Journal of Geography and Regional Planning Vol. 5(12), pp. 328-338, 30 June, 2012
Available online at http://www.academicjournals.org/JGRP
DOI: 10.5897/JGRP12.026
ISSN 2070-1845 ©2012 Academic Journals

Full Length Research Paper

Drivers of housing technology adoption in South Africa

Oludele Akinloye Akinboade* and Mandisa Putuma Mkowena

Independent Consultant, Pretoria, South Africa.

Accepted 4 May, 2012

This study seeks to understand factors influencing the adoption of housing technology by home builders in South Africa. Builders that construct simplexes are more cautious in technology adoption. Those that construct simplexes and apartments are more likely to stick to tried and tested housing technologies. The most influential sources of new technology advice are sub-contractors, home buyers and National Home Builders Registration Council (NHBRC) seminars. That South African builders are cautious about improving building styles implies that membership of the National Home Builders Registration Council needs to strengthened and that the council needs to be used as the platform to educate builders about advantages of building improvements.

Key words: Technology adoption, housing sector, home builders and South Africa.

INTRODUCTION

In 1994, South Africa crossed into a new era that saw the end of the nefarious apartheid regime and the beginning of a new democratic era. The end of apartheid marked an end to the state policies (including housing) that supported racial discrimination and segregation. In line with the new dispensation the democratic government formulated a white paper on housing, entitled, "A new Housing policy and Strategy for Housing". This policy is based on the principle of capital subsidy. A strong targeting mechanism is used, in which subsidy allocations are based on household income, with the lowest earners accessing the full grant and those earning close to R3500 accessing a lesser grant (Adler and Oelofse, 1996: 116). Therefore, by 2006, 2.4 million houses were built but the official backlog, as of 2007, still stood at about 2.2 million houses.

The rate of technological change in the home building industry in South Africa is not fully understood by managers in other industries, academics, and the wider public as a whole. It is puzzling why some individual home builders adopt new technologies faster or at higher rates than others? It is important to know the determinants of technology adoption so that it can help predict adoption patterns and how to encourage adoption of beneficial technologies.

This paper examines drivers of technology adoption in the housing sector of South Africa. An empirical investigation into the adoption of technological innovations by small- and medium-sized home building firms was conducted using multiple regression analysis of data collected from interviewing over 120 home builders across South Africa.

The overall aim is to determine what distinguishes home builders who are early adopters of technological innovations from others. These should explain the reasons for adoption of housing technologies before they are widely diffused to others.

The importance of technology to the sector would be highlighted before the literature is reviewed on technology adoption in the housing sector. Then the theory of diffusion comes next, while research method and results of the study follows. Factors influencing the adoption of housing technology by home builders in South Africa are later examined and lastly conclusion.

IMPORTANCE OF HOUSING IN ECONOMIC AND SOCIAL DEVELOPMENT

It is widely acknowledged that housing is important to people's quality of life and health. Apart from being a very valuable asset, housing has a much wider economic, social, cultural and personal significance. The processes

*Corresponding author. E-mail: economist_oa@yahoo.com. Tel: 076 631 2263.

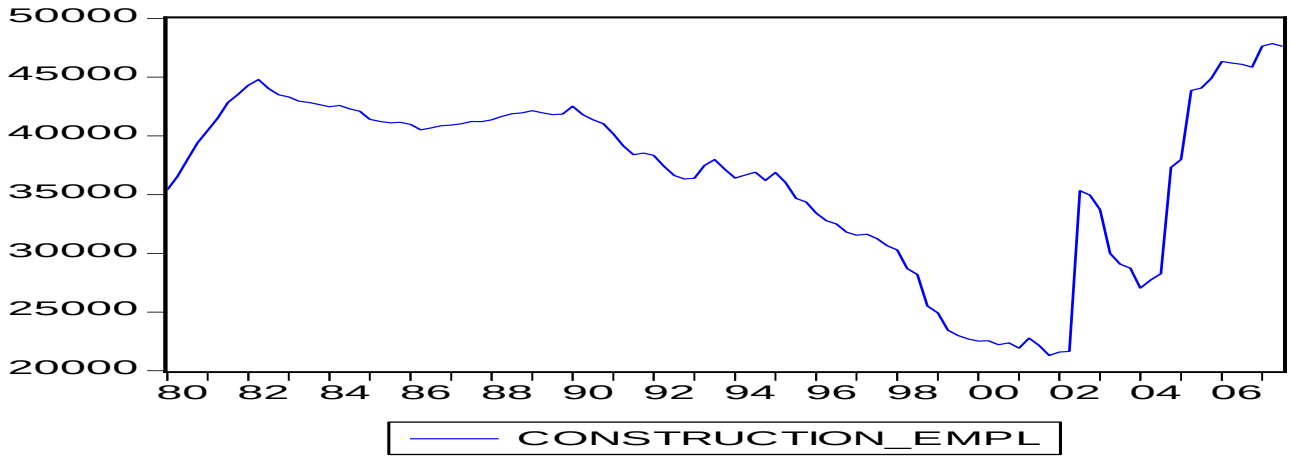

Figure 1. Construction employment 1980 to 2007. Source: South African Reserve Bank (SARB), 2008.

