An investigation into the viability of using self-sustaining shipping container homes as an affordable and sustainable approach to student housing.

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Introduction

South Africa faces a major shortage of student accommodation. In 2016, the Department of Higher Education reported that the supply of student accommodation only made up 18% of the demand (SA Commercial Prop News, 2016a). This shortage has manifested as a result of South African cities being inefficient and inequitable, largely due to their low density and sprawling nature (Massyn *et al.*, 2015). With municipalities facing expenditure and financial challenges, the backlog in student housing and infrastructure has become increasingly prevalent. As a result, the proximity to urban infrastructure and locations, within the city, corresponds with high property prices as the demand for housing in well-located areas exceeds the supply. With many universities in South Africa being located within the urban peripheries and areas alike, demand for affordable student accommodation is often not met by supply due to competition from other uses offering more attractive returns (SA Commercial Prop News, 2016b). This is due to the fact that the land prices, coupled with development costs, means that private sector developers and investors require high enough rentals to warrant attractive returns. Furthermore, the surplus in demand drives up the price of existing supply causing students to pay high prices to live in overcrowded facilities with poor living conditions. Although a small percentage of the student market demand does warrant attractive returns in the upper rental bracket, the majority of the demand dose not.

The University of Cape town (UCT) and the University of the Western Cape (UWC) have, on a number of occasions, called on private sector to make available any vacant accommodation for students paying between R3000 and R4000 a month, identifying that as the range where there is the largest shortage of supply. McGaffin *et al.* (2016) summarises this issue by indicating that the challenge lies in addressing the value versus cost equation, where the value that a project can generate covers the total cost, including the desired return. It can therefore be seen that, in order for student accommodation to be an attractive investment option to the private sector, the cost element of the equation needs to be reduced in order to increase returns without jeopardising affordability to the consumer.

Drawing from International Case Studies

In investigating ways in which the cost component of the equation can be addressed, international case studies provided a potentially viable approach for affordable student accommodation (Uittenbroek and Macht, 2009; Botes, 2013; Islam *et al.*, 2016). The Netherlands faced similar market inefficiencies to South Africa and due to rent ceilings regulating the rentals charged for student accommodation, it became increasingly difficult for the private sector to add to the supply of affordable student accommodation using conventional construction practices. The Keetwonen development in Amsterdam and the Utrecht University's student accommodation development in the Netherlands provided an example of where shipping container architecture was used for student accommodation in order to address the value versus cost equation.

In recent years, container developments have grown in popularity both abroad and locally due to a number of benefits apparent in container architecture over conventional brick and mortar (Grant, 2013; Sun *et al.*, 2017). The oversupply of containers in the shipping industry has reduced the cost to purchase a raw container for use in construction, however this surplus in supply has led to its own dilemma. The cost of shipping an empty container back to its origin is expensive and leaving containers in port is costly and takes up valuable space. As a result, and seeing as containers are not biodegradable and therefore not suitable for landfill, there is a growing need to either reuse or melt down and recycle containers. Melting down a container for recycling uses around 8 000kw of energy whereas reusing a container and converting it into a fully furnished home only uses around 400kw (Palma Olivares, 2010). Therefore from an environmental perspective, just based on the energy saving in converting as opposed to recycling a container, container conversions should be encouraged (Bernardo *et al.*, 2013).

Research Outline

Conventional brick and mortar construction cannot viably provide affordable student accommodation in South Africa. International case studies have shown that container architecture may provide a more affordable and sustainable approach to construction due to the supply surplus in the shipping industry and the relatively low energy intensive conversion process. It was therefore identified that there is potential to combine the supply surplus and the need to reuse containers to address the shortage in affordable student accommodation through container conversion into student housing units.

The problem statement for this research was stated that:

"Little is known about the viability of using shipping containers as an approach to student accommodation within a South African context."

This led to the following research question:

"What is required to implement shipping containers as an environmentally and financially suitable solution to student accommodation?"

The research proposition was stated that:

"Shipping containers can be used as a suitable approach to address the shortage in affordable student housing."

