# ADOPTION OF ALTERNATIVE TRANSPORT TECHNOLOGIES IN THE CONSTRUCTION INDUSTRY

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**ABSTRACT**
This research examines how the construction industry adopts alternative transport technologies. This paper presents the general characteristics of the adopter and what his perceptions are towards innovative transport technologies. The study focused on four rates of innovation, related tot alternative transport technologies. The results show that 83% of the respondents choose innovation over no innovation; more than half of the respondents choose an innovation that can be characterized as "architectural". Further, the perceived benefits of the innovation characteristics for an incremental innovation are higher then the perceived benefits for an architectural or radical innovation. Finally, from the ventures that chose to innovate, smaller companies prefer an architectural - more challenging - innovation rather then an incremental innovation.

**Keywords**: adoption processes, transport technologies, construction industry

## INTRODUCTION

Transportation of materials in the construction industry is surrounded by a number of logistical problems, such as bad transport planning, long waiting times at construction sites, and strict environmental regulations and time schedules (Agapiou et al., 1998; Cox and Ireland, 2002; Risku and Kärkkäinen, in press; Voordijk, 2000). There are, however, several technologies available to solve these problems. Examples of these technologies are the application of ICT and simulation tools when planning transport (Ort and Schoormans, 2004; Power and Simon, 2004; Russell et al., 2004) and the implementation of alternative transport technologies besides the dominant mode of road transport when transporting construction materials.

In general, benefits from new technologies depend on the extent to which these technologies are adopted and utilized (Mitropoulos and Tatum, 1999). The construction industry has a reputation of being slow in adopting and utilizing new technologies. Our understanding of how construction organizations make decisions to adopt new technologies is very limited. Several important questions remain. How does the need for technological change emerge? How do managers select new technologies? Is innovation driven by company goals, internal and external organizational actors, or does it happen only when environmental conditions allow it?

The purpose of this study is to provide insights in the in the adoption processes of a particular set of technologies in the construction industry and the factors affecting these processes. Research focuses on the adoption of new transport technologies in the construction industry.

The conceptual framework is based on literature on technology-adoption and entrepreneurship. Empirical research focuses on a particular part of the construction industry; the road construction industry. The outline of the paper is as follows. First, our theoretical framework is introduced. Secondly, we characterise processes in the road construction industry. Then, the research design and the first empirical results are presented. The paper ends with discussion and conclusions.

**THEORETICAL FRAMEWORK**

Entrepreneurship is a process, directed by the entrepreneur (individual or organization), in which opportunities are recognized, prepared and exploited. The aim of this process is creating value (Van der Veen and Wakkee, 2004). The first stage of the process, *opportunity recognition*, is the stage where the entrepreneur identifies initial ideas. The second stage, *opportunity preparation*, is where the entrepreneur develops the initial ideas into feasible concepts. The last stage, *opportunity exploitation*, is where the opportunity is realized and brought to exploitation. This process takes places in a social system (Groen, 2005; Parsons, 1977). The process and the social system theory together make up the Entrepreneurship in Networks (EiN) model. This model conceptualizes that within the entrepreneurial process four kinds of capital are accumulated to create value:

- Economic capital; can be seen as the financial resources, mainly money, a venture has available.
- Strategic capital; can be seen as the way a venture positions itself in the market, and attains a certain power.
- Cultural capital; can be seen as the knowledge, know-how, experience, and values a venture puts into practice
- Social capital; the relations an entrepreneur and his venture has with his environment, how he acts in his network.

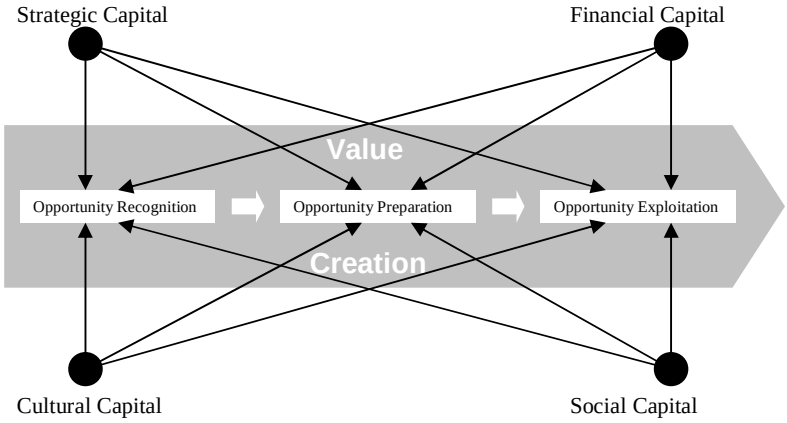


*Figure 1 - EiN model (Van der Sijde et al., 2005)*

The central hypothesis of the EiN model (see Figure 1) is that entrepreneurs for each of these four dimensions will need sufficient capital to create sustainable enterprises within networks (Groen, 2005). Schumpeter (1934) associates entrepreneurship with innovative and change oriented behavior, whereas the latter include also task-related motivation, expertise, and expectation of gain for self. Entrepreneurs need to create value, for this the need new innovative ways to achieve this. In general, there are three types of innovation.