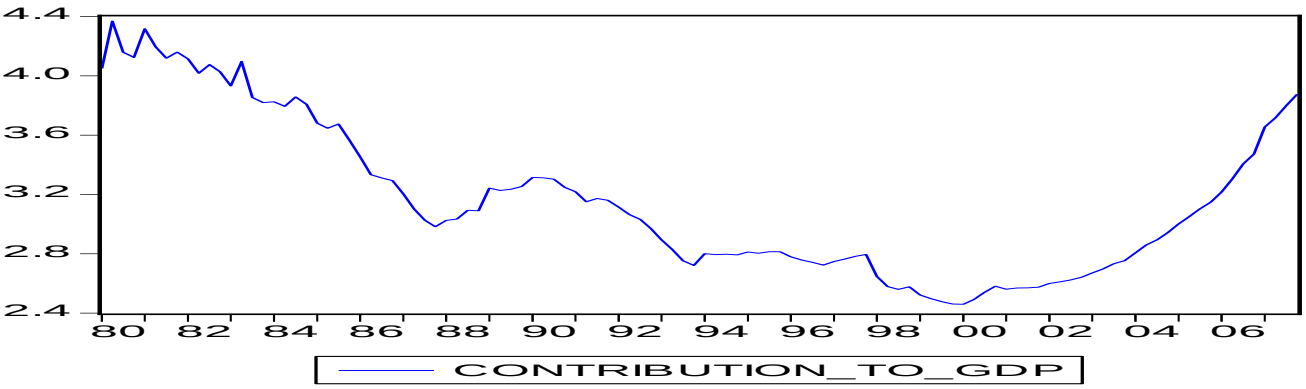

Figure 2. Sector's contribution to GDP**.** Source: South African Reserve Bank (SARB), 2008.

leading to the construction of houses, from deeds registration, the approval of house construction plans, the construction of houses, the manner of house exchange etc., all have an impact on economic development goals such as equity and poverty eradication. For example, house construction techniques and location of housing can influence and be influenced by cost consideration, raw material availability, cultural and religious affiliations etc (Figure 1).

Housing construction is particularly important in employment generation, particularly for unskilled labour. As such, the construction industry is the third-largest source of employment in South Africa. Employment in construction has escalated since 2002 and currently stands at around 47,620, though the sector's share of total non-agricultural employment remains small at 0.57 at the end of the third quarter of 2007 down from 0.8 as achieved in 1980. Between December 2006 and September 2007, 1771 new jobs were created in the construction sector or about 1.3% of new jobs created in the non-agricultural sector of the economy (Figure 2).

Importance of technology to industry

Adoption is said to occur when an organization invests in and uses an innovation. This process takes place in two stages. When it involves primary adoption, it is an organization-level decision to adopt an innovation, while secondary adoption involves adoption of the innovation by individual users in the organization (Zaltman et al., 1973; Russell and Hoag, 2004).

Lall (2001) recognizes the sheer speed and magnitude of technical change which make the *ability to innovate and use new technologies* critical to industrial success. He suggests that old technologies do not fade away but often become redundant at all factor prices. He suggests that being an efficient and competitive producer does not require generating frontier technologies but using technologies effectively as they appear and change; and that for the bulk of the developing world it is the ability to efficiently absorb, use and adapt technologies that matters.

He further argues that technology-intensive activities

have stronger development benefits. They result in more sustained and deeper learning. They offer more prospects for continued productivity increase. They have more spillover benefits (by creating useful knowledge, skills and capabilities for other activities). Low technology activities do generate learning, but the stagnant technological base limits the learning that takes place.

Understanding home builder adoption behaviour is important in order to stimulate the diffusion of energy-efficient and environmentally-friendly innovations.

The propensity to adopt low uncertainty, non-diffused housing technological innovations is associated with having at least one individual with an architectural or engineering background involved in innovation-related activities. These individuals apparently apply engineering principles to reduce the uncertainty of innovations related to physical performance, but cannot reduce the uncertainty of high uncertainty innovations related to market acceptance. This propensity is also associated with having a more positive attitude about adoption of innovations and/or higher tolerance of uncertainty. This factor does not play a critical role in relatively early adoption of high uncertainty innovations apparently because it is overwhelmed by the need for effective gathering and processing of information about innovations.