The aim of the research was to establish the suitability of using shipping container units for the purpose of student accommodation from a financial and environmental perspective. In order to address this aim, a number of objectives were identified are stated as follows:

i. Understand what the requirements are for a typical student-housing unit in terms of amenities and dimensions.
ii. Analyse the trend of sustainable developments and identify the perceived benefits.
iii. Analyse international case studies where reused shipping containers have been successfully integrated into developments.
iv. Identify the challenges that container developments may face in a South African context.
v. Evaluate the financial feasibility of using shipping containers for student housing units.
vi. Examine the feasibility of such units from both developers' and investors' points of view.

The outcomes of the aim and objectives of the research were achieved through a comprehensive review of literature before interviewing four Cape Town based companies involved in a combination of student housing development, sustainable container conversions and the management of student housing facilities. These companies were analysed as four case studies to collect qualitative data used to address objective *iv* in particular. A feasibility study was then conducted for case studies 2,3 and 4 from both the developers' and the lenders' perspective. The feasibility study was used to achieve objectives *v* and vi.

Methodology

Drawing from the literature review on container developments (both internationally and within South Africa), in addition to the South African student housing market, case study analysis was chosen as the most appropriate research method to address the research objectives.

Case study analysis requires the investigation into the specific cases related to the subject in order to understand the reasons behind the occurrence of various subject related phenomena. The aim of this research was to gain a better understanding of the reasons behind the student housing shortage and why conventional development methods were not deemed feasible, and to determine the viability of using shipping containers as a means of addressing the shortage in student accommodation in an affordable and environmentally sustainable manner.

Figures and data obtained through the case studies were then applied in a quantitative manner through a Discounted Cash Flow (DCF) as a means of evaluating the qualitative data through practical financial representation. Data was collected through semi-structured, face-to-face interviews, of companies currently involved in a combination of student housing developments, sustainable container conversions and the management of student housing facilities. The selection of case studies was based on convenience and purposive reasons. Case studies were selected for convenience based on their proximity to Cape Town, and relative ease of access. Case studies were then selected based on their appropriateness in terms of the research and qualitative data that they could offer. As a result of the purposive selection, only case studies relating to residential container conversions were selected.

The analysis of international case studies and the review of literature were then compared to the findings from the local case study analysis. Through Pattern-Matching analysis, the reoccurring patterns that arose from the literature review were cross examined and matched with the reoccurring patterns that emerged from the analysis of the local case studies in Chapter 4. Following the matching of patterns, a feasibility study was performed for case studies 2, 3 and 4 in order to evaluate the financial viability of each case study using a converted student accommodation container unit as the unit of analysis. A feasibility study was not conducted for Case Study 1 as the nature of the business did not warrant the same unit of a analysis as the other case studies. A cross-case analysis was then applied in order to simplify and depict these various patterns and financial outcomes. This analysis served as a simplified interpretation of the data from which a “Roadmap to affordable student accommodation” was developed. The cross-case analysis and roadmap formed the conclusion on which the research proposition could be supported or refuted. From the results of the data, it was concluded that the research proposition was supported.

Findings

A number of patterns emerged through the analysis of literature pertaining to container architecture. These patterns formed the basis for constructing appropriate interview questions used to gather and filter qualitative data from the South African case studies.

Overview of Cases

Case Study 1 (CS1): The company involved in CS1 specialises in the selling, converting and renting of containers. This company operates at scale, as one of the largest privately-owned container sale, rental and conversion companies in Africa, with branches in Cape Town, Johannesburg and Pretoria. The bulk of its operations revolve around the rental of containers and refrigeration units for storage. The conversion projects are a smaller part of their overall operations. These projects include the conversion of containers into site offices, classrooms, ablution facilities and the preparations for residential units. These preparations include the insulation, cutting and implementing of plumbing and electricity provisions, after which the container is passed on to the client who is responsible for their plumbing and finishes.

