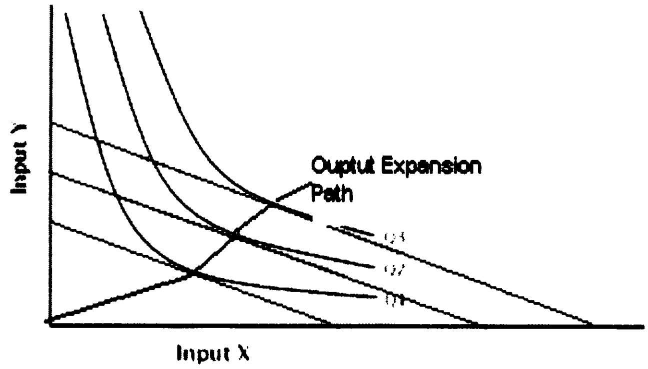

Figure 2 - Isoquant Isocost Graph

Total cost therefore is expressed as; TC = (w)*(X) + (r)*(Y)

Where:
w = unit cost of Input X
r = unit cost of Input Y (Earl 19995)
Given the long run assumption that all inputs are variable, a long run average cost curve can be drawn from the above information - The assumption of this theory is that factor prices and technology remain constant over the long run – this is not strictly true, but will be discussed further in the analysis.

The SRAC and LRAC

The SRAC of housebuilding measures the cost of producing houses at a fixed level of investment and technology. Each SRAC is assumed to be u-shaped according to classical economic theory and can be expressed as a function of (Hillebrandt 2000):

- The unit quantities of material, labour, and plant
- The unit cost of each input
- The company overheads
- The technological and managerial efficiency of the process

Such an analysis can be used to formulate the average cost at any output, in the short run however the overheads are assumed to be constant. There may be changes in the technological and managerial efficiency as workers may learn and pick up new skills very rapidly without any additional investment. Regarding housebuilding and perhaps construction in general there are a number of different technologies that can be adopted for any scale of output. For a small contractor the obvious choice is to opt for a labour intensive low asset type of production where there is a minimal degree of mechanisation involved in the project, and much of the production is outsourced. This is possible in small markets and small projects, but as the firm decides to increase its' output in the short run it will find itself faced with one of three possible outcomes (Koutsoyiannis 1979):

1. The company is constrained by the economies' ability to provide adequate skilled staff and equipment on demand, forcing it to import at great cost.

2. The economy is capable of supplying production inputs, but the cost of administering an organisation with minimal fixed assets and large output are excessive.

3. The economy is capable of supplying production inputs, and the costs of administering such an operation are acceptable.

Because there is a transaction cost associated with outsourcing portions of the work, it is expected that in the long run as a company grows, greater portions of the work will be done in house. Due to the intermittent nature of construction work in reality however, there is a tendency to limit the fixed assets of production. In this situation the opportunity for a contractor to expand is largely constrained by the size of the market – if the market is small there will be very little division of labour and therefore few independent specialist suppliers for a company to outsource work packages to (Ive and Gruneberg 2000). The only choice for a contractor growing at a faster rate than the overall market is to establish in-house divisions for every new operation or import skills and other inputs.

This has two main drawbacks; firstly the firm must bear the cost of organisational learning – if the undertaking is unfamiliar, the early phases are likely to be riddled with administrative and procedural mistakes and additional expenses. It will be necessary to train staff, establish protocols, and possibly import a great deal of expertise (Hillebrandt 2000). All this will add to the unit cost dramatically. Secondly there is increased liability for companies with such high overheads – they are unable to adapt to an adverse change in market conditions without shutting down departments or laying off staff. The LRAC analysis is also affected by certain production technology choices; a firm may either choose to outsource as much of its production as possible, or conduct all of its operations in house. This decision is largely determined by the extent of the market – a large market is likely to have greater competition thereby reducing the cost of outsourcing, making it cheaper than doing work in house(Ive and Gruneberg 2000). In small developing markets however, it is unlikely that the relevant skills and technology will be widely available enough for outsourcing to be possible in high volumes of production. A firm will therefore have to forge the market by creating the relevant skills and technology in-house. This inevitably creates a massive administrative requirement.

Essentially the LRAC constitutes the envelope of short run average cost curves, since each SRAC represents the output at a different level of fixed cost. In truth there are an infinite number of such SRAC's giving the LRAC one of three potential profiles (Ferguson and Gould 1977):

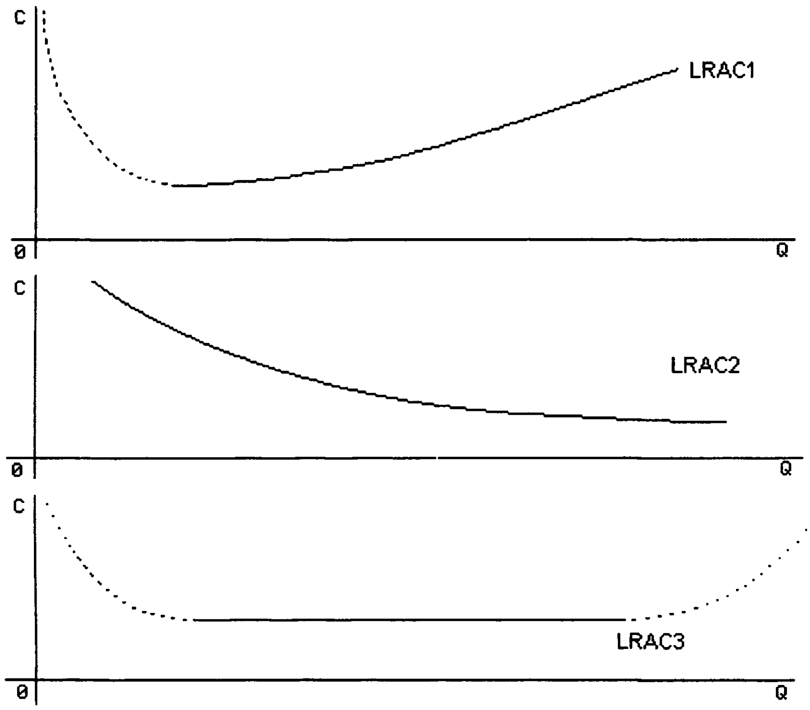

Figure 3 - LRAC Types

The first indicates initially *increasing economies of scale*, then *decreasing economies of scale*. The second indicates perpetually increasing economies of scale. The third indicates increasing economies of scale followed be a long period of constant returns to scale, which eventually decrease.

The distinction between small, medium, and large firms in this thesis is based entirely on the size of its fixed asset base. A small firm is therefore bound to outsource virtually all of its operations except at the smallest output – which its minimal fixed costs are able to cater for. In contrast a large firm is bound to conduct all operations in-house except those at very large output.

As an economy grows in size there is an inevitable degree of specialization by certain firms – since the market is able to maintain any particular specialty and allow such firms a competitive advantage. This reduces the overall cost of production compared to large firms in small markets who are obliged to conduct all operations in house (Ive and Gruneberg 2000).

Determinants of economies of scale:

Koutsoyiannis (Koutsoyiannis 1979) classifies the determinants of economies of scale into 4-categories as described below:

Production–engineering relationships – the idea that a larger product requires relatively less production input, i.e. volume vs. surface area. This is largely inapplicable to prefabrication given that we are limiting our analysis to a particular type of output. It would however apply in the case of apartment blocks versus individual houses. Apartment blocks for example, may economise on materials because one wall is only required to separate two dwellings for example.

Indivisibilities of input – below a certain scale of production certain inputs are inefficient since they have a minimum level of output. This is critical to both industrialisation and traditional housing. Traditional housing can benefit from economies through the mechanisation of its site operations; for example a digger may be used in place of manual labourers for high outputs. Industrial housebuilding depends very much on a high output since there is an inevitable degree of fixed investment – factory space, cranes, and casting facilities are all indivisible inputs into the production process – this difference in fixed investment implies that industrial construction is much more able to benefit from the investment into plant and facilities at sufficient output. Additionally this principle can be applied to the sourcing of materials from abroad which may be cost effective only above a certain volume.

Specialisation/division of labour – efficiency of production can increase when the scale of production allows scope for specialisation. This principle is critical to the average cost of production. A factory environment is much more conducive to specialisation and the division of labour because there is greater control over the work method. On-site construction depends very much on the ability of certain aspects of production to be flexible in regard to other operations. In this respect therefore, industrial construction should benefit from the economies of specialisation to a much greater degree than traditional construction.