It is popular to hold the view that the slow diffusion of building innovations is because home builders are excessively conservative and do not appreciate the benefits of technological innovation. Builders could interpret the uncertainty inherent in innovations as a high risk. Risk must be minimized because profit margins are so low that failure of any sort could result in a net loss on a project.

Alternative technology as a solution to South Africa's housing problem

Technology application is a crucial input in housing. Building materials could account for 65 to 75% of the total cost of construction in India (National Housing and Habitat Policy of India, 2008). In an effort to speed up housing delivery, the Gauteng Department of Housing (GDH) is complementing conventional housing construction with alternative building technologies. As a result, 17 houses were built in the Innovation Hub in Soshanguve near Pretoria, where different non-conventional building technologies were tested (Khoza, 2008).

There are two pilot projects initiated in the country. One project involves the construction of 858 houses in Kaalfontein extension 22, Ekurhuleni Municipality. Investec Bank Limited has partnered with Mino Global Properties (Pty) Limited, the company that has been awarded this contract. Through this partnership, Investec is providing bridging finance to carry out the contract and deliver much-needed houses within a period of five months.

The technology being used is such that houses are built using pre-cast, insulated concrete panels which are moulded in specifically designed steel moulds. The wall panels are being manufactured in a mobile plant on site and then erected on conventional foundations, joined together by specifically designed joints. The entire process from casting moulds to a completed house can take an average of eight hours and five houses can be built per day as compared to the three months it takes to build a house using conventional methods. Another pilot project is underway at Nomzamo where part-polystyrene bricks are used.

This will assist the GDH to meet its targets and provide a quality homes to the people. 'Alternative building technology is key in assisting government to accelerate the eradication of informal settlements.' The success of this project will provide an opportunity for similar projects throughout the country and speed up the process of housing delivery, hence eradicating the backlog (Khoza, 2008).

Similarly, the National Department of Housing is undertaking investigations in respect of the use of alternative building technologies which will meet all the requisite standards for quality, norms and standards and still facilitate rapid housing delivery.

THE THEORY OF DIFFUSION

The theory of diffusion is important in the field of the management of technology and innovation. It highlights the diffusion of innovations within communities and the adoption of innovations by individuals. Rogers (1995) stipulates five elements in the diffusion or adoption of innovations viz:

(1) Diffusion has four basic elements: innovations, social systems, communication channels, and time.
(2) There are two primary types of communication channels: mass media and interpersonal.
(3) The innovation-decision process can be conceptualized as having five stages: knowledge, persuasion, decision, implementation, and confirmation.
(4) There are three important aspects of the social system: social structure, norms, opinion leaders and change agents.
(5) The rate of diffusion of an innovation is influenced by five characteristics of the innovation: relative advantage, compatibility, complexity, trial-ability, observability.

REVIEW OF LITERATURE ON TECHNOLOGY ADOPTION IN THE HOUSING MARKETS

Much of the literature on technology adoption is inspired

by Mansfield (1968, 1989) who argue that expected profits play a prominent role in technology adoption. Therefore, the traditional economic point of view sees cost-benefit considerations and utility maximization as the main determinants of an individual's technology adoption decision (Faiers et al., 2007).

However, home building is a localized business in which home buyers respond to word-of-mouth effects more than to mass media or other types of advertising. A builder's reputation is therefore critically important to his success. Some factors encourage increased levels of innovation in the housing industry. These include the slowing down of growth in the industry. This causes home building companies to encounter pressure to maintain profit levels through more efficient operations (Baker, 2006). As home building slows and competition increases, theory suggests that builders may begin to innovate in order to increase their efficiency and therefore profitability.

The adoption of new technologies can provide substantial benefits to the housing industry. These include increased housing affordability, increased profitability, enhanced product quality and durability and reduced environmental footprint (Paevere and Mackinzie, 2007).

In general, the construction industry is regarded as a laggard as it is perceived to be tardy in adopting new innovations. This is attributable to the fragmented nature of the industry. Von Hippel (1988) suggests that the fragmented nature of an industry such as housing can serve to reduce the amount of innovation and diffusion. Fragmentation within the housing industry raises the costs of innovation because of the complex interactions among the various subcontractors that may be required to introduce or adopt new processes or products. Sometimes, it is the home buyers who are conservative and reject innovations by insisting that builders offer traditional materials and designs.

Oster and Quigley (1977) suggest that local codes and regulations, the extent of unionization, and the relative size of home building firms affect the adoption of innovation. Inconsistent local building codes could limit the potential market of innovations.