Case Study 2 (CS2): CS2 involves a company that develops and manages student housing for UWC. CS2 currently manages a 'student village' development housing 2 000 beds. This development was completed using conventional brick and mortar building materials, and since then, CS2 has been investigating the viability of developing a new student housing development constructed out of shipping containers. The shipping container development has passed the preliminary design phase and the concept designs and prototypes have already been completed. The new development is said to house up to 3 000 beds. CS2's company is currently in negotiations with a factory in China, that will manufacture the units, as well as with multiple potential stakeholders and investors in South Africa to secure finance.

Case Study 3 (CS3): The company involved in CS3 specialises in the conversion of containers into residential units, with a focus on high end finishes. All conversions are completed with an underlying focus on sustainability and ensuring developments are as self-sufficient as possible. CS3 is a privately-owned company based in Cape Town with aspirations of opening branches in Johannesburg and Durban. Although CS3 specialises in container housing units, it has been involved in the development of various medical clinics across the country. CS3 targets clients seeking quality container housing units used for residences, Air B&B units or holiday homes. CS3 is also involved in exporting units overseas, thanks to the cheaper production costs in South Africa, relative to international competition. CS3 has expressed deep interested in the development of student housing units, however, they have yet to come to an agreement with the City Council and Government in order to acquire suitable land to make this interest a reality. CS3 is not currently developing at scale but focuses on quality without compromise, although CS3 explicitly states that 'it makes sense' to use containers for the purpose of large scale student accommodation. Similarly to Uittenbroek and Macht (2009) and Brandt (2011), CS3 believes that the modularity, dimensions, cost benefits and reduced construction times, make containers ideal for student housing units.

Case Study 4 (CS4): The company analysed in CS4 specialises in off the grid, self-sustainable micro homes, made entirely out of shipping containers. These homes are completely prefabricated, with the intention of being as sustainable and space saving as possible. There is no fixed design and CS4 develops units to the specific taste and requirements of their clients. Although the company's factory is based in Paarl, it has the infrastructure in place to deliver anywhere in South Africa as well as abroad. Currently CS4 is operating with the intention of actively promoting the concept of container homes to induce volume demand and so CS4 is not running its operation for profit maximisation. The majority of CS4's current customer base is exclusive eco lodges and private residences.

Reoccurring Patterns

A number of reoccurring pattern emerged in all of the case studies as well as through the review of literature and international examples. These patterns related to features and benefits of container architecture as well as the common challenges of implementing them within a South African context. These patterns were cross examined in relation to the case studies:

Structural benefits

The analysis of the four South African case studies revealed a common consensus on the structural benefits that containers demonstrate from a building design and construction perspective. Containers are designed to withstand the harshest weather conditions on the open seas for decades. The container is constructed to meet standardised dimensions and designed to carry excessively heavy loads while simultaneously needing to be stacked up to eight units high for ease of transport. From a construction perspective, the case studies revealed that their standardised dimensions and modularity allow for easy and cost-effective prefabrication, transportation and on-site installation of converted units. In addition to being robust and structurally sound building components, the case studies explicitly stated that their modularity and stackability make them ideal for use in high-density developments. As indicated by CS2, the dimensions of a 12m container perfectly suit the space requirements of a student-housing unit. The dimensions of a typical 30m by 30m container can comfortably fit two bedrooms, bathroom and kitchen in a single self-contained unit. Each unit can then be stacked on top of another, up to six units high, without the need for additional structural support. All case studies reported that additional components such as stairwells and walkways can be constructed and easily fitted externally without impacting on the structural integrity of the stacked units. The combination of structural benefits translates into cost reductions, time savings and improved sustainability for container developments compared to conventional brick and mortar.

Cost Benefits

The cost of acquiring a raw container is relatively cheap when compared to the cost of conventional building materials. In addition to the straightforward cost of materials, all four case studies indicated a reduction in labour costs of between 30% and 40% and a reduction in total construction costs of around 50%. According to the case studies, these cost reductions come as a result of the structural benefits stated. The prefabrication and modular characteristics of containers means that all that is needed is a modular design and units can be standardised and constructed in a controlled factory environment, thereby reducing time and associated costs. CS3 reported that a single 30m, self-contained student-housing unit could be constructed at an all-in cost of R5 500 per square meter. This would include any external structural components needed if the unit were stacked on top of another and include high-end finishes. CS3 also added that the marginal cost decreases with each additional container converted. Furthermore, a comparative 30m unit constructed using brick and mortar and finished to a similar quality would cost upwards of R8 000 per square meter.