- The first one is incremental or continuous innovation, this concerns step by step minor improvements of products processes or services. It can be seen as some kind of an evolution theory, in which the species “upgrades” itself slowly to the environment.
- The second type of innovation is the discontinuous or radical innovation; this type of innovation permits entire industries and markets to emerge, transform, or disappear providing a firm a significant advantage (DeTienne and Koberg, 2002). Consequently,

this type of innovation usually triggers the Schumpeterian process of creative destruction (1934).
- The last, the architectural innovation applies technological or process advances to fundamentally change some component or elements of the business (O' Reilly and Tushman, 2004). This innovation is, compared to the other two types, an 'in between' innovation.

The innovation in general is defined as an idea, practice, or object that is perceived as new by an individual or unit of adoption. Adoption is a decision to make full use of an innovation as the best course of action available (Rogers, 1983).

A mainstream general theory on adoption is the "perceived innovation characteristic theory" (Rogers, 1983). A more specific model, the Technology Acceptance Model (TAM), is developed for the adoption of IT (Davis et al., 1992). The main difference is the focus of the two models: Rogers emphasizes the characteristics of the innovation, so the expectations an adopter has about the innovation. In the TAM model, the emphasis is put on the adopter characteristics, so to what extent typical features of the adopter influence the innovation adoption.

Rogers (1983) underpins that there are different success rates of adoption. To explain these different rates of adoption Rogers recognizes five criteria:

- Relative advantage; is the degree to which an innovation is perceived better than the idea it supersedes.
- Compatibility; is the degree to which an innovation is perceived as being consistent with existing values, past experience, and needs of potential adopters.
- Complexity is the degree to which an innovation is perceived as difficult to understand and use.
- Trialability; is the degree to which an innovation may be experimented with on a limited base.
- Observability; is the degree to which the results of an innovation are visible to others.

In general, innovations that are perceived by receivers as having a greater relative advantage, compatibility, trialability, observability and less complexity will be adopted more rapidly then other innovations (Rogers, 1983). Tornatzky and Klein (1982) confirm this and state that the attributes of the innovation at hand as perceived by the adopter have proven to be significantly instrumental in predicting adoption. Diffusion is the process by which an innovation is communicated trough certain channels over time among the members of a social system (Rogers, 1983). The diffusion process is driven by individual perceptions and knowledge of people acting in a network. So the innovation adoption is also very much dependent on the adopter features and in which coherence the adopter interacts with others. The perceived innovation characteristics are predictors in terms of the innovation adoption itself but do not explain why the adopter has a certain attitude to this innovation. Tornatzky and Klein (1982) state that real objective attributes of an innovation do not exist and that the adopter will always chose an innovation which matches to their own system of values (Tornatzky and Klein, 1982).

The TAM is much more focused on adopter characteristics for predicting the innovation adoption which is influenced by two important elements: one is the perceived usefulness and the other is the perceived ease of use. Davis et al. (1989) define perceived usefulness as 'the degree to which a person believes that using a particular system would enhance his or her job

performance'. Perceived ease of use refers to 'the degree to which a person believes that using a particular system would be free of effort'. Hee-dong Yang and Youngjin Yoo (2002) state that the validity and reliability of these two constructs have been well supported by various studies.

## THE ROAD CONSTRUCTION INDUSTRY

The objective of this study is to provide insights in the in the adoption processes of alternative transport technologies in the road construction industry and the factors affecting these processes. In general, road construction projects are executed all over the country on changing locations. The major input for road construction projects in terms of bulk materials is asphalt. Asphalt is produced at asphalt installations and transported by trucks to the location of the construction projects. Major problems for this time critical product are traffic jams and long waiting times at construction sites when delivering asphalt.

In road construction, the site manager has the most important position in organizing the project. He is responsible for the planning and safety and health issues new forms of procurement as turnkey and design and construct have resulted in an increase of the tasks and responsibilities of the site manager. For this manager, progress of work and prevention of disturbances has the highest priority. Slack in the use of equipment and asphalt is of minor importance. Acquisition of new projects has also become part of his activities. When a road is constructed, maintenance and repair provides work for a long period afterwards. Relations with existing clients are of utmost importance for getting work in the future; future work is often based on projects in the past.