Innovation adoption is a mixture of push and pull influences (Warren, 2004). User perceptions of the characteristics of an innovation can affect its adoption. Up to thirty distinct characteristics of the particular technology have been found to significantly affect adoption (Tornatzky and Klein, 1982). These include the relative advantage the innovation offers compared to the costs involved in adopting it, its complexity and compatibility with the adopting organization, and how observable the results of the innovation are (Al-Qirim, 2003; Rogers, 1995; Russell and Hoag, 2004). Housing consumers are generally averse to risks and builders will adopt technologies in line with consumers preferences (Koebel et al., 2004).

Home builder's organizational environment is diverse involving a number of external groups and industries which may influence the effectiveness of the adoption decision. The following groups and industries, among others, often influence or are influenced by builders' technology adoption decisions:

1) Architects and other house designers
2) Institutions such as universities, especially the engineering faculties
3) Banks
4) Building material or component manufacturers
5) Building material retailers
6) Developers
7) Home buyers
8) Local building departments and planning boards
9) Realtors
10) Subcontractors
11) Local and national trade associations

There is considerable diversity among these groups, which makes communication and anticipation of their actions difficult, thereby increasing the uncertainty of the adoption decision. Most of the groups are in the private sector (for example, developers, banks, contractors), while several are in the public sector (for example, code agencies, building departments). Some have national or international operations (for example, raw material suppliers); others typically operate only in a small local area (for example, architects, contractors etc). Some of the organizations are product-oriented (for example, suppliers, manufacturers); others are service-oriented (for example, architects, banks). Several of the groups have distinct professions or occupational trades associated with them.

Koebel et al. (2004) studied innovation in residential building industry. They found the following characteristics associated with higher levels of adoption of new products, materials, and practices in home building. The types of home building firms most likely to be early adopters were:

(1) Modular builders and multifamily builders.
(2) Single-family custom home builders.
(3) National and regional builders.

These more innovative firms were also more likely to:

(1) Have a technology advocate within the building firm.
(2) Stress the importance of being creative and the first to use new products.
(3) Use technology transfer programmes like the Partnership for Advancing Technology in Housing (PATH) and universities.
(4) Use union labour at least sometimes.

These firms also stressed the importance of:

(1) Homebuyers who are aware of and want new products and materials.
(2) Reliance on established manufacturers standing behind their building and construction products.

The types of home building firms that wait until new products, materials, and practices have been around much longer were more likely to be local firms and single-family production builders.
These later adopters also were more likely to:

(1) Emphasize marketability and profit.
(2) Associate the firm's success with land development.
(3)Emphasize the "tried and true" and the risks of new materials and products (marginal statistical significance).

Large builders seem to be first to adopt new materials that offer a cost savings, improvements in production, reduced call-backs, or reduced exposure to liability. Smaller builders are often first to adopt technologies where high consumer awareness of a material exists, the price of the new technology is significantly higher than what it replaces, or the home construction process must be substantially altered Koebel et al. (2004).

RESEARCH METHOD

The propensity to adopt housing technology is examined for a random sample of 120 home builders in South Africa. Data has been collected through a semi-structured questionnaire administered to ascertain the extent and drivers of technology acquisition in the housing sector of South Africa during the previous five years. On other occasions, it was followed by direct face-to-face interviews necessary to ensure data validation. The variables included in the questionnaire are the particular type of housing technology to be adopted, the age of business, whether the firm engages in any multi-family construction etc.

The study seeks to explain what factors explain differences in the builders' technology adoption decisions.

(1) Which category of home builders are likely to be early adopters of particular types of building technology compared with others?
(2) What approaches do home builders use in technology adoption?
(3) What types of building technologies have been tried and tested previously and which ones have been discontinued upon trial by home builders.
(4) Which professional category has the most influence on building technology adoption?
(4) To what degree can technology adoption be explained by perceived economic and non-economic factors including, access to information sources, and specialization in building construction types?

RESULTS

Nature of business

The average life of businesses is 13.5 (almost 14 years), this means that most builders started their businesses after 1994. This could be attributed to the need for houses as there was a serious backlog inherited from the apartheid regime. The consequences of this backlog were physically reflected in overcrowding, squatter settlements and increasing land invasions in urban areas, and generally by the poor access to services in rural areas.

Socially and politically, this backlog gave daily impetus to individual and communal insecurity and frustration, and contributed significantly to the high levels of criminality and instability prevalent in many communities in South Africa, hence there was an urgent need for new houses to be built to counteract this problem. It is evident from the results of the survey that the houses built are balanced (for example, 81 town houses, 74 simplexes, 77 single family detached houses and 78 apartments). This means there is a consistent demand for all types of housing in the country.