Time Benefits

The reduced labour costs stipulated come as a result of a reduction in the construction time of container units, that is attributed to their modularity and standardisation. All case studies reflected a reduction in total construction time of at least 50% when compared to conventional practices. CS3 and CS4 indicated that a typical 30m unit would take between six to eight weeks to manufacture. CS2 indicated that the same 2 000 bed development that took two years to develop using conventional brick and mortar would take only one year using containers. The manufacturing of modular student container housing, using a standardised design, in large factories would further reduce construction time.

Sustainability Benefits

In addition to the energy saving in reusing containers as opposed to melting down and recycling, container architecture offers significant sustainability benefits when compared to conventional brick and mortar construction. Container architecture offers up to 40% water saving and energy saving of as much as 90% during the construction process and over the lifespan of the development. Container developments can also provide around a 20% saving on land space on average, when compared to similar developments using conventional architecture. The nature of the development process involving container architecture reduces construction waste by up to 80%. Finally, each case study explicitly stated that container architecture encourages the use of sustainable technologies and sustainable construction practices such as insulation, solar, water and other energy saving technologies. This is due to the nature of the conversion process and the ease and cost effectiveness of the implementation of such technologies into container developments.

Challenges

The Case studies reflected similar challenges to those identified by Botes (2013). In a South African context, the more immediate challenge is that of overcoming the negative stigma amongst South Africans regarding living in container housing. It is believed from the case studies that this is due to the fact that many South Africans still view housing as brick and mortar and do not consider alternative architecture to be of the same quality. The case studies revealed that this challenge can be overcome by making consumers and investors aware of the benefits that container architecture offer over conventional brick and mortar as well as the better value for money. Another challenge facing container development is that the price of a "raw" container is linked to the Rand Dollar exchange rate and therefore fluctuations in the rate of exchange can impact of the viability of a project. Finally, the biggest challenge that links directly to student accommodation is the lack of affordable land in suitable locations. It is the understanding of the case studies as well as Botes (2013), Massyn *et al.* (2015) and McGaffin *et al.* (2016) that without the establishment of effective public private partnerships (PPP), South Africa cannot hope to achieve densification and complete such developments as affordable student accommodation at scale. Only through effective PPP can issues of land affordability and the backlog in housing and infrastructure be addressed.

Financial Feasibility Summary

A number of variables were established through the interview process as well as through the review of literature. For the sake of simplicity, it was decided to keep variables constant over the three financial feasibility studies of CS2, 3 and 4, unless explicitly addressed and stated differently. All feasibility cases were conducted using a base rental of R3 000 per room per month, identified as being the lower end of affordable range for student accommodation by UCT, UWC and CS2. A holding period of 10 years was applied to each case, at the end of which the development was assumed to be valued at a capitalisation rate of 12% and sold. Three different discount rate scenarios (13%, 14% and 15%) were applied to each case as well as a standard 10-year commercial loan at an LTV of 70%. The loan imposed three different financing cost situations in order to take the lenders perspective into account. These rates are 12%, 13% and 14%. These variables and differing scenario rates were kept constant over the three cases.

CS2

The feasibility analysis for CS2 involved the comparison of a conventional bricks and mortar versus container student housing development. The development is a three storey, six-bedroom student accommodation development. Each unit is fully fitted with quality finishes and specifically designed for student use, allowing for safety, easy maintenance and access from an operational standpoint. The total capital outlay for the conventional brick and mortar construction is R1 157 400 and a total equity contribution of 30% is R347 220. Due to the cost saving benefits identified in CS2, the total capital outlay for the construction, using containers, is R810 000 with an equity contribution of 30%, being R243 000.