Stochastic economies – these are benefits resulting from the use of large inventory, in particular the use of spare capacity to spread risk. In traditional construction because every product and process is conducted on-site and therefore bespoke, there is no possibility of manipulating inventory to spread risk. In industrial housebuilding however, with the use of standard components a firm may stockpile walls, floors, staircases, or other standard sections this making it much easier to respond to market conditions.

According to the above theory industrial housebuilding should benefit from mass-production to a much greater degree than traditional construction. In practice however it remains to be seen whether or not these determinants of economies of scale are applicable. It may be the case that there is a constraint on the economies' ability to provide for certain inputs into the production process.
The Ugandan economy must be analysed with a view to understanding the inputs into the prefabrication process, which are as follows:

- Management of the casting process
- Management of the assembly process
- Production facility plus storage space
- Transportation of components to site
- Labour with relevant skills
- Materials (cement, aggregates, sand, reinforcement)
- Infrastructure (roads, electricity, and fuel)

The effect of scale on traditional housebuilding in Kampala will now be explored using case studies of various housing projects in Kampala, and this exploration will be used to highlight the impact of the above factors in conjunction with a general macroeconomic analysis.

Chapter 4 – The Ugandan housebuilding sector

The purpose of this chapter is to present and discuss data surrounding the factors affecting the cost of construction in Kampala, in the following chapter this material will be used to construct LRAC curves for traditional and industrial housebuilding in Kampala.

Summary of infrastructure and resource capacity:

Energy & Transportation

Uganda is presently facing the most acute energy crisis in its modern history; the consumer is presently paying US $0.17/kWh of electricity compared with US $0.9 for Kenya, and $0.6 for Tanzania (Appendix 3).
The official explanation for the shortage in output from the local hydroelectric power stations is that of lowered water level in Lake Victoria – following the recent 15% drop in average rainfall; the UN however, accuses the Ugandan government of exceeding the permitted water flow through the dam (Ibid).
Fuel supply is also inadequate: Uganda depends entirely on imported petroleum; there have been significant complications transporting fuel to Kampala largely because the Kenyan government places limits on the transportation of fuel by road, and the pipeline transporting fuel from Mombasa is already operating at capacity. Diesel has often been out of stock, and fuel in general is very expensive. The price of diesel is currently at US $1.1 per liter, and petrol at $1.3 per liter – much higher than in neighbouring countries.
The combined result is a less attractive climate for investment firstly because the overall demand side of the economy is dampened, and secondly because the costs of production are unfavourable compared with neighbouring regions.

The growth of Ugandan industry thus far has been dependent on having a relatively healthy energy industry – this no longer being the case presents a problem for its' short term future(Ibid). The government has however provided a few initiatives to sustain Ugandan industry; earlier this year it waived taxes on diesel for generators over 100 KVA, and introduced extended depreciation allowances on the purchase of new generators. Much has already been invested into alleviating the energy crisis but the ministry of energy estimates that US $4.4bn of investment will be required by 2025 to meet Uganda's energy needs (Ibid).

Despite such promises all interviewees were pessimistic about the situation, and expected the crisis to continue unabated for at least the next 5 or 10 years.

Transportation was a thriving industry in Uganda following the recent decades of rapid expansion and inter-regional trade. Particularly since Uganda is a landlocked country and depends quite heavily on the Kampala-Mombasa route for much of its trade. The road network has continued to expand although maintenance has not been quite so effective (Ibid). Excess maintenance on the trucks due to long distance deterioration is estimated to add 10-15% to the cost of transportation (Appendix 4).

Plant

Haulage companies such as Interfreight and Hauliers operate by renting low-loaders and trucks from independent owners and small firms. They own minimal amounts of haulage plant, but significant warehousing and storage space (Appendix 4). There are independent garages for servicing, independent dealers for purchasing, and numerous banks and institutions for financing the purchase of plant. This level of fragmentation indicates a relatively advanced industry. The operating company concerns itself with none of the maintenance, depreciation, and ownership requirements, putting it in a better position to cope with fluctuations in market demand which are responded to by a reduction or increase in the number of independent small suppliers. The industry is more or less competitive and the rates are constant with regards to scale since the cost of ownership and maintenance is spread throughout the industry (Ibid).

In the immediate short run there is a surplus capacity of 30-40 (30-tonne) deliveries within the Kampala area per day. This is priced at approximately US$150 per trip. Should a company require greater than 50 deliveries per day in the short run, the price may rise to approximately $300 per trip, since the operating company would have to go to extraneous lengths to provide the service (Ibid). In the long run however the market will quite easily absorb such a sustained increase in demand and prices should return to relative normality.

Cranes are also widely available; 10-15 cranes over 80-tonnes can be sourced locally at any given point in time – although the operability of such cranes is subject to access conditions around the site (Ibid).

The prices are however, vulnerable to macro-economic conditions. Prices have risen steeply in recent years as a result of the cost of diesel, the excess maintenance due to bad roads, and high electricity prices (which affects the competitiveness of all the supporting industries in the supply chain). Presently the effect of all these factors is at an all time high, it is anticipated moreover, that the present situation will continue unabated for at least another decade (Ibid).

Materials

Cement is produced locally in two major plants; the Hima Lafarge cement factory in Kasese, and the Tororo Cement factory in Tororo. Hima Lafarge is a subsidiary of the Kenyan cement producer Bamburi Portland. Ugandan cement consumption in 2005 was approximately 1,000,000 tonnes, 350,000 tonnes of which was produced at the Hima Kasese plant, 500,000 tonnes produced at the Tororo Factory, and the remaining 150,000 tonnes imported from Bamburi Kenya by Hima Lafarge(Appendix 1).

Both companies plan to make major investments to be able to cope with the growing demand for construction in Uganda. At present the Tororo Factory is capable of producing over 750,000 tonnes annually, and expects to expand further as the market requires. The Hima plant in Kasese expects to be able to produce 1,000,000 tonnes annually by 2008(Appendix 1).

These output estimates are slightly optimistic however, the reality is that the Tororo plant is operating below optimum output capacity, and the investment in the Hima Kasese plant was planned before the Ugandan energy crisis reached its' current height. The conditions of producing cement locally is such that the cost is equal to importing from Kenya. If the energy crisis persists in Uganda, it may become favourable to source all cement from Kenya where the production situation is far more appealing. In this situation the price is unlikely to rise above the current UGShs 20,200 per bag for ordinary Portland cement and UGShs 18,200 for Pozzolanic Portland Cement (which displays a much slower curing time).

Scale discounts are available on large orders, for example Hima cement will offer a UGShs 300 per bag discount on orders over 300,000 bags (Appendix 1).

In summary then, the average cost of production of cement in Uganda would present itself with a downward sloping AC curve were it not for the present energy crisis. This puts a barrier on the practicability of producing cement locally, and the surplus cement (OPC) is imported from Kenya at a standard price of 20,200 shillings per bag (Appendix 1).

Land

Land prices in slightly out of town industrial zones vary from $100,000-$200,000 per acre. Generally for a site with reasonable access to main roads, and up to 10km from city centre the price will be approximately $160,000 per acre (Appendix 4).

Manpower

Unskilled labour is abundantly available and costs no more than US $60 per month. Slightly more skilled and trained workers will earn approximately $100 per month. Trained specialist staff such as drivers and crane operatives will earn approximately $200 per month. Most firms employ such staff through in-house HR staff. Administration staff are paid approximately $150 per month (Appendix 8).
Managers are widely available but generally not reputed to be very effective without significant training. Most firms estimate an 18-24 month training programme before a graduate is ready to work unsupervised in a construction management role. Such staff are paid $200-$500 per month depending on the details of the job (Appendix 8). Competent senior managerial staff are difficult to find locally; and the cost of sourcing such employees from abroad is exacerbated by a $1000 monthly fee imposed by the government for expatriate staff working in Uganda. There are growing levels of professional managerial staff in Uganda – but most managers feel that the supply is still inadequate.

Cost breakdown of housing projects in Kampala

Below is a table showing the cost breakdown per unit of an average single storey $100m^2$ floor area house in the Kampala area according to the estimates of the 4 housebuilders interviewed.

Cost Breakdown by Percentage

	Akright	PSL	NHCC	SCES
Materials	30	50	45	65
Labour	15	15	10	15
Plant	5	5	5	10
Site management	20	10	10	5
Overheads	30	20	30	5

N.B. Estimates based on average house size 100m squared floor area

Figure 4 - Companies Cost Breakdown

Akright Properties

(Refer: Appendix 5)

Akright properties is one of the largest Housebuilders in Uganda. It conducts virtually all operations in-house; including planning, design, construction, marketing, and sales. Last year the company produced 400 houses, and expects a similar output in the short term future. The products range from cheap single storey homes for less than UGShs50m, to luxury homes sold at over UGShs300m. But most homes are targeted at low-middle income urban households, and are sold for UGShs 50-75m. The company builds on large estates with over 100 houses per estate. The technology adopted is traditional style labour intensive construction – which is almost invariably the preference for all Ugandan construction. The plant involved consists simply of hand tools, concrete mixers, and vibrators, much of which is owned, but can also be rented whenever necessary. The high cost of site management was explained by the fact that the company produces a multitude of different house types and sizes within one project. A high level of overheads also highlights the tendency for the firm to conduct much detailed design and planning in-house as it believes this is the more efficient mode of production.