Approach to technological diffusion

On the issue of selecting new housing technologies, the builders prefer to use the standard of materials that meet but not exceed the current code minimum and market expectations. Only few builders adopt new technologies. This is understandable as it is difficult to just accept the new technology at the first instance for businesses as they are sceptical of risks that might occur when using the new technology hence they prefer to stick to "tried and tested".

The firms have admitted that they are likely to invest time or money to improve the ability to purchase and develop the best land in the next 5 years. This is very likely as businesses know that investing in the best land would bear profits in the near future as more people will be demanding new houses. Surprisingly though, firms are not willing to invest their time or money to reduce defects or call-backs in houses being built. This explains the poor quality of houses that are being built around the country recently. Builders are more concerned about reaching the target on a particular period compromising quality. This in turn is a waste of funds as they will be required to rebuild at an extra cost should a situation like that arise. Results were obtained regarding adoption of technologies (Table. 1).

Rain water catchments and storage technology is cited the highest rated *neve*r *tried* followed by wind and petrol driven rope water pumps and solar electricity or solar distillation and geyser technology. Wind and petrol driven rope water pumps, Solar distillation and geysers and Insulated concrete wood and cement bricks are housing technologies that are cited the most as *tried and discontinued*. Insulated concrete forms, wood-cement composite panels, solar electricity or insulated concrete wood and cement bricks are the technologies *that* are most in current use (Table 2).

Panelised walls, light gauge steel exterior walls and structural insulated panels are housing technologies that are cited the most as never been tried. Light gauge steel

Table 1. Products that the firms have ever tried, tried but discontinued, or are currently being used during the past 5 years.

Product	Never tried (%)	Tried but discontinued (%)	Currently using (%)
Solar distillation and geysers	23	34	42
Wind and petrol driven rope water pumps	37	35	28
Insulated concrete wood and cement bricks	13	34	53
Wood-cement composite panels (WCCP)	11	33	55
Insulated concrete forms (ICF)	13	28	59
Solar electricity	23	24	53
Rain water catchment and storage	47	32	21

Table 2. Building products that firm has ever tried, tried but discontinued, or is currently using during the past 5 years.

Product	Never tried (%)	Tried but discontinued (%)	Currently using (%)
Structural insulated panels (SIP)	32	38	30
Light gauge steel exterior walls	36	46	28
Panelized walls	38	30	42
Ultra-high-efficiency (HVAC)	25	35	40
Fibre cement siding	14	38	48
Wood/plastic composite decking lumber	23	34	43
Fibre glass doors	25	12	63

Table 3. Modeling builders' decision to wait for a while before technology adoption.

	Coefficient	Standard error	t-value	t-probability
Constant	-1.30199	0.7481	-1.74	0.084
Age business	-0.0371884	0.04510	-0.825	0.411
Duplex	-0.0310288	0.6755	-0.0459	0.963
Simplex	-1.20310	0.7017	-1.71	0.089*
Single house	0.560199	0.6887	0.813	0.418
Apartment	-0.370681	0.6733	-0.551	0.583
Log-likelihood	Number of states	Number of observations	Number of parameters	Baseline log-likelihood
-35.9936039	2	120	6	-39.00996
Test: Chi^2(5)	AIC	AIC/T	Mean(await adoption)	Var (await adoption)
6.0327 [0.3030]	83.9872079	0.699893399	0.1	0.09

Newton estimation (eps1=0.0001; eps2=0.005): Strong convergence; * represents significance at 10% level of significance.

exterior walls structural insulated panels (SIP) and fibre cement siding are cited the most as housing technologies *tried but discontinued*. Fibre glass doors, fibre cement siding and Wood/plastic composite decking lumber are cited as technologies that are *most in current use*.

Logit model of technology adoption

A logit model is estimated to evaluate the factors influencing the adoption of housing technology by home builders in South Africa. The logit analysis models are used to test the probability of home builders identifying particular factors as influencing their decision to adopt building technologies. The logit method is useful because the dependent variables that the study intends to test are binomial (Table.3).

It appears that builders that construct simplexes are more cautious in technology adoption. Results are not significant for builders of duplexes, single houses and apartment complexes. Neither is the age of business important in explaining builders' decision to adopt a cautious approach to technology adoption (Table 4).

Builders that construct single houses and apartments are more likely to be the first to adopt housing technology. Results are not significant for builders of duplexes and simplexes. Neither is the age of business important in explaining builders' decision to be an early adopter of building technology (Table 5). Builders that construct simplexes and apartments are more likely

Table 4. Modeling builders' decision to be the first to adopt housing technology.