Equipment is a critical resource in the execution of road construction projects. The equipment fleet represents the largest long-term investments in many road construction firms. Consequently, equipment management decisions have significant impacts on the economic viability of construction firms. Asphalt equipment such as asphalt distributor, asphalt spreaders, and paving machines used to spread and compact asphalt, demand high investments. Small equipment is often used before roads are paved. Examples are different sorts of ram compactors. In this study, the focus is on the adoption of alternative transport technologies in the road construction industry. The concepts will not (now) be elaborated, but are related to the extent of "radicalness" of the innovation.

## HYPOTHESES AND RESEARCH MODEL

Accordingly, several studies have proven the significance of both the innovation characteristics and the adopter characteristics on the innovation adoption process. Van der Veen (2004), who combined the two models, remarked that perceptions are formed in the context of the firm.

In this paper adoption theory is incorporated into the entrepreneurial process, especially in the first stage (opportunity recognition) end partly the second stage (opportunity preparation). In the first stage a conceptual choice is made which needs further preparation to develop a tangible innovation. However the focus of this paper is on the "technology adoption" (see Figure 2). Based on the literature discussed the following three hypotheses are formulated:

- H1: The greater the perceived benefits of an innovation for an organization, the more likely the organization will adopt that particular innovation.
- H2: The higher the joint value of each of the four capitals, the more likely an organization will adopt a more discontinuous innovation.
- H3: The perceived innovation characteristics are formed in the adopter characteristics.

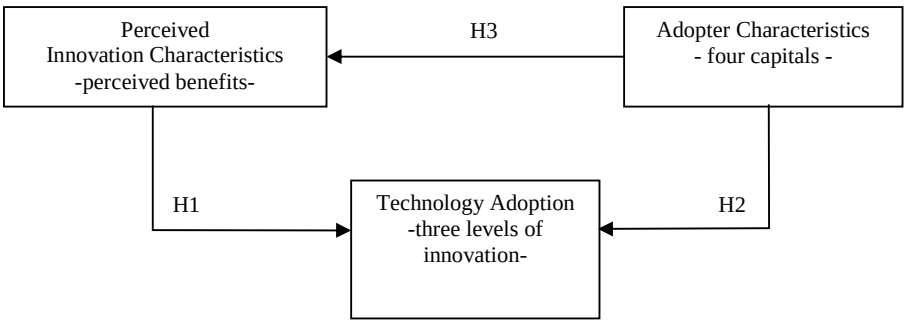


*Figure 2 - Technology Adoption Model*

**RESEARCH DESIGN**

After analyzing experiences (collected by desk research) with alternative transport technologies, data was collected by a survey under managers of firms involved in the chain of production, transport and use of asphalt. The topics of the survey focused on factors affecting adoption processes of alternative transport technologies, such as objectives of the firms and the company's external environment and internal characteristics. Data analysis contained a prioritization regarding adoption processes of alternative transport technologies of the firms analyzed.

The operationalization of research variables can be acquired from Table 1. Most of the items are adapted from Van der Veen (2004) (in Table 1 "VdV"), Rogers (1983) (in Table 1 "Rog") and a meta analysis of Damanpour (1991) (in Table 1 "Dam"). Several items were self developed (in Table 1 "Self-d"). Items were measured on seven point Likert scales, percentages and multiple choice questions. The population included all asphalt producing and/or utilizing organizations. For the Netherlands 36 companies are found who are about 95% of the total population. Perceived observability is a left out variable of the innovation characteristics in questionnaire because of its estimated insignificance in relation with road construction business.

The concepts are related and arranged to four rates of innovation

- no-innovation
- incremental -minor- innovation
- architectural -in between- innovation and
- radical –major- innovation.

*Table 1 - Operationalization of the research variables*

| **Adopter Characteristics** | | | |
|---|---|---|---|
| | Variable | Tested on | Source |
| Economic Capital; Financial position | Innovation budget | • Turnover/ fte$^{+}$ | Self-d |
| Strategic Capital; Strategic posture | Entrepreneurial orientation | • Being first with new actions and innovations$^{+}$<br>• Amount of implemented innovations$^{+}$<br>• Not afraid of taking risks$^{+}$ (consequently gain higher returns) | VdV & Dam |
| | Customer and competitor orientation | • Customer focused$^{+}$<br>• Reaction on competitor actions$^{+}$<br>• Collaboration / partnerships$^{+}$ | VdV & Dam |
| Cultural capital; Knowledge and experience | Level of formal knowledge & road construction experience | • Educational level of organization$^{+}$<br>• Educational level management team$^{+}$<br>• Fte on R&D$^{+}$ | VdV & Dam |
| Social Capital; Network contacts | Activated information network | • Searching for solutions outside the company$^{+}$<br>• Searching for opportunities$^{+}$<br>• Visiting seminars and meetings$^{+}$ | VdV & Dam |
| **Innovation characteristics** | | | |
| Variable | | Tested on | Source |
| Perceived relative advantage | | • Concept improves the quality$^{+}$<br>• Concept improves the efficiency$^{+}$<br>• Concept improves the effectiveness $^{+}$<br>• Concept improves the reliability$^{+}$ | Rog |
| Perceived compatibility | | • Concept fits within image/mission$^{+}$<br>• Concepts becomes obligatory forced by external environment$^{+}$ | Rog |
| Perceived complexity | | • Concepts can be implemented easily within own organization$^{+}$<br>• Concept can be implemented easily within collaborating organizations$^{+}$ | Rog |
| Perceived trialability | | • Concept can be experimented with$^{+}$ | Rog |
| **Technology Adoption** | | | |
| | Innovation type: | | Source |
| 0 | no innovation | | Self-d |
| 1 | incremental innovation | | Self-d |
| 2 | architectural innovation | | Self-d |
| 3 | radical innovation | | Self-d |