NHCC

(Refer: Appendix 6)

The National Housing and Construction Corporation is a former ministry which is now in the process of being privatized. It has the capacity to produce over 800 homes per year, but is only producing 200-300 homes annually. As with Akright the production technology is traditional labour intensive construction on large estates. A high level of overheads was explained by the heavy management burden, and the fact that the firm is in possession of a large amount of old plant and machinery and excess staff. In this case it should be pointed out that this expense is largely as a result of corporate inefficiency than an ideal choice of production technology.

Property Services Limited
(Refer: Appendix 7)

PSL is a prominent family owned real estate developer that has recently expanded into housebuilding. The output is approximately 600 houses annually – in the form of one estate. It does not do any design or construction in-house; rather architects and contractors are subcontracted portions of the work. PSL does however purchase land, prepare specifications, and manage the project process. PSL displays lower proportions of overheads and site management for their projects, largely because they choose a relatively standardized output and focus their projects on cost control rather than product quality.

Specialised Construction and Engineering Services Ltd
(Refer: Appendix 8)

Specialised is a small individually owned contractor engaging in small scale housebuilding, up to 4 houses annually. It operates with virtually nil fixed assets – and only 2 employees who are employed on a project basis.
The cost of site management here is much lower than other firms because the entrepreneur conducts much of the site operations and therefore is only in need of assistants – rather than professional employees. A slightly higher expense is plant – which must all be hired and therefore is slightly more expensive. The company cited experience of project management from a previous level of fixed assets and output of 25 homes annually. This example however, is discussed in the analysis.

It must be noted that the data set was not large enough to obtain an accurate assessment of the average cost of housing in Kampala. Because of the variances in the operations of each individual firm and the reluctance to divulge accurate cost data, it was decided that the analysis would also take into consideration the experiences of the contractors at each level of output and fixed costs.
The limitations experienced at the respective outputs of each of these firms are discussed now in the analysis.

Chapter 5 Analysis

Analysis – Traditional Housebuilding

The LRAC curves of industrial and traditional housebuilding will be drawn by amalgamating a series of SRAC curves at sequential levels of output.
The analysis of traditional housebuilding will be done by drawing the SRAC curve at each level of output according to the experience of the housebuilders interviewed.
The analysis of industrial housebuilding will consider two different types of long run; firstly in terms of a *Planning Horizon*, i.e. that at a given point in time (such that the technology of the industry and the size of the market is unchanged) the firm may select the most appropriate levels of investment/fixed plant for all levels of output (In the planning horizon, the major decision affecting the costs of the firm is the choice of production technology – or the degree of fixed investment).
Secondly, in the *Practical Long Run,* where the selection of appropriate levels of investment will consider the effects of time – i.e. that the market may expand, technology may improve and the industry may advance. For simplicity of analysis it will be assumed that the firms are concentrating all of their output within single estates.

Constraints in the production of traditional housing

The output of the firm will be broadly categorized into 4-different scales of production:

- Small – up to 10 houses annually
- Medium – up to 50 houses annually
- Large – up to 600 houses annually
- Major – over 600 houses annually

This indicates the productively efficient level of output for the firms' level of fixed investment, or the level of output at the lowest point on the average cost curve. It is possible for these firms to operate at higher or lower outputs, but it would be inefficient. In theory there are infinite different degrees of fixed investment for infinite quantities of output. For the purpose of this analysis however, we will interpolate between the different degrees of fixed investment stated.

Small Scale Production

The degree of mechanization typically employed by Ugandan contractors for small scale production is limited to the use of mechanical hand tools. There is little need for external staff since most skills can be contracted for the duration of the project. Quantity surveyors working in other companies can be hired to perform small tasks for approximately 60,000 shillings per day. Project managers can be contracted for the duration of a contract. Administration is carried out by the entrepreneur – but is minimal in any case. Specialised Construction and Engineering Services reported using one site manager for a plot of 4-double storey houses, no other internal staff, and a project duration of 1 year. The site manager was responsible for contracting foremen and skilled labour. Thus the company was able to operate with minimal fixed costs. The company however noted the expense of externally supplied services. The daily rate for an external QS is approximately ¼ the monthly rate for an internal one. In consequence the QS had a minimized involvement and cost control during the project was not particularly effective. External foremen were in general highly unreliable and sometimes lacked incentive to produce quality work since there are no formal contracts to enforce work relationships – contracts are in fact written, but for such minor works there is no prospect of enforcing them. The major problem encountered was that although the staff were technically capable of fulfilling their tasks, there is lack of professionalism that renders labourers and tradesmen highly unreliable. The company is forced to monitor the work intensely to ensure that work is carried out to an adequate standard.

Regarding the use of plant and mechanization the firm believed that labour-intensive techniques were cheaper, except on foundation construction in much larger projects where diggers could be hired at reasonably competitive rates.

For these reasons the company felt that with such a level of fixed staff, the cost would increase sharply above 5 units annually if the company were to subcontract large portions of the work. The SRAC curve therefore takes the following shape where the lowest point represents approximately 5 units:

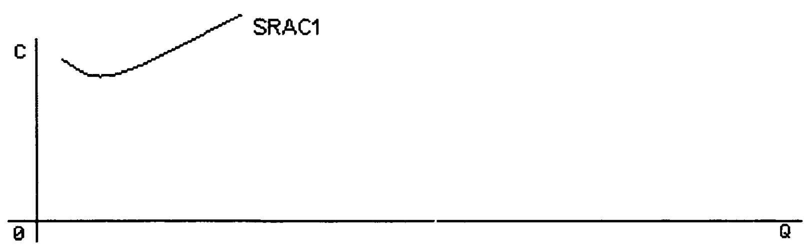

Figure 5 - SRAC1 - Traditional Housebuilding

Medium Scale Production

Projects of 50 houses or more benefit from the opportunity to standardize their processes. Specialised Construction and Engineering Services describes a project of 25 housing units where it employed two full-time QS, a senior experienced project manager, and four further site managers responsible for site administration generally – raising the total management to 20% of the project cost. The production technology remained highly labour intensive – only a slight increase in the size of concrete mixers etc. The firm at this point was constrained by its staff and office space primarily. An increase in output would have required space to accommodate managerial staff, and there would have been a need to internalize the Human Resource management so as to ensure better reliability amongst the tradesmen. Ironically the firm refrained from employing tradesmen and staff, but cited the fragmentation of work in-between contracts as an explanation. The additional expense of managing external trades was seen as justified. Although unwilling to disclose full figures, the firm stated that the project displayed a slightly lower marginal revenues at this point compared with smaller projects. The SRAC for this project (SRAC2) is as follows with the lowest point representing approximately 25 houses:

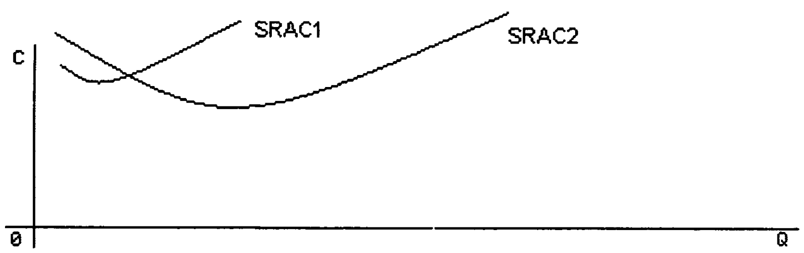

Figure 6 - SRAC2 Traditional

Large scale production

Large projects up to 600 units are fairly rare – but benefit from significant economies in the supply and use of materials. Small discounts on scale purchases as well as the on-site production of concrete blocks for example are fairly common, the latter of which is estimated to save approximately 5% on the cost of walling for such a project in the experience of PSL.

The prospect of subcontracting portions of the work to smaller contractors thereby reducing the overall management/administrative burden was not perceived to present a cost saving to any of the three major housebuilders interviewed – it was felt that subcontractors were lacking professionalism and commitment to the project. Because the legal infrastructure is not efficient enough to deal with contractual disputes and the spread of information is limited, there is little incentive for subcontractors and contractors to behave in a co-operative fashion.