	Coefficient	Standard error	t-value	t-probability
Constant	-2.22263	0.6564	-3.39	0.001
Age business	-0.0468479	0.03009	-1.56	0.122
Duplex	-0.0345553	0.5582	-0.0619	0.951
Simplex	0.425817	0.5189	0.821	0.414
Single house	1.26914	0.5715	2.22	0.028**
Apartment	1.01453	0.5559	1.83	0.071*
Log-likelihood	Number of states	Number of observations	Number of parameters	Baseline log-likelihood
-63.0695343	2	120	6	-71.52888
Test: Chi^2(5)	AIC	AIC/T	Mean(first to adopt)	Var (first to adopt)
16.919 [0.0047]***	138.139069	1.15115891	0.283333	0.203056

Newton estimation (eps1=0.0001; eps2=0.005): Strong convergence;***, **,* represent significance at 1, 5 and 10% levels respectively.

Table 5. Modeling builders' decision to stick to tried and tested technology.

	Coefficient	Standard error	t-value	t-probability
Constant	-1.14650	0.6724	-1.71	0.091
Age business	-0.0799122	0.03972	-2.01	0.047**
Duplex	0.689509	0.6638	1.04	0.301
Simplex	1.34588	0.6457	2.08	0.039**
Single house	-0.294759	0.6424	-0.459	0.647
Apartment	-1.40207	0.6301	-2.23	0.028**
Log-likelihood	Number of states	Number of observations	Number of parameters	Baseline log-likelihood
-45.1108418	2	120	6	-52.4275
Test: Chi^2(5)	AIC	AIC/T	Mean(stick to tried)	Var (stick to tried)
14.633 [0.0120]**	102.221684	0.851847363	0.158333	0.133264

Newton estimation (eps1=0.0001; eps2=0.005): Strong convergence;** represents significance at the 5% level of significance.

Table 6. Modeling builders' decision not to exceed building code minimum.

	Coefficient	Standard error	t-value	t-probability
Constant	-0.731459	0.4946	-1.48	0.142
Age business	0.0726930	0.02720	2.67	0.009***
Duplex	0.236430	0.4863	0.486	0.628
Simplex	0.164562	0.4551	0.362	0.718
Single house	-1.37748	0.4663	-2.95	0.004***
Apartment	-0.193504	0.4687	-0.413	0.681
Log-likelihood	Number of states	Number of observations	Number of parameters	Baseline log-likelihood
-70.7188782	2	120	6	-79.88069
Test: Chi^2(5)	AIC	AIC/T	Mean (not exceed code min)	Var (not exceed code min)
18.324 [0.0026]***	153.437756	1.27864797	0.383333	0.236389

Newton estimation (eps1=0.0001; eps2=0.005): Strong convergence; *** represents significance at the 1% level of significance.

to stick to tried and tested housing technologies. Older businesses tend to innovate. This is because age of business is negatively correlated with the decision to stick to tried and tested technology. Builders of duplexes and single houses do not stick to tried and tested technologies (Table 6).

Older businesses tend not to exceed minimum building codes. Building single houses is negatively associated with the decision not to exceed minimum building codes (Table 7). Builders of simplexes attempt to exceed minimum building codes while those that build apartments significantly do not (Table 8).

Table 7. Modeling builders' decision to exceed minimum building code.

	Coefficient	Standard error	t-value	t-probability
Constant	-1.47300	0.7907	-1.86	0.065
Age business	-0.0606660	0.04454	-1.36	0.176
Duplex	-0.451332	0.7279	-0.620	0.536
Simplex	1.80161	0.7576	2.38	0.019**
Single house	0.307123	0.7378	0.416	0.678
apartment	-2.02735	0.7500	-2.70	0.008***
log-likelihood	Number of states	Number of observations	Number of parameters	Baseline log-likelihood
-34.4680106	2	120	6	-43.22766
Test: Chi^2(5)	AIC	AIC/T	Mean (exceed code min)	Var (exceed code min)
17.519 [0.0036]***	80.9360212	0.674466843	0.116667	0.103056

Newton estimation (eps1=0.0001; eps2=0.005): Strong convergence; ***, ** represent significance at 1% and 5% levels respectively.

Table 8. Modeling builders' decision to improve building styles.

	Coefficient	Standard error	t-value	t-probability
Constant	0.838070	0.6158	1.36	0.176
Age business	-0.00802293	0.03374	-0.238	0.812
Duplex	0.496648	0.5886	0.844	0.401
Simplex	0.938464	0.5906	1.59	0.115
Single house	0.338040	0.5676	0.596	0.553
Apartment	0.272259	0.5965	0.456	0.649
log-likelihood	Number of states	Number of observations	Number of parameters	Baseline log-lik
-44.009817	2	120	6	-47.12094
Test: Chi^2(5)	AIC	AIC/T	Mean (Improve style)	Var (Improve style)
6.2222 [0.2852]	100.019634	0.83349695	0.866667	0.115556

Newton estimation (eps1=0.0001; eps2=0.005): Strong convergence.