In every discount rate and cost of finance scenario, the container development proved to be a more viable option than the brick and mortar one. The payback periods for the container option are 5,25 years, 5,55 years and 5,88 years with costs of finance of 12%, 13% and 14% respectively. The discounted payback periods, which take the time value of money into account, still provides a payback period of less than 10 years at all three discount rates. Even at a cost of finance of 14% and a discount rate of 15%, the discounted payback period is 8,11 years. On the contrary, for the brick and mortar option only the simple payback periods are less than 10 years. Once the time value of money is taken into account, the discounted payback periods are greater than 10 years at all three discount rates regardless of the cost of finance. In addition to the payback periods, the after-tax IRR (ATIRR) also stands in favour of the container option. Regardless of the rate of interest, the container option is more viable than the brick and mortar option. Although both the brick and mortar option and the container option both produce positive ATIRRs the container option boasts a return of more than double that of the brick and mortar option in every scenario. For example, at a 12% cost of finance the ATIRR for the conventional brick and mortar unit is 13% compared to 34% for the container unit.

CS3

CS3 looks at a standard two-bedroom unit that is purchased and transported to a location in Cape Town. The unit is fully furnished and has quality finishes and amenities. There are no additional green installations or extra energy saving features from an operational standpoint. The costs and construction time have been derived from the interviews, whereas operating costs of 40% were taken from CS2 and based on the same operating costs experienced in conventional student accommodation (no reduction in operating costs). The total cost of one unit is R183 000 inclusive of transportation costs, with an equity amount of 30% being R54 900.

In each scenario, CS3 provides a payback period of five years at the given base rental. Even at a discount rate of 15%, the discounted payback periods are still within five years at 3,89 years, 4,1 year and 4,34 years for their respective costs of finance. This reflects an attractive discounted payback period when considering the container units from the perspective of a rental asset. As the rental increases, the payback period decreases. For example, should the base rental increase from R3 000 per room per month to R3 500, the discounted payback period at a discount rate of 15% would decrease from 4,34 years to 2,59 years. At finance interest rates of 12%, 13% and 14%, the two-bedroom container unit provides an IRR of 49%, 48% and 47%

respectively. The high IRR confirms the same investment potential as the short payback period. As Costello and Preller (2010) pointed out, the IRR of a development is the most widely used by investors to evaluate the attractiveness of a project in terms of financial feasibility. CS3 reflects an attractive investment proposition of using containers for affordable student accommodation. Both the short-discounted payback periods and the attractive IRRs make CS3 a lucrative investment opportunity when looking at container student accommodation as a rental asset catering for the affordable rental range.

CS4

CS4 looks at the viability of a completely self-sustainable, off-the-grid, two-bedroom student container unit. The unit is designed with the intention saving energy and offers green features through plumbing, electrical and insulation. These features reduce the operating costs over the lifespan of the container but have added to the upfront construction costs. The remaining parameters were kept consistent with CS2 and CS3 with the only difference being the inclusion of transport into the construction cost.

In each scenario, the off-the-grid container had a payback period of less than 10 years. Even at a discount rate of 15%, the discounted payback periods at the respective costs of finance were 7,89 years, 8,03 years and 8,06 years. Despite the high initial costs of making the container self-sustainable, from an investment perspective, the discounted payback period is still less than the duration of the loan used to finance the investment. The IRRs in each scenario produces a positive return, and although not as attractive as the IRRs of CS3, CS4's self-sustainable containers still provide an attractive investment option for affordable student accommodation. At the cost of finance of 12%, 13% and 14%, the ATIRRs are 36%, 35% and 34% respectively. The self-sustainable element of the container would also prove to be cost saving over the entire lifespan of the container unit, which may also add to the attractiveness of the investment, should the desired holding period be longer than 10 years. In addition to this, the quality of the finishes and appeal to environmental sustainability would suggest that, although CS4 is financially viable at a base rent of

R3 000 per room per month, it may be better suited to the higher end of the rental market where rentals are higher and consumer requirements more focused on quality rather than affordability.