All the large contractors (PSL, NHCC, Akright) cited that the cost of supervision was large – and not reduced noticeably with scale. Mechanization remains low – the companies may employ a digger for the construction of foundations but the cost saving is seen as insignificant by all three major producers, Akright, NHCC, and PSL. All three contractors felt that the cost of administration for such an output put their overheads at a point where they were only just able to compete with smaller contractors on price. All three contractors had complaints about the availability of skilled and trustworthy staff.

This level of production therefore marks the efficient scale of production for traditional housebuilding. Harry Potts of PSL states that the marginal profit in traditional housebuilding is continually decreasing and becomes negative approximately between 600 and 1000 houses annually.

The SRAC for this scale of production (SRAC3) therefore is as follows;

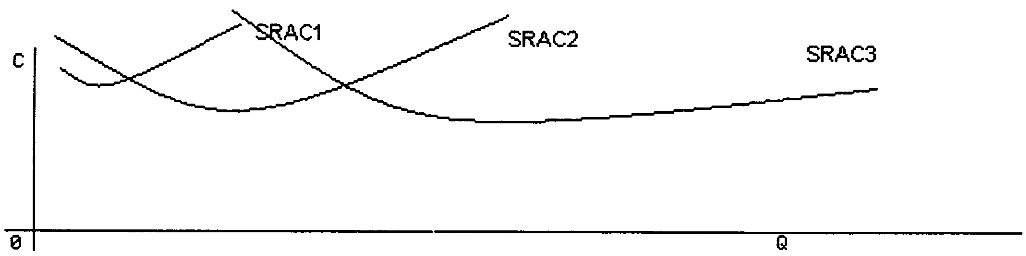

Figure 7 - SRAC3 Traditional

Major manufacturer

Construction firms in Uganda do not operate at outputs of above 600 units annually. Estates of such a size usually spread the construction over a period of several years. According to the experience of the major housebuilders such an output is not profitable due to the excess cost of managing the production process, the result would be negative marginal revenues. The consensus is that marginal revenue is constantly decreasing in the long run, and becomes negative approximately between 600 and 1000 homes annually.

The SRAC (SRAC4) curve for this production is therefore as follows, where the lowest point on the SRAC4 curve is higher than the lowest point on the SRAC3 curve.

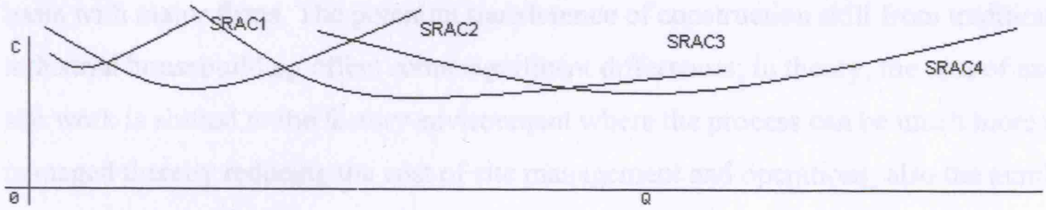

Figure 8 - SRAC4 Traditional

LRAC Traditional Housebuilding

The LRAC for traditional housebuilding in Kampala can therefore be drawn by taking the envelope of SRAC curves, and takes the following shape;

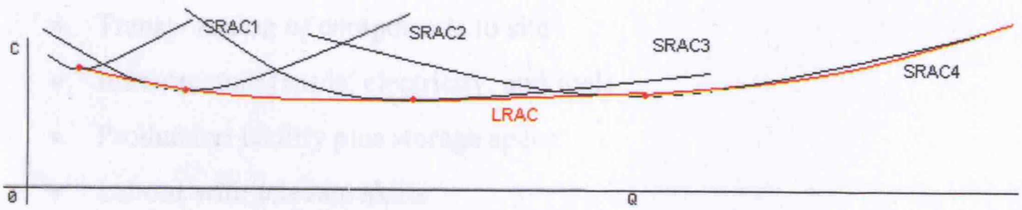

Figure 9 - LRAC Traditional

As discussed in the explanations of each SRAC curve thus far, the rising average cost is explained by a shortage in the reliability of skilled labour. It also becomes highly onerous for the management of firms to administer the site operations in large projects and subcontracting is seen as being similarly unreliable due to a lack of professionalism among local small contractors. The majority of local tradesmen and labourers are officially self-employed, but in reality they are simply operating outside the bounds of proper legal procedure. The absence of direct employment is the most likely the reason for lack of proper training and regulation amongst the local trades, but housebuilders cited fragmentation of contracts as the major reason for their aversion to employing large number of trade staff.

Analysis - Industrialised housebuilding

We have demonstrated that the major hindrance to economies of scale in the long run in traditional housebuilding is the complexity that arises when dealing with unreliable and unskilled construction staff. This is why small contractors are able to compete on a unit cost basis with major firms. The potential transference of construction skill from traditional to industrial housebuilding offers some significant differences; in theory, the cost of excessive site work is shifted to the factory environment where the process can be much more easily managed thereby reducing the cost of site management and operations, also the number of tradesmen required on site is reduced, and many new skills are required.

The additional investment in the factory facility is justified by the cost savings from more efficient site processes overall and therefore requires a significant scale of production. The question of whether or not the cost of prefabricated housing is justified by scale depends on the ability of the economy to provide adequately for the inputs into the process, which are as follows:

- Materials (cement, aggregates, sand, reinforcement)
- Transportation of components to site
- Infrastructure (roads, electricity, and fuel)
- Production facility plus storage space
- Labour with relevant skills
- Management of the casting process
- Management of the assembly process

Constraints in the production of industrial Housing

Materials

Materials of prefabrication are generally similar to those used in traditional construction, but used in different proportions. Therefore the effect of scale on material supply is also negligible. Surplus cement is imported from Kenya at no additional cost, and other raw materials are available in abundance. Therefore there is no constraint on the long run supply of materials.

Transport

In the immediate short run there may be a limitation on the industries' ability to provide for large orders – trucks have to be ordered and imported, there is therefore a slight delay before the independent suppliers will be able to satisfy large demands. Such plant therefore will present a short run constraint only.

Infrastructure

Of the four contractors interviewed all were in agreement about the fact that the supply of infrastructure was a significant burden on the costs of the firm, but were not able to conclude anything about the effects of scale. There are negligible scale discounts on fuel purchases, if anything a shortage in supply might raise the cost of diesel and therefore transportation. The same is true for electricity – although industries are eligible for significant discounts on the price of electricity, a long run shortage may result in load shedding and inefficient production. Precast factories are however dependent upon electric cranes and electric concrete mixers for even the most labour intensive techniques. As output expands however there may be a need for construction firms to expand their output into regions without adequate access conditions; government policy however, is keen on supporting industry with infrastructure investment. Therefore infrastructure is expected to present no barrier to economies of scale.

Production facility

The production facility requires a fixed investment that varies with the cost of inputs and the choice of output. Labour intensive techniques are preferred in Uganda because of the abundance of cheap labour. What is required therefore is an enclosed space, molds, a cement mixer, and overhead cranes. At higher outputs space restrictions may require a more capital intensive production technique – a casting machine capable of producing approximately 60,000m^2 annually will cost approximately £120,000. The availability of space for production around Kampala is not seen to be a problem for many decades yet.

Labour

Cheap labour is available in abundance. Traditional construction in Kampala operates by sourcing relatively unskilled labour and tradesmen from independent contacts on a temporary basis. Unskilled labourers are often found waiting outside the site every day – and are arbitrarily selected for the job. This procedure is favoured by contractors who wish to minimize the administration and risk associated with having permanently employed site staff. The result however, is a shortage of properly skilled and trained workmen and a heavy site management burden. Therefore although labour remains very cheap – it becomes unproductive at higher outputs. In industrialized housebuilding there are two aspects to production; on-site and off-site/factory. Factory production typically attains productivity through specialization of its workforce and repetition of processes. This requires the presence of permanent staff and a deliberate training scheme.
Site staff are required to be similarly skilled in the installation of concrete panels. An industrial firm will therefore have to employ greater numbers of permanent staff, and to train these staff thoroughly to ensure the correct caliber of work.

Management

Managerial staff are often permanently employed. The three large housebuilders interviewed stated no major problem with the supply of managers – but it was noted that an 18-month training period is required before the utility of graduates is seen.