Builders in South Africa are cautious about improving building styles. None of the factors included in the model is significant. The age of business or the type of building specialty of home builders influences their decision to adopt technologies that can improve building styles.

Drivers of housing technology adoption

In this study, the dependent variable is the propensity to adopt high/low uncertainty housing technologies that are not widely diffused. This has been measured by the number of technological innovations that a builder has reported using regularly from a list of housing technologies included in the survey (Table 9).

As expected, engineers have the most influence over the businesses' decision to use a new type of technology, followed by managers and then project or construction managers. This could be attributable to the fact that they are updated about new technologies and products that incorporate sustainable building materials (Table 10).

Engineers are also the main decision makers when it comes to the advocacy of new housing or construction products, materials and practices. This is because an engineer is able to determine what it takes to keep the house in place. For example, foundation walls may require additional steel, or firms may have to use a stronger type of concrete. Following them, the other influential decision makers are project or construction managers.

In the case of professionals that make decisions on switching of building materials, purchasing new building materials and changes in house designs and construction processes, managers are the main decision makers in most companies concerning switching. Sales or marketing managers also have a serious input (Table 11). Purchasing managers are the ones who have the most influence when it comes to the purchase of building materials. They are the ones familiar with the costs attached to the products needed for building (Table 12).

Engineers are the main decision makers when it comes to home design followed by the project or construction manager and the designer or architect (Table 13). Sales or marketing managers are the main decision makers when it comes to the construction process as they are the ones who determine the cost of the final product to the

Table 9. Professionals that have the most influence over the decision to use a new type of technology.

Professional category	Proportion of respondents' view (%)
General manager/owner/president/partner	41.6
Purchasing manager	9.2
Designer or architect	28.3
Engineer	56.7
Project or construction manager	34.2
Sales or marketing manager	5.8

Table 10. Professionals that have a strong advocacy of new housing or construction products, materials, and practices.

Professional category	Proportion of respondents' view (%)
General manager/owner/president/partner	22.5
Purchasing manager	13.3
Designer or architect	20
Engineer	45.8
Project or construction manager	35
Sales or marketing manager	5

Table 11. Professionals that have most input on decision of buying building materials.

Professional category	Proportion of respondents' view (%)
General manager/owner/president/partner	16.4
Purchasing manager	24.6
Designer or architect	11.5
Engineer	13.1
Project or construction manager	15.6
Sales or marketing manager	18.9

Table 12. Professionals that have most input on decision in home design.

Professional category	Proportion of respondents' view (%)
General manager/owner/president/partner	15
Purchasing manager	30.8
Designer or architect	38.3
Engineer	48.3
Project or construction manager	42.5
Sales or marketing manager	28.3

client. Another serious input comes from project or construction managers as they are the ones who make decisions on the ground.

Influence of information sources on technology diffusion in the housing sector

Reaching out into the environment for information about innovations that are being considered for adoption helps potential adopters reduce both task-related and environment-related sources of uncertainty associated with innovations. Potential sources of information include: architects and other house designers, home buyers, local material suppliers, trade magazines, manufacturers' literature and service representatives, other builders, seminars and trade shows, and subcontractors. Builders who talk with manufacturers' sales representatives, or

Table 13. Professionals that have most input on decision of the construction process.

Professional category	Proportion of respondents' view (%)
General manager/owner/president/partner	5.2
Purchasing manager	6.1
Designer or architect	19.1
Engineer	14.8
Project or construction manager	24.4
Sales or marketing manager	30.4

Table 14. Influence of information sources on housing technology adoption.

Information source	Not influential (%)	Very influential (%)
Consultants	16.7	14.1
Trade shows	6.7	20
Home buyers	8.3	34.2
Internet/world wide web	9.2	19.2
Mail or fax advertisement	10.0	24.2
Sales and supplier representatives	7.5	17.5
Manufacturers' toll free numbers	6.7	20.8
NHBRC seminars	15.0	28.3
Observing other builders	19.2	11.7
Public Seminars	12.5	27.5
Sub-contractor advice	5.8	39.2
Trade publications	13.3	10.8
Universities and Universities of technology	39.2	20

view and touch an innovation at a lumberyard or home show are more apt to understand how the product works than are builders who just see pictures of the product in trade magazines. Builders who ask one or two home owner customers for their opinion of an innovation are less likely to be uncertain about whether future customers will reject the use of the product in their homes.