Consolidated Figures

Table 1 shows the exact outcomes of the financial feasibility of the three case studies on the discount rate of 15%. CS2 (B) represents the conventional brick and mortar unit and CS2 (C) represents the container unit. ATCF1, ATCF2 and ATCF3 represent the after-tax cash flows at a cost of finance of 12%, 13% and 14% respectively.

Table 1: Table of consolidated figures

	Consolidated figures table			
	CS2 (B)	CS2 (C)	CS3	CS4
Discounted PB period @ 15%				
ATCF1	>10	8,04	3,89	7,89
ATCF2	>10	8,08	4,10	8,03
ATCF3	>10	8,11	4,34	8,06
After Tax Internal Rate of Return				
ATCF1	13%	34%	49%	36%
ATCF2	12%	33%	48%	35%
ATCF3	12%	32%	47%	34%

Conclusion

This research served to investigate whether the issue of the oversupply shipping containers could be used to address the issue of the lack of supply of affordable student accommodation. Essentially asking the question of whether containers are suitable for the construction of student accommodation and what it would take to implement container student housing in the context of South Africa. This outcome was achieved by constructing the research question and objectives, conceptualised by a thorough literature review, following the appropriate methodology to gather findings and, finally, drawing the conclusions pertaining to the original objectives. These conclusions are presented in this section.

Realisation of Research Objectives

i. *Understand what the requirements are for a typical student-housing unit in terms of amenities and dimensions.*

It is generally understood that the rental determines the quality and amenities available in typical student accommodation. Often facilities such as toilets and kitchenettes are communal and shared although students are prepared to pay higher rentals for self-contained units where amenities are shared between two people.

ii. *Analyse the drivers behind the growing interest in container architecture.*

The adoption of container architecture is driven by the structural benefits that such units hold, which translates into, cost saving, time saving and better sustainability.

iii. *Analyse international case studies where reused shipping containers have been successfully integrated into developments.*

Uittenbroek and Macht (2009), Botes (2013),Grant (2013) and Islam *et al.* (2016) provide various examples and identify similar patterns that arose in the literature.

iv. *Identify the challenges that container developments may face in a South African context.*

These were identified to be the negative stigma, fluctuations in Rand Dollar exchange rates, and the lack of affordable land in suitable locations.

v. *Evaluate the financial feasibility of using shipping containers for student housing units.*

Containers proved to viably address the shortage of student accommodation within the affordable range of R3 000 per room per month.

vi. *Examine the feasibility of such units from both developers' and investors' points of view.*

The analysis revealed containers to offer attractive returns from the developers' perspective while incorporating various costs of finance from a lender's perspective.

Realisation of Research Question and Proposition

"What is required to implement shipping containers as an environmentally and financially suitable solution to student accommodation?"

The research proposition is supported, based on both the qualitative data obtained in the findings as well as the quantitative data obtained through the conducting of the financial feasibility studies. Containers can be used as a suitable approach to address the shortage in affordable student accommodation. Due to their structural characteristics, containers are perfectly suited for the application of student accommodation and the corresponding time and cost saving benefits allow for financially viable construction that meets an affordable level of rental. In order to implement containers as an environmentally and financially suitable solution to student accommodation, the negative stigma surrounding living in container housing needs to be overcome. Furthermore, the establishment of effective PPP is needed in order to overcome the remaining challenges and develop large scale, affordable student accommodation in South Africa.

Proposed Roadmap to Affordable Student Accommodation

Based on the outcomes of the research findings, a consolidated model that incorporates the literature and the findings has been developed as shown in Figure 1. *Roadmap to Affordable Student Accommodation*. The roadmap indicates the inability of conventional construction practices to meet affordable student housing demand and reveals that containers can offer a solution to add to supply. Adopting the use of containers has its own set of challenges that need to be overcome. However, with the establishment of effective PPPs, these challenges can be overcome and containers can be used to provide affordable student accommodation at scale that is environmentally sustainable, financially viable.