LRAC Industrial Housebuilding Planning Horizon

The LRAC curve in the planning horizon for industrial housebuilding therefore is subject to the same constraints as traditional housebuilding; the supply of reliable skilled labour. In the planning horizon therefore, where the state of the industry is fixed it can be said that the LRAC for Industrial housebuilding is as shown below, where the firm is able to derive initial increasing returns from economies of mass production, but soon encounters major inefficiencies due to the absence of reliable skilled labour. The output at which the firm is likely to experience negative marginal returns is affected by the exact degree of labour productivity – no empirical data regarding this is available but given the belief that the factory environment is more conducive to maximizing the utility of labour, and that fewer numbers of workers are required for the assembly of prefabrication on site, the point at which the LRAC begins to rise can be said to be higher than that of traditional housebuilding, possibly over 1000 units annually. Given the degree of initial investment and the industrial learning curve it is unlikely that the average cost in these circumstances will be lower than traditional housebuilding.

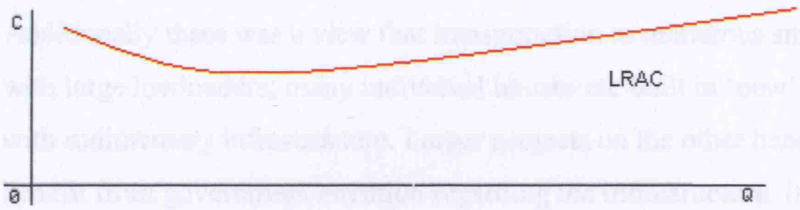

Figure 10 - LRAC Industrial Planning Horizon

Industry in General in Uganda is believed to derive benefits from economies of scale because of the greater emphasis it places on the training of staff and the prospect of mechanization once the staff numbers become inefficient. If industrialized concrete factories were able to maximize the value of their staff through continuity and training, then the availability of skilled staff would not be a constraint, and the expense of managing the manufacturing process would be reduced accordingly – such a situation is only possible however, in the practical long run.

LRAC Industrial Housebuilding - The Practical Long Run

In the practical long run the firm must consider how the industry may change over time and subsequently how this may affect the choice of production technology and output decisions.

At early stages of production the firm is faced with a shortage of skilled labour and the need to conduct all operations in house – in this situation all the interviewed contractors felt it would be impossible to cater for individual housebuilders in disparate locations using prefab components; primarily because the indivisibility of resources such as cranage and design would mean each site would be insufficiently large to attain any economies of scale – despite the fact that there might be better efficiency management. The management and labour skill relevant to prefabrication are nonexistent. There is perhaps a certain degree of transference between the two production technologies but this would still take some time. Given that most traditional firms require an 18-month training period before seeing the utility of their graduate staff, one can assume that the learning period for staff on industrial housebuilding to be similar – provided that the training procedure is also similar. If the firm itself is at an early stage of organizational learning then there may be inadequate training for the staff, resulting in an even longer gestation period. In the absence of skilled staff it will also be necessary for the firm to bring skilled management from abroad.

Additionally there was a view that transportation to numerous small sites would be difficult with large lowloaders; many individual houses are built in 'new' out-of-town locations with rudimentary infrastructure. Larger projects on the other hand are better planned and benefit from government attention regarding the infrastructure. It is therefore only practical in the short run to concentrate the firms' construction efforts into large scale projects. Harry Potts of PSL was of the view that in housing projects of over 700 units it would be profitable to set up rudimentary casting yards on-site – this would avoid the necessity for large investment into factory space and complex machinery.

As the industry expands however, it would be possible for a factory to supply components to independent contractors based on a standard specification of components. In this situation the contractor is responsible purely for assembly, and the design is based on the manufacturers product. The presence of a plant would benefit the economy of the process through the economies of scale provided by supplying to numerous construction firms.

A third state of industry development is when there are numerous casting plants able to supply to a large segment of the housebuilding industry; plants can be located so as to serve different regions and thereby reduce the costs of transportation. In addition there may now be specialist precast concrete transportation and erection firms. At this state of development it may be feasible to apply prefabrication techniques to much smaller projects, or indeed any project with adequate transportation facilities and erection space.

As the Ugandan economy grows the strain on the companies energy supply will obviously multiply. The industrial firms interviewed felt that the promises made by the Ugandan government were of some value, and that coupled with international support the energy crisis would be solved – it was felt however that this would take another ten years or so. During this ten years the cost of production might increase further and hamper the competitiveness of prefabrication.

The LRAC of prefabrication in Kampala considering the effect of projected market changes may be categorized into three stages where each stage corresponds to a different period of development of prefabrication within 'practical long run.'

Stage 1

The market is unable to provide for construction skill, a firm will therefore have to conduct all operations in-house and provide training for its permanent staff. The result is a need for very large fixed costs and therefore high scale of production. The firm will derive some economies of scale from the plant it has invested – but will shortly be constrained by the lack of prefabrication skill.

Stage 2

The market is specialized to a certain extent, allowing the industry to be divided into separate producers of concrete components and assembly firms; some economies of scale can be attained through the supply chain with lower fixed costs for each firm. The firm will be able to attain lower costs from specialization in the market place – but will be constrained by the absence of minor services such as specialist crane operators and design firms. This will happen at least after the minimum staff training period of 24 months, and may take up to 10 years.

Stage 3

The industry is highly specialized and prefabrication is able to cater to many segments of the market. There are numerous independent suppliers and each firm through a specialized operation has access to a wider market, and skilled staff are widely available. This results in lower costs for the overall process. Such a level of advancement is likely to be possible after approximately 10 years.

Given the growth of the market and the change in skill that is projected to occur in the market the industrial organisation takes different forms. In the beginning there is only one firm undertaking all the activities, but eventually many other firms join the industry and there is specialization, competition and more efficiency.
In this situation the average cost of production of precast components over time is demonstrated in the chart below:

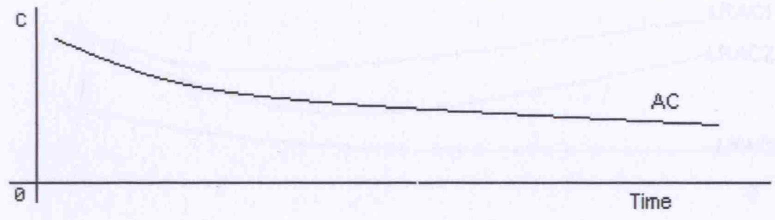

Figure 11 - Industrial Average Cost Over Time

In the attempt to combine the effects of time and scale on the production of prefabricated components, we would have three separate LRAC curves, each at a different point in time. Using the three stages described above the LRAC at each point in time would look as follows;

Stage 1 (LRAC1)

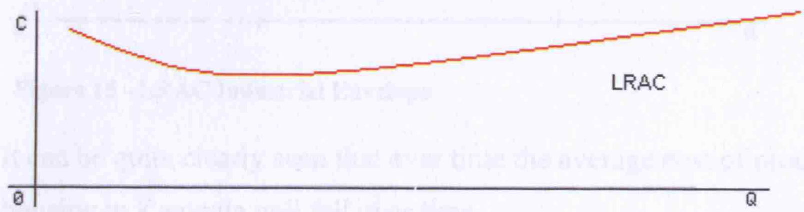

Figure 12 - Industrial LRAC1 Stage 1

Stage 2 (LRAC2)

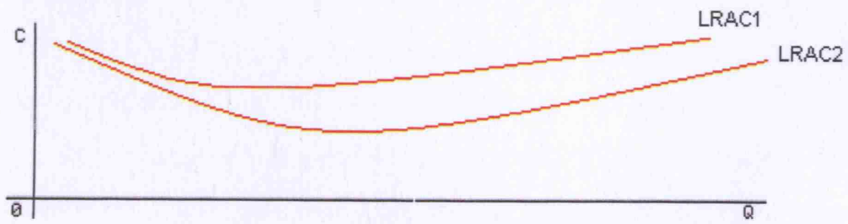

Figure 13 - Industrial LRAC2 Stage 2

Stage 3 (LRAC3)

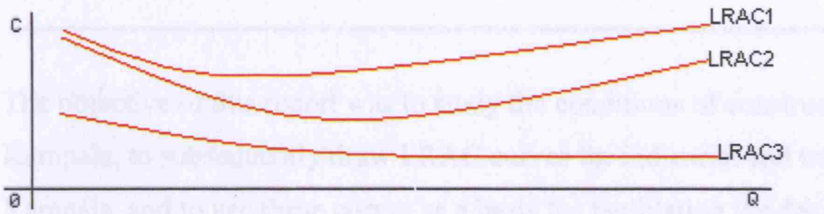

Figure 14 - Industrial LRAC3 Stage 3

Taking the envelope of these three curves we arrive at a Long Run time based Average Cost of production for prefabricated housebuilding in Kampala – which looks as follows (LRAC-Time).