The study sought to know how influential each of the following information sources are in keeping South African builders up to date on new building and construction products, materials and practices. The study seeks to examine whether the adoption of non-diffused technologies is facilitated by tapping into many sources of information about innovations. These include:

1) Architects / house designers
2) Homeowners / customers
3) Local material suppliers
4) Magazines, newspapers, and newsletters
5) Manufacturers literature and service reps
6) Other builders
7) Results of your own testing (such as laboratory or field tests other than trying it in one of your houses)
8) Seminars and trade shows
9) Subcontractors (Table 14).

The most influential sources of new technology advice are sub-contractor advice, home buyers and NHBRC seminars. Universities and universities of technology are mentioned as the least influential as information sources regarding new technologies followed by observing other builders.

Conclusion

This study has examined factors influencing the propensity to adopt housing technologies for a sample of 120 home builders in South Africa. We have studied a number of housing technologies and examined whether they are currently being used, tried and abandoned or never tried. There is a need to further promote the use of rain water catchments and storage technology, wind and petrol driven rope water pumps and solar electricity or solar distillation and geyser technology. Similarly, panelised walls, light gauge steel exterior walls and structural insulated panels, light gauge steel exterior walls structural insulated panels (SIP) and fibre cement siding should be promoted. This will be more useful if engineers embrace them given the role that engineers play in the building process in South Africa. Builders that

construct simplexes are more cautious in technology adoption. Those that construct simplexes and apartments are more likely to stick to tried and tested housing technologies.

The most influential sources of new technology advice are sub-contractor advice, home buyers and NHBRC seminars. That South African builders are cautious about improving building styles implies that membership of the National Home Builders Registration Council needs to strengthened and that the council needs to be used as the platform to educate builders about advantages of building improvements. The link between South African universities and universities of technology with the home building industry needs to improve.

REFERENCES

Adler T, Oelofse M (1996). The Housing Subsidy Scheme. In Rubenstein S, Rust K (eds). A Mandate to Build. Cape Town: IDASA.

Baker K (2006). Market Data for Housing Innovation: A Policy Agenda and Plan, Joint Center for Housing Studies, Harvard University, November. W06-6.

Faiers A, Cook M, Neame C (2007). Towards a contemporary approach for understanding consumer behaviour in the context of domestic energy use. Energy Policy, 35(8): 4381-4390.

Khoza N (2008). Delivering low cost housing using alternative technology, TradeInvest SA, 22 May. Available from http://www.tradeinvestsa.co.za/news/229476.htm, accessed 3-09-08

Koebel CT, Papadakis M, Houdson E, Cavell M (2004). The diffusion of innovation in the building industry. Available at http://www.huduser.org/Publications/PDF/Diffusion_Report.pdf, accessed on 13-09-2008.

Lall D (2001). National strategies for technology adoption in the industrial sector: Lessons of recent experience in the developing regions, Background paper for the United Nations Development Programme's Human Development Report 2001: Harnessing Technology for Human Development.

Mansfield E (1968). Industrial Research and Technological Innovation. Norton, New York, USA.

Mansfield E (1989). The Diffusion of Industrial Robots in Japan and The United States, Res. Policy, 18:183-192.

National housing and habitat Policy of India (2008). Chapter 25, Housing. Available from http://www.amb-inde.fr/pdf/chp25.pdf, accessed 3-09-2008.

Oster SM, Andquigley JM (1977). ‘‘Regulatory Barriers to the Diffusion of Innovation: Some Evidence from Building Codes,’’ Bell J. Econ. 8**:** 361–377.

Paevere P, Mackinzie C (2007). Emerging technologies and timber products in construction- literature review. Forest and wood products research and development corporation, Australia.

Rogers EM (1995). Diffusion of Innovations. The Free Press, New York, NY.

Russell DM, Hoag AM (2004). People and information technology in the supply chain: Social and organizational influences on adoption, Inter. J. Phys. Distr. Logist. Manag., 34(2): 102-122.

South Africa Revenue Service (2008a). Overview of the housing sector, Pretoria.

South African Reserve Bank (2008b). Electronic Database, Pretoria.

Tornatzky LG, Klein KJ (1982). Innovation characteristics and innovation adoption implementation: a meta-analysis of findings. IEEE Trans. Eng. Manag., 29(1): 28-45.

Warren M (2004). Farmers online: drivers and impediments in adoption of Internet in UK agricultural businesses. J. Small Bus. Enterp. Dev., 11(3): 371-381.

Zaltman G, Duncan R, Holbeck J (1973). Innovations and Organisations, Wiley & Sons, New York.