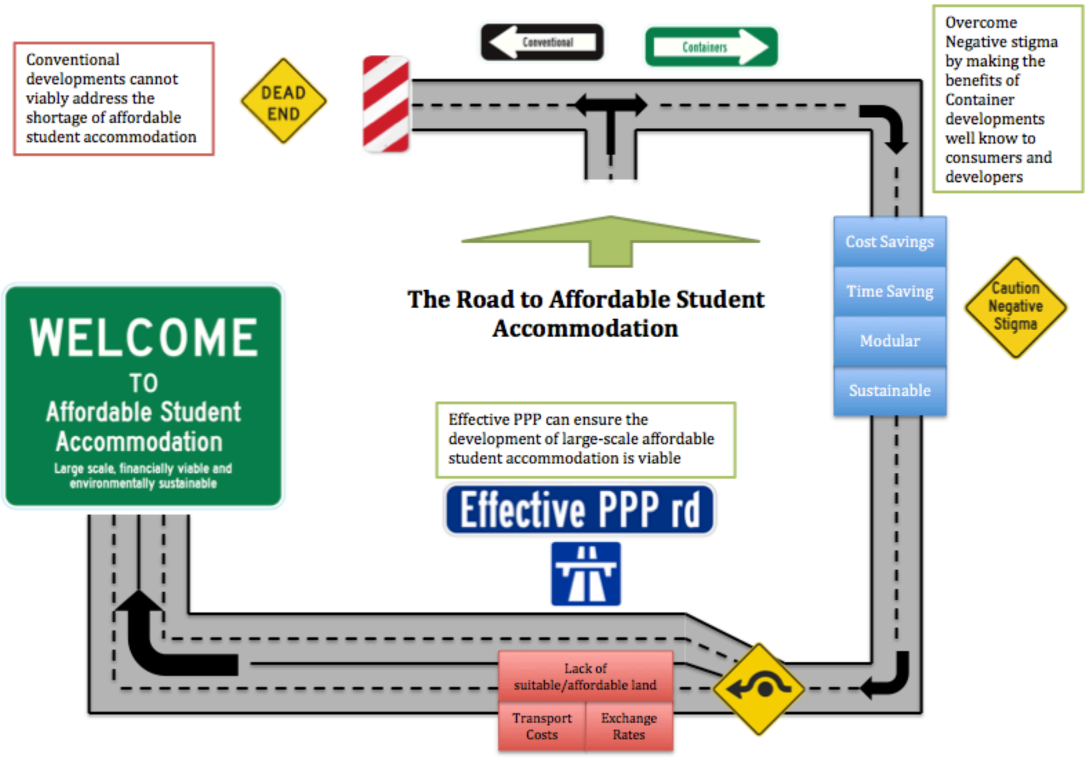

Figure 1. A roadmap to sustainable, viable and affordable student accommodation using container units.

Recommendations for Implementation

The following are recommendations proposed by drawing on the conclusions herein. They pertain to the implementation of affordable student accommodation by government and private sector within a South African Context.

1. ***Encourage the adoption of prefabricated container housing for student accommodation:*** These container homes have proven to have the potential to offer a viable and cost-effective solution to the student housing shortage. From an investment perspective, they have shown to make economic sense and provide an attractive return for both the finance Lender and the Borrower while still meeting the levels of affordability and quality required by the consumers. Encouragement comes from banks and other financial institutes that offer finance for container developments, perhaps even at a

favourable rate in order to incentivise container development. Government could also encourage their use in low cost housing programs as a suitable means of providing affordable, high-density rental schemes in urban areas.

2. ***Promote Public Private Partnerships***: The success of any student accommodation is reliant on the land on which it is situated, its proximity to the university and other amenities, and its affordability to the students. It is imperative for government and universities to come together and provide developers with suitable land in order to effectively combat the student housing shortage. Containers have provided an economically viable approach for developers; the land is the only remaining factor limiting its implementation.

Recommendations for Further Research

1. Investigate other alternative building practices and compare them to container housing in terms of their potential for affordable student accommodation.
2. Conduct a comprehensive feasibility analysis for each case study
3. Evaluate the viability of large-scale student accommodation developments using containers.
4. Segment and analyse the student accommodation market.

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