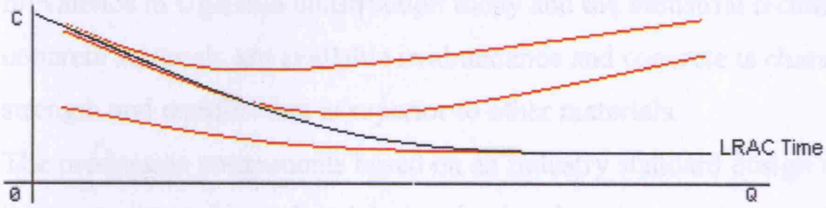

Figure 15 - LRAC Industrial Envelope

It can be quite clearly seen that over time the average cost of producing prefabricated housing in Kampala will fall over time.

Conclusion

The objective of this report was to study the conditions of construction production in Kampala, to subsequently draw LRAC curves for industrial and traditional housebuilding in Kampala, and to use these curves as a basis for facilitating the decision to use industrial or traditional housebuilding techniques for housing projects in Kampala.

It was decided for the sake of simplicity to limit the analysis to a particular type of output (low cost housing in large projects), and to particular production techniques; traditional housing of brick and block walls with cast in-situ floors as compared with the industrial technique of precast concrete. The traditional housebuilding technique was chosen for its prevalence in Ugandan construction today and the industrial technique was chosen because concrete materials are available in abundance and concrete is characterized by a durability, strength and comfort that is superior to other materials.

The production components based on an industry standard design was highlighted as being the most appropriate industrial organizational arrangement from which to stem the analysis because this arrangement would be most conducive to the establishment of a large scale industry output where previously none existed – as is the case with Kampala. Reason being that the industry is more easily able to limit the expense of design and is able to attain high output of a single product.

The research conducted into the Ugandan economy revealed major difficulties in the cost of industrial production related to high energy and fuel prices. Large outputs were not however believed to affect the unit cost of such inputs – if anything government subsidies would reduce the cost at high volumes. Additionally it was perceived that with the aid of government investment and foreign aid much of the infrastructure related drawbacks of production in Kampala would diminish over time – as they have done in general for the last twenty years. As a contingency the supply of certain materials from neighboring countries such as Kenya was seen as a relief from the expense of local production.

The experience of local housebuilders operating in Kampala demonstrates that the major restriction on high output cost effectiveness is the supply of reliable skilled labour, which is caused by a lack of training for local staff in the absence of permanent employment. In the event that industrial housebuilding continue to follow the same policy as traditional housebuilding (subcontracting all labour and trade works), they are likely to encounter the same constraint in the quality of staff. Because however industrialization is dependent upon specialization of staff and large outputs, it is more likely that staff will be permanently employed and trained. The vertical fragmentation through the supply chain that would then become possible in the prefabrication industry is also a contribution to the economies of specialisation. In this scenario it is very likely that over time the average cost of housebuilding will reduce and that with sufficient scale of production eventually industrial housebuilding will become cheaper than traditional housebuilding. The two LRAC curves are superimposed below:

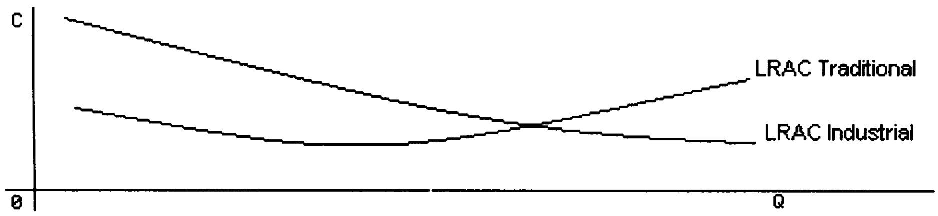

Figure 16 - LRAC Traditional vs. Industrial

The lowest point on the LRAC Traditional curve represents a point between 600 and 1000 units annually, and the crossover point represents a point over 1000 units. Given the necessary period of time (between 2 and 10 years) whilst prefabrication develops into a mature industry with experience, skills, and supporting enterprises, there are two paths the industry may take; firstly a heavily subsidized scheme is possible whereby the industry is set up and an independent body (such as government) bears the opportunity cost of operating with a less than efficient technique until the industry matures and costs are reduced – with the returns being realized after a long period of sustained high output. Secondly it is possible using private enterprise that the industry grows into prefabrication by gradually increasing the degree of standardization in its traditional construction projects – for example assembly skill and manufacture can be facilitated by the introduction of casting yards for small components on site in projects of approximately 600 units. Such an intermediate technique saves on the cost of major investment and is an important step towards prefabrication.

Prefabrication therefore presents a promising opportunity in the Ugandan market – but requires a carefully managed transition process to ensure its' profitability.

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Appendix 1

Interview with Arthur Bagurukayo, Key Accounts Executive, Hima Cement Uganda

-Range of Products:

OPC, HPC, RHC

-Capacity:

350,000 tonnes annually, increase to (1,000,000 tonnes 2007)
50% of Ugandan consumption including imports from Kenya

-Scale discount:

UG Shs300 on orders over 30,000 bags

-Production constraints

Power fuel, 150,000 bags imported from Kenya.
Current price standard OPC UG Shs20,200 per bag, 18,200: HPC

Bar power + fuel prices cost of production decrease with scale. Raw materials available locally in abundance

Expect energy crisis to persist for long time – but cement price reduce with scale.

Also Tororo Cement output 500,000 tonnes, capacity 800,000, to expand significantly 2008.

Refer attached data sheet for concrete technical detail.

Hima
Cement

WORKS, P. O. BOX 37, KASESE
TEL (+256)78-400180 483-44165 44212 FAX (+256)78-400286 483-44064

CEMENT ANALYSIS TEST CERTIFICATE OF

Jul-06

CUSTOMER: TYPICAL

CEMENT TYPE: MULT- PURPOSE

STANDARD SPECIFICATION: CLASS CEM II / B-P 32.5 N

PHYSICAL TESTS:

PARAMETER		SPECIFICATION	RESULT
SPECIFIC SURFACE	Cm^2/g	Not specified	4849
STANDARD CONSISTENCY	%	Not specified	31.85
SETTING TIME	INITIAL (Minutes)	Not less than 60	294 ✓
	FINAL (Minutes)	Not more than 600	418
SOUNDNESS (LeChatelier)	(mm)	Not more than 10	0.3
EN- 196 MORTAR PRISM	At 2Days (N/mm^2)	Not specified	10.2
COMPRESSIVE STRENGTH	At 7Days (N/mm^2)	≥16	20.6
	At 28Days N/mm^2)	≥32.5≤52.5	35.2
CHEMICAL ANALYSIS			
LOSS ON IGNITION %		Not specified	5.90
INSOLUBLE RESIDUES%		Not specified	9.16
SULPHURIC ANHYDRIDE %		Not more than 3.5	1.85
CHLORIDE %		Not more than .10	0.076

Signed

CHEMIST

CHIEF CHEMIST

Date:23.06.06

CEMENT ANALYSIS CERTIFICATE .

CUSTOMER : 0

CEMENT TYPE : PORTLAND CEMENT

STANDARD SPECIFICATION : CEM I 42.5 N

BRAND NAME : POWERPLUS

PHYSICAL TESTS

TEST		SPECIFICATION	UNIT	RESULT
SPECIFIC SURFACE			cm^2/g	3103
STANDARD CONSISTENCY		-		
SETTING TIME	INITIAL	Not less than 60	Minutes	230
	FINAL		Minutes	293
SOUNDNESS	without aeration	Not more than 10	mm	0.40
	7 days' aeration		mm	
KS EAS 18 -1 PRISM COMPRESSIVE STRENGTH	At 2 days	Not less than 10	N/mm^2	19.8
	At 28 days	Not less than 42.5		49.1
		Not more than 62.5		

REMARKS AVERAGE RESULTS FOR CEMENT DESPATCHED FROM THE FACTORY DURING THE MONTH OF APRIL 2006

Yours faithfully ,
BAMBURI CEMENT LIMITED

J. KOMBO
OPTIMIZATION ENGINEER

Appendix 2

Interview David Killick, Works Manager Bison Iver Factory

Summary of Main Details

Plant Capacity:
800,000 meters squared precast annually
£15.50 per metre squared production cost

Plant:
10 casting machines (£120,000 each, 12-15 year lifespan)
2 x Automated mixer (£80,000 each)
4 x Forklift
1 x Sideloader
1 x Loading shovel
1 x Tractor
1 x Dumper Truck
2 x Tower Crane
£230,000 annual maintenance expenditure

Staff:
124 total
12 administration, including 4-managers

Appendix 3

Interview Abid Alam – Managing Director Alam Group of Companies, Chairman Uganda Manufacturers Association, Vice Chairman East African Business Council.