*Rog is source Rogers (1983), VdV is Van der Veen (2004) Self-d items which are self developed. "$^{+}$" is positively associated to more prestigious adoption, " $^{-}$"is negatively associated to more discontinuous adoption*

**RESULTS**

The results show that 83% of the respondents choose innovation over no innovation; more than half of the respondents choose an innovation that can be characterized as "architectural" (see Table 2). No respondents made a choice for an architectural or radical innovation.

*Table 2 - Choice of innovation types*

| **Innovation type** | **Choice of respondents** | **# of respondents** | **Average size of respondent's companies (in fte)** |
|---|---|---|---|
| no innovation | 17% | n=2 | 153 |
| incremental innovation | 25% | n=3 | 317 |
| architectural innovation | 58% | n=7 | 190 |
| radical innovation | 0% | n=0 | |

*Sample size $n_{(12)}$ = 32% of total population*

Further, as Table 3 shows, the perceived benefits of the innovation characteristics for an incremental innovation are higher then the perceived benefits for an architectural or radical innovation. The perceived benefits are higher for those who made a choice for a particular innovation then those who chose another. This is in support of our first hypothesis.

*Table 3 - Innovation characteristics projected on innovation types*

| | **Perceived relative advantage** | | **Perceived compatibility** | | **Perceived complexity** | | **Perceived trialability** | | **Average score** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $K^*$ | $C^{**}$ | $K^*$ | $C^{**}$ | $K^*$ | $C^{**}$ | $K^*$ | $C^{**}$ | $K^*$ | $C^{**}$ | $\sum^{***}$ |
| incremental innovation | 40% | 80% | 24% | 62% | 54% | 81% | 79% | 57% | 43% | 74% | 51% |
| architectural innovation | 33% | 57% | 28% | 35% | 51% | 68% | 60% | 66% | 39% | 56% | 42% |
| radical innovation | 28% | - | 25% | - | 36% | - | 60% | - | 32% | - | 32% |

*$K^*$ explains the average score of the innovation characteristic variable given by the respondents who do not chose this particular innovation type.*

*$C^{**}$ explains the average score of the innovation characteristic variable only given by the respondents who chose that particular innovation type.*

*$\sum^{***}$ explains the total average score of the innovation characteristic variable given by all respondents for a particular innovation type.*

The summed capitals do not discriminate between the architectural innovation and the "no innovation" choice (see Table 4). Companies that choose for incremental innovation have the largest amount of the four capitals in their organizations. Further, it appears that the larger the (average size) of the company the higher the total amount of the four capitals. The second hypothesis can only be confirmed with regard to the network capital. The (so far) collected data are not substantial enough to study the third hypothesis.

*Table 4 - Adopter characteristics projected on innovation types*

| | **Economic capital*** | **Strategic capital*** | **Cultural capital*** | **Social capital*** | **Summed capital** |
|---|---|---|---|---|---|
| no innovation | 0.11 | 0.64 | 0.57 | 0.60 | 1.92 |
| incremental innovation | 0.45 | 0.68 | 0.83 | 0.68 | 2.64 |
| architectural innovation | 0.29 | 0.62 | 0.46 | 0.59 | 1.91 |

* *Each of the capitals is the average result per respondent group indicated on a scale from 0 to 1.*

**PRELIMINARY CONCLUSION**

Reflecting the results on the hypotheses, the data support in almost all cases hypothesis 1; the companies who choose for a certain innovation type, perceive in general a higher benefit value to this kind. The first results show that hypothesis 2 is not supported by the data; although the network capital is the only element that has a positive association to more radical technology adoption. There seems to be a positive relation between the size of a company (in fte) and the value of the four capitals. From the ventures that chose to innovate, smaller companies prefer an architectural -more challenging- innovation rather then an incremental innovation. A possible explanation for these outcomes could be that the perceived trialability needs a more elaborated network which offers ventures the resources they need to adopt an architectural innovation. At this moment additional data is collected to enable a more extensive evaluation.

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