Infrastructure related issues:

- *Electricity $.17 KWh, Kenya .9, Tanzania .6*
- *Owen falls dam weak, new dam not operational – lowered lake level.*
- *Government draining lake level – violation of 50-year old agreement with Egypt.*
- *Corruption in government*
- *$4.4bn required by 2025 to meet requirements – need help from international aid*
- *agencies and governments.*
- *Many subsidies for generators purchase – Purchase tax waived and depreciation allowance increased.*
- *But diesel price high also, $1.1 per liter (petrol $1.3) – cheaper in Nairobi.*
- *Kenya government restrictions on transport by road. Pipeline inefficient.*

Recently very bad climate for investment. Dependent upon foreign aid

Appendix 4

Interview Dilip Bhandari Finance and Commercial Director Interfreight Uganda Limited

Plant:

Virtually nil, all trucks and cranes hired in
Office and Storage space only

Cost of haulage within Kampala area:

$150 per trip 30-tonne lorry.

Local capacity:

All haulage firms in Kampala, 30-50 deliveries daily, 10-15 large cranes.
Orders approx 200 per day, price up to $300 per trip

Constraints

Fuel, Maintenance. Bad roads add 10-15% to cost of transport.
Significant economies of scale for management, proportionate effect of fuel, economies of scale for storage space.

Expect costs to decrease with higher demand – transport infrastructure must keep pace however.

Abundant supply of industrial land around Kampala, approx $150,000 to $200,000 per acre.$160,000 current site.

Appendix 5

Cost Breakdown Housing Project – Akright Properties ltd.

Establish:

1) Extent of operations, i.e.

-Volume of output (Homes per month?)
400 homes per year

-Type of output (Timber/steel/concrete units?)
Traditional houses

-Range of output (Panels/volumetric units?)
Houses

-Services offered (Design, Installation?)
Design, Construction, Sales

-Target market distribution (Self-build, Large projects?)
Large estates, private buyers

2) Costs of operations

e.g. UGShs 75m House 2 bedroom

	Percentage of total cost
Materials	30
Labour	15
Plant	5
Site management	20
Overheads	30

Discussion questions

-From a production perspective, what are the capacity constraints on the production of prefabricated housing in terms of the following (attempt to express relationship to output, and supply constraints):

1) Materials
Obtain list of suppliers if possible
Evaluate scale-discounts, possibility of outsourcing, and degree of imports

Bricks offer small scale discounts. Clay bricks are ordered at UGShs 150 per brick, but larger orders will allow 140 shillings per brick. This price includes delivery to site.

Cement is generally similar, the price remains constant at any scale of output.

E&M components are widely available – much is imported, but there is never any shortage – the market is able to respond fairly quickly to any demands.

2) Manpower
Consider training periods and staff turnover, + administrative requirements at different scales of production.

Will induce a positive marginal productivity initially, but eventually levelling out at a maximum output of 2-3 homes per manager at any given point in time.
There is an 18 month training period for managers or technical staff from graduate.
Other labour is in abundance – but unreliable, site work becomes riddled with inefficiencies. Managers must work twice as hard not efficient.

3) Plant
Consider intervals of depreciation and degrees of investment

Virtually nil plant involved. Small concrete mixers and hand tools generally widely available.

-What is the degree of inter-sectoral involvement, i.e. how many other firms are involved in the supply chain of the production of prefab housing and what are their roles? (alt: What would the production of prefab housing entail without the contribution of such other firms/suppliers in the construction sector?)

Much work depends on industrial suppliers – bricks and materials often purchased as inclusive of transport, which is also independent. Minimal subcontracting however – all works carried out by main contractor using skilled tradesmen who are widely available – but need extensive supervision.

Appendix 6

Cost Breakdown Housing Project - NHCC

Establish:

3) **Extent of operations, i.e.**

-Volume of output (Homes per year)
800-900

-Type of output (Timber/steel/concrete units?)
Traditional houses

-Services offered (Design, Installation?)
Design, construction, sales

-Target market distribution (Self-build, Large projects?)
Large projects, individual buyer

Costs of operations

e.g. UGShs 75m House 2 bedroom

	Percentage of total cost
Materials	45
Labour	10
Plant	5
Site management	10
Overheads	30

Discussion questions

-From a production perspective, what are the capacity constraints on the production of prefabricated housing in terms of the following (attempt to express relationship to output, and supply constraints):

4) Materials
Obtain list of suppliers if possible
Evaluate scale-discounts, possibility of outsourcing, and degree of imports

Abundance of materials, rising prices generally

5) Manpower
Consider training periods and staff turnover, + administrative requirements at different scales of production.

Available but managers unable to cope with large projects. Cost overruns and delays frequent. Labour difficult to organise.

6) Plant
Consider intervals of depreciation and degrees of investment

Owned plant old and inefficient

-What is the degree of inter-sectoral involvement, i.e. how many other firms are involved in the supply chain of the production of prefab housing and what are their roles? (alt: What would the production of prefab housing entail without the contribution of such other firms/suppliers in the construction sector?)

Extensive supply chain in traditional construction, prefab will need to operate at very high output

Appendix 7

Cost Breakdown Housing Project – Property Services Limited

Establish:

4) **Extent of operations, i.e.**

-Volume of output
500-600 homes per year

-Type of output (Timber/steel/concrete units?)
Traditional houses

-Range of output (Panels/volumetric units?)
Houses

-Services offered (Design, Installation?)
Planning, Sales

-Target market distribution (Self-build, Large projects?)
Large estates, private buyers

5) **Costs of operations**

e.g. UGShs 75m House 2 bedroom

	Percentage of total cost
Materials	50
Labour	15
Plant	5
Site management	10
Overheads	20

Discussion questions

-From a production perspective, what are the capacity constraints on the production of prefabricated housing in terms of the following (attempt to express relationship to output, and supply constraints):

7) Materials
Obtain list of suppliers if possible

Evaluate scale-discounts, possibility of outsourcing, and degree of imports

Small output can be easily catered for by the market, at higher output (single project) costs can be saved by on site blockmaking and joinery etc.

E&M components are widely available – much is imported, but there is never any shortage – the market is able to respond fairly quickly to any demands.

8) Manpower
Consider training periods and staff turnover, + administrative requirements at different scales of production.

Significant training period for fresh graduates to undertake managerial responsibility. High output on dispersed projects requires extensive managerial and administrative burden.

9) Plant
Consider intervals of depreciation and degrees of investment

Diggers and mixers widely available with independent maintenance firms at insignificant cost.

-What is the degree of inter-sectoral involvement, i.e. how many other firms are involved in the supply chain of the production of prefab housing and what are their roles? (alt: What would the production of prefab housing entail without the contribution of such other firms/suppliers in the construction sector?)

Much work depends on industrial suppliers – bricks and materials often purchased as inclusive of transport, which is also independent. Minimal subcontracting however – all works carried out by main contractor using skilled tradesmen who are widely available – but need extensive supervision.

Appendix 8

Cost Breakdown Housing Project – Specialised Construction and Engineering Services

Establish:

6) Extent of operations, i.e.

-Volume of output
2-5 homes per year

-Type of output (Timber/steel/concrete units?)
Traditional houses

-Range of output (Panels/volumetric units?)
Houses

-Services offered (Design, Installation?)
Construction only

-Target market distribution (Self-build, Large projects?)
Private clients

7) Costs of operations

e.g. UGShs 75m House 2 bedroom

	Percentage of total cost
Materials	65
Labour	15
Plant	10
Site management	5
Overheads	5

Discussion questions

-From a production perspective, what are the capacity constraints on the production of prefabricated housing in terms of the following (attempt to express relationship to output, and supply constraints):

10) Materials
Obtain list of suppliers if possible

Evaluate scale-discounts, possibility of outsourcing, and degree of imports

Abundant materials, price inclusive transport, negligible scale discount

11) Manpower
Consider training periods and staff turnover, + administrative requirements at different scales of production.

Highly unprofessional staff, unreliable work, and corruption mar work progress. Managers hired on basis of trustworthiness rather than ability. Past record very important

12) Plant
Consider intervals of depreciation and degrees of investment

Hand tools only.

-What is the degree of inter-sectoral involvement, i.e. how many other firms are involved in the supply chain of the production of prefab housing and what are their roles? (alt: What would the production of prefab housing entail without the contribution of such other firms/suppliers in the construction sector?)

Minimal, subcontracting not in fashion.

Previous project 25 houses, extra staff, QS managers, admin. Same problems of incapable unreliable staff. Profit margin higher on small projects.

Prefab requires heavy investment not favoured by contractors. Possible in long run.

See attached bill of Quantities sample:

Item	Description	Qty	Unit	Rate Ugx	Amount Ugx
	BILL No. 8 **DAYWORKS**				
	SUMMARY				
1	LABOUR				3,187,800
2	MATERIALS				7,995,375
3	PLANT				7,797,000
	TOTAL BILL No. 5 (DAYWORKS) TO GRAND SUMMARY				**18,980,175**

Item	Description	Qty	Unit	Rate Ugx	Amount Ugx
	DAYWORK - LABOUR				
	In accordance with the conditions of Contract, the Contractor shall be paid daywork rates for extra work that cannot be properly measured and valued and the Contractor is to insert in the space provided below the basic rate of cost detailed hereunder.				
	Labour				
1.01	Leading hand (ganger)	240	hrs	950	228,000
1.02	Unskilled labourer	240	hrs	350	84,000
1.03	Scaffolder	240	hrs	750	180,000
1.04	Concretor	240	hrs	750	180,000
1.05	Steel fixer	240	hrs	750	180,000
1.06	Mason	240	hrs	750	180,000
1.07	Roofer	240	hrs	750	180,000
1.08	Carpenter	240	hrs	750	180,000
1.10	Welder	240	hrs	750	180,000
1.11	Plumber	240	hrs	750	180,000
1.12	Electrician	240	hrs	750	180,000
1.13	Plasterer	240	hrs	750	180,000
1.14	Tiler	240	hrs	750	180,000
1.15	Glazier	240	hrs	750	180,000
1.16	Painter	240	hrs	500	120,000
1.17	Drainlayer	240	hrs	750	180,000

Item	Description	Qty	Unit	Rate	Amount
				Ugx	Ugx
	Sub-Total				2,772,000

Item	Description	Qty	Unit	Rate Ugx	Amount Ugx
	Total Brought Forward				**2,772,000**
	Add				
1.18	To the basic nett rates of labour used for work carried out on dayworks, an addition of ______ % which is to include for task work and incentive schemes, tools, standing scaffolding, supervision, insurance, transport, profit and overheads.		%		415,800
	TOTAL (DAYWORK - LABOUR) TO SUMMARY				**3,187,800**

Item	Description	Qty	Unit	Rate Ugx	Amount Ugx
	DAYWORK - MATERIALS				
	Where materials are supplied which are not mentioned in the list hereunder then payment of such materials shall be based only on the approved invoice cost for materials specifically authorized by the Architect.				
2.01	Cement	50	bag	19,000	950,000
2.02	Sand	10	ton	17,000	170,000
2.03	Aggregate	10	ton	35,000	350,000
2.04	Murram	10	ton	15,000	150,000
2.05	Hardcore	10	ton	15,000	150,000
2.06	Steel reinforcement	500	kg	2,000	1,000,000
2.07	Sawn timber	2	m^3	300,000	600,000
2.08	Wrot timber (mahogany)	2	m^3	600,000	1,200,000
2.09	100mm diameter PVC pipe	2	pcs	25,000	50,000
2.10	Paint gloss	5	lts	5,000	25,000
2.11	Paint emulsion	5	lts	3,500	17,500
2.12	6mm sheet glass	3	m^2	50,000	150,000
2.13	150 x 150 x 6mm white glazed wall tiles	3	m^2	10,000	30,000
2.14	Burnt red clay tiles	5	m^2	15,000	75,000
2.15	Three lever mortice lock	5	no	55,000	275,000
2.16	100mm steel butt hinges	10	prs	2,000	20,000
2.17	Steel casement door lock	5	no	78,000	390,000
2.18	Oil based primer	20	lts	5,000	100,000
2.19	16mm square armoured PVC cable	1	roll	1,250,000	1,250,000

Item	Description	Qty	Unit	Rate	Amount
				Ugx	Ugx
	Sub-Total				6,952,500

Item	Description	Qty	Unit	Rate Ugx	Amount Ugx
	Total Brought Forward				**6,952,500**
	<u>Add</u>				
2.20	To the basic nett rates of materials used for work carried out on dayworks, an addition of ______ % which is to include for unloading and storing as necessary, machinery etc available on site, profit and overheads.		%		1,042,875
	TOTAL (DAYWORK - MATERIALS) TO SUMMARY				**7,995,375**

Item	Description	Qty	Unit	Rate	Amount
				Ugx	Ugx

Item	Description	Qty	Unit	Rate Ugx	Amount Ugx
	DAYWORK - PLANT				
	The following rates must be inclusive of drivers and/or attendants:				
3.01	Grader truck	12	hrs	70,000	840,000
3.02	Dumper	12	hrs	25,000	300,000
3.03	Lorry, five tonne tipper	12	hrs	25,000	300,000
3.04	Concrete mixer (5/3.5)	12	hrs	12,500	150,000
3.05	Concrete vibrator	12	hrs	7,500	90,000
3.06	Crane - 10 tonne	12	hrs	125,000	1,500,000
3.07	Crane - 20 tonne	12	hrs	150,000	1,800,000
3.08	Roller	12	hrs	70,000	840,000
3.09	3/4 Cubic Metre Tractor Excavator with loading attachment	12	hrs	80,000	960,000
	Sub-Total				**6,780,000**
	Add				
3.10	To the basic nett rates of materials used for work carried out on dayworks, an addition of ______ % which is to include for driver and /or attendants, fuel and consumables stores, supervision, insurance, road license, profit and overheads.		%		1,017,000
	TOTAL (DAYWORK - MATERIALS) TO SUMMARY				**7,797,000**

Appendix 9

Interview – David Williams, LonTop Housing Ltd.

Cost Breakdown Housing Project

Establish:

8) Extent of LonTop operations, i.e.

-Volume of output (Homes per month?)
Unavailable: international operation

-Type of output (Timber/steel/concrete units?)
Steel products

-Range of output (Panels/volumetric units?)
Panels and frames

-Services offered (Design, Installation?)
Design, engineering and installation. No in-house production; panels entirely outsourced.

-Target market distribution (Self-build, Large projects?)
Medium to large size projects. Minimum efficient scale: 700m^2 project.

9) Costs of operations

-Basic materials (Cost per unit of output/per unit of time)
Data unavailable. All panels sourced from international independent manufacturers and delivered to site as and when required.
Very little advantages due to bulk buying – generally up to 5% maximum. Can sometimes be up to 15%, but very much depends on market position of seller.
Cement & aggregate for foundations generally available in abundance, as well as local contractors to prepare foundations.

-E&M Materials (Cost per unit of output/per unit of time)
Data Unavailable. All equipment sourced internationally as above unless cheaply available locally – must consider import taxes.

-Labour; Skilled/Unskilled (Cost per unit of output/per unit of time)
250 man days required for 1000m^2 of building, therefore 6 months. 1 supervisor for 10 men. Minimal skills required. Never shortage of trainable labour. Therefore few restrictions.

-Equipment, tools & plant (Investment and depreciation)
10 loft containers will contain 1000m^2 of building, minor cranage required on site, generally all plant hired.

-Overheads/Profit (Design and planning)
≈10% Profit.
Cost of design, engineering, and management 10-15% of total project cost.

-Other costs
Losses due to transport mishaps – 3 out of 40 containers went 'missing' en route during recent project in Kazakhstan.
Storage of materials on site – generally require two month buffer for projects in developing countries.

Discussion questions

-From a production perspective, what are the capacity constraints on the production of prefabricated housing in terms of the following (attempt to express relationship to output, and supply constraints):

13) Materials
Obtain list of suppliers if possible
Evaluate scale-discounts, possibility of outsourcing, and degree of importation.
No increase in costs as production increases, possible slight decrease.

International trade facilitates cheap supply of labour at given scale

14) Labour
Consider training periods and staff turnover, + administrative requirements at different scales of production.

Local abundance, no increase in cost

15) Plant
Consider intervals of depreciation and degrees of investment

Generally all hired, some productivity advantages with scale.

-What is the degree of inter-sectoral involvement, i.e. how many other firms are involved in the supply chain of the production of prefab housing and what are their roles? (alt.) What would the production of prefab housing entail without the contribution of such other firms/suppliers in the construction sector?
Almost total dependence – supply, installation, site works, labour, all outsourced. Inconceivably expensive without this social structure – but globalised trade means that there is always such a provision. Generally estimate an increase of 15% on cost for application of TopHousing technique in Uganda. Highly complex management of process – not even cheaper in England, but due to type of output.

-How would you imagine the conditions of production to differ in the context of less developed economies?
See above.

-How does the Long Run Average Cost Curve of industrialised housebuilding behave in practice? i.e. Does the Average Cost per unit of output decrease, increase, or remain constant as the scale of production increases?

As below: