CIB TG85: R&D Investment and Impact

Abstracts of chapters in the CIB TG85 book: *R&D Investment and Impact in the Built Environment* (09 April 2013)

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- Frédéric Bougrain – "*Impact of the French Innovation and Research Policy on Construction Firms*"
- Suvi Nenonen, Miimu Airaksinen and Terttu Vainio – "*Investments in Innovations - Finnish R&D Functions in Construction and Real Estate Sector"*
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- Elen Marie Kyrkjebø Hvide, Marit Støre Val, Svein Bjørberg, Tore Haavaldsen – *"Potential of Sustainability in Existing Buildings – An Assessing Method"*
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TG85 Book Abstracts (Organised Alphabetically by Country)

Authors: Judy Kraatz and Keith Hampson (Australia)

Abstract: The Australian Sustainable Built Environment National Research Centre (SBEnrc) is the successor to the Australian Cooperative Research Centre (CRC) for *Construction Innovation*. Established on 1 January 2010, the SBEnrc is a key research broker between industry, government and research organisations for the built environment industry. The SBEnrc is continuing to build an enduring value-adding national research and development centre in sustainable infrastructure and building with significant support from public and private partners around Australia and internationally.

This chapter will build on the work done by SBEnrc through: (i) an *audit and analysis of R&D investment* in the Australian built environment (1990-2010); (ii) the analysis of *three case studies of past R&D investment* in Australia intended to illustrate the nature of such investments; (iii) the development of *Construction 2030* roadmap for the Australian construction industry; and (iv) *policy guidelines* for future R&D Investment which draw upon each of these preceding bodies of work.

The first case study investigated road construction safety initiatives within the Queensland Department of Transport and Main Roads. The second case study focused on green buildings initiatives led by the Western Australia Government since 2003. And the third case study explored the evolution of digital modelling uptake in the Queensland Department of Housing and Public Works since the mid-1980's including implementation of building information modelling (BIM) from the mid 2000's and current moves towards integrated project delivery (IPD).

The chapter will outline the methodology and outcomes of the Australian roadmap for R&D investment *Construction 2030*. C2030 identifies a series of R&D priorities for the Australian construction and property industries highlighting 3 key areas requiring active research and a further 3 requiring contextualisation and adaptation for Australian conditions.

In conclusion this chapter will make recommendations for policy guidelines intended to maximise the value of R&D investments to public and private organisations, and develop a set of strategies to allow public and private sector organisations to more profitably engage in research to secure business and policy impact.

Authors: Mercia Bottura Barros, Francisco Ferreira Cardoso and Lúcia Helena de Oliveira (Brazil)

Abstract: Brazil is the world's fifth largest country and the fifth largest population. In 2010, the construction sector grew 11.6 per cent, compared to 2009. The number of jobs has been growing while social inequality has decreased. A major contributor to the development of the construction sector is

the Programa de Aceleração do Crescimento (PAC, Growth Acceleration Programme), launched by the Federal Government in 2007. Focusing on the development of the construction sector, the Brazilian Government has fostered government bodies such as Financiadora de Estudos e Pesquisas (FINEP, Financial of Studies and Projects) and the Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP, Foundation for Research Support of the State of São Paulo), allocating resources for R&D for the academic and the private sector.

Brazil has invested approximately one per cent of its GDP in R&D in recent years (2000 to 2010), whereas 55 per cent of the resources have come from the public sector and 45 per cent from private sources. Joint actions between the government and private enterprises have frequently occurred. Despite public sector innovating efforts, the construction sector still has one of the lowest levels in terms of programmes or resources invested in innovation processes. To exemplify, three case studies focused on R&D are presented. They are being carried out by different private segments of the construction sector and two of them have academic partners. The first involves a supply chain dedicated to cement mortar, the second is regarding a large contractor with expertise in infrastructure and the third refers to a real estate company.

In order to study, analyse and define guidelines for the development, dissemination and evaluation of technological innovations in construction for permanent and continuous improvement, actions have been undertaken by the Programa para Inovação Tecnológica em Construção (PIT, Program for Technological Innovation in Construction) that involves different stakeholders including the Associação Nacional de Tecnologia do Ambiente Construído (ANTAC, National Association of Technology of the Built Environment), which brings together researchers linked to universities and research institutions. This chapter will present the main barriers to the dissemination of innovation within the sector and defined priority R&D projects identified by this group and a set of actions that will be needed over the next decade in order to ensure the success of the PIT.

Authors: Aminah Robinson Fayek, Jeff Rankin, Saiedeh Razavi and Russell Thomas (Canada)

Abstract: The construction industry in Canada, as in most countries, is characterised by its diversity and fragmentation. Its investment in R&D has tended to lag behind that of other industries, although this has been changing in recent years through the support of federal and provincial funding agencies, including the Natural Sciences and Engineering Research Council of Canada and the National Research Council of Canada, and their respective programs. This chapter provides an overview of the Canadian construction industry. It discusses both past and present trends in Canadian R&D investment and impact, as well as the mechanisms through which R&D are funded. Statistics comparing the Canadian construction sector to other sectors are presented, and major initiatives in construction R&D are described.

Several case studies of public and private funded R&D are presented to characterise the different types of R&D undertaken by the industry. Challenges in securing R&D investment and measuring its impact are discussed and recommendations are made on (i) how to better align the various parties involved in R&D in the Canadian construction industry; (ii) how to meet the needs of diverse organisations, and (3) how to address the fragmentation of not only the industry but also its R&D.

A roadmap and strategy for future R&D investment in construction in Canada is presented to address the identified challenges and meet the needs of industry, government, and academia.

Authors: Kim Haugbølle (Denmark)

Abstract: During the 1990s and early 2000s, a range of policy reports argued that the Danish construction R&D investments were lagging behind international comparators. In 2001-2002, a committee on building and housing research was established to analyse the R&D investments and generate a roadmap for new research priorities, increased public/private R&D collaboration, improved dissemination of research-based knowledge, and reorganisation of the technical support infrastructure.

This chapter will (i) describe the organisational structure of Danish building and housing research, (ii) quantify the Danish construction R&D investments; and (iii) provide an update on recent developments in the Danish R&D environment.

This study applies an adapted triple helix perspective on the interaction between government, academia and business. It is based on a comprehensive quantitative survey and analysis of R&D investments and profiles of individual research institutes.

The survey adopted a resource area perspective. Contrary to most other construction business policy studies, resource areas include the four industries: primary industry (e.g. raw material extraction), manufacturing industry (e.g. production of building components), supporting industry (e.g. production and leasing of construction machinery) and service industry (e.g. contractors and consultants).

The study outcomes indicate the following lessons to be learned: (i) the definitions applied in studies of R&D investments has a significant impact on the conclusions to be made; (ii) public construction R&D expenditures are disproportionate compared to other research fields; (iii) private R&D investments primarily take place in the manufacturing industry; and (iv) the R&D roadmap seems to have had little impact on construction R&D.

Authors: Suvi Nenonen, Miimu Airaksinen and Terttu Vainio (Finland)

Abstract: The Finnish *Roadmap for Built Environment 2050* indicated the significance of holistic R&D projects as future success factors for the construction and real estate industry. The research and development activities in the Finnish construction and real estate sector are supported by different funding organisations. The role of Finnish funding agency for technology and innovation, Tekes, is to support high-quality research that generates significant commercial potential for businesses while also improving competitiveness and welfare for society at large. Research projects are carried out in close collaboration with practice, using the field not only as a source of data but as a reflection and way of steering the research process. The shared interest is in research results that are relevant for the academic field and practical implementation.

In order to provide possibilities to encourage practice-driven research, the Strategic Centre for Science, Technology and Innovation of the Built Environment has been created by the Ministry of Employment and Economy. This paper describes the Finnish national innovation system, its focus areas and activities

in the field of construction and real estate, and provides an overview of some successful projects. The methodology is based on a literature review and analysis of a variety of evaluations.

Based on the international evaluation conducted in 2012, Tekes has performed well and is among the world's leading innovation agencies. With its activities Tekes has contributed to increasing research intensity, increased cooperation between companies and knowledge infrastructure in Finland and helped build knowledge and competences to increase the international competitiveness of Finnish enterprises. Specifically, activities in the public sector and reduction of energy consumption of buildings were mentioned as an achievement in public sector innovations, which are a specific form of user-driven innovation.

The R&D activities have an extensive challenge in investigating the provision and development of a myriad of services and capturing the full spectrum, from property strategy, space management and communications infrastructure to building maintenance, administration and contract management. In today's knowledge landscape, there are powerful drivers for multi-disciplinary research. This paper concludes by describing the key elements for achieving the synergy between and across different disciplines.

Author: Frédéric Bougrain, (France)

Abstract: In 2008, France spent USD54 [1] billion on R&D, equivalent to 2.1 per cent of the national GDP and accounting for approximately 3.8 per cent of global R&D expenditure. For many years France has been characterised as a country where state intervention was needed to guarantee the wealth and the strength of the economy. Most of the funds dedicated to R&D focused on large programmes limited to specific sectors such as nuclear, space, aeronautics, telecommunications, and defence, and were mainly monopolised by large companies. Therefore, SMEs were often ignored. However, this scheme has been challenged by the growing role of the European Union and French regions in national programmes. Under the new institutional framework public expenditures are not only devoted to R&D but also to innovation.

The French construction industry (building construction, installation and finishing, and civil engineering) is characterised by a large number of firms with less than 10 employees. Conversely, firms employing more than 250 people are limited, representing less than 0.1 per cent of the construction firms and approximately 20 per cent of the total production. R&D expenditures of these firms are very limited. In volume, construction is the sector with the smallest budget dedicated to R&D. Consequently, the national policy supporting R&D tends to ignore construction.

However, the most innovative firms can still receive the support of the public finance agency supporting innovation. This agency covers part of the expenditures dedicated to Research, Development and Innovation (RDI). In 2007, the government launched a national research programme dedicated to the industry and focusing on low energy buildings.

The chapter will first characterise the evolution of the French national policy in the domain of research and innovation. Then, it will examine the role of RDI for construction companies and describe two public schemes aiming to support innovation within construction firms and the diffusion of low energy

[1] EUR42 billion at a exchange rate of USD1.2859/Euro1 (USA Federal Reserve System 2012 average exchange rate)

buildings. Finally, the analysis will present the role of R&D in the innovation strategy of a small sample of construction companies located in the Aquitaine region (South-West of France).

Author: Alexandra Staub (Germany)

Abstract: The German government has developed a robust series of research and development programs aimed to make Germany a leader in technologically advanced materials and building practices. There are four key players in the German system: the government (federal and state), universities and their associated institutes, non-university research institutes such as the Fraunhofer or Max-Plank Institutes, and industries (manufacturing and construction companies). The federal government is attempting to directly shape research directions through a series of competitive, tightly defined grant programs, while the other players develop proposals and ideas within these administratively set parameters. Unique to this process is the interplay between research topics initiated by the government funding agencies and those initiated by the researchers themselves. Results are published, making them publically available. This chapter will focus on the most important German programs and their aims in the areas of technology, "building culture" and organization, making use of impact analyses from the Centre for European Economic Research (ZEW) where available. A special focus will be on the federal program "Zukunft Bau" (future building), initiated in 2009.

The chapter will examine each of the major focus areas of building and construction research: energy efficiency and the use of renewable energies, new concepts and prototypes for energy efficient buildings, zero- and plus-energy buildings, new materials and processes, sustainable building and building quality, effects of demographic changes for buildings (for example the effect of the ageing population structure), technical standards and contracts, and modernization of existing buildings.

In addition to a broad summary, two to three examples from these areas will be examined in more detail, using published research reports and other data. The examples will be chosen to illustrate a variety of research approaches. The chapter will conclude by assessing Germany's current R&D approach as a driving force towards increased international standing.

Author: Geoffrey Shen and Jingke Hong (Hong Kong, People's Republic of China)

Abstract: The establishment of a systematic funding mechanism for research in Hong Kong can be traced back to the 1960s. It stemmed from the principle that R&D investments, in creating an education hub and providing a bond between institutional collaborations and economic development, plays an important role in the growth of Hong Kong as an international metropolis. The University Grants Committee (UGC), established in 1965, aimed to provide appropriate tools and incentive mechanisms to encourage and assist tertiary academic institutions to improve their international competitiveness as well as to play a proactive role in strategic planning and policy making. Subsequently, the Research Grants Council (RGC), established by the government of Hong Kong in 1991 as a subsidiary under the UGC, focused on meeting the needs of the tertiary institutions in Hong Kong in the field of academic research. This chapter will introduce the research grants system in Hong Kong, including its corresponding organizational structure. It will analyse the past 20 years of R&D investment through publicly-funded schemes such as the General Research Fund (GRF), Collaborative Research Fund

(CRF),Theme-Based Research Scheme (TBRS), Public Policy Research Fund Scheme (PPRFS) and other government grants such as the Innovation and Technology Fund (ITF) as well as private-sector funds from the industry in Hong Kong. Through the various strands of funding for R & D activity, good progress has been made in terms of its underpinning of economic development. However, as the following case study in the domain of the construction industry indicates, there are areas fertile for achieving greater performance and efficiency of the R & D funding system. The authors use an analysis of the total R&D funding in the discipline of Civil Engineering, Surveying, Building and Construction to show how it is allotted through competitive processes to the eight UGC-funded institutions.

Author: Arun Kashikar (India)

Abstract: India is poised for a massive upturn in economic and social growth. Investments in research, until recently, lagged behind that of China, the European Union and the USA. The Indian government has made concerted efforts to drive investments towards science and technology. These efforts are reflected in the XI Five Year Plan (2007-12), through ambitious programs covering: substantial support to basic research, enlarging the pool of scientific manpower, strengthening Science and Technology infrastructure, implementing selected national flagship programs with direct bearing on the technological competitiveness, and establish globally competitive research facilities and centres of excellence. The current share of R&D in terms of the national GDP is approximately 1 per cent, which is very low compared to more developed countries.

The Indian innovation system is still in its nascent stage. Consequently, 75-80 per cent of the domestic R&D is carried out by the public sector, 20-25 per cent by private enterprises and around 3 per cent by universities.

R&D in the housing and construction sector in India is currently dominated by government bodies including the Centre for Scientific and Industrial Research (CSIR), the Department of Scientific and Industrial Research (DSIR), the National Building Organisation (NBO) and the Building Material and Technology Promotion Council (BMTPC).

Until recently, construction in India was done mainly by manual labour due to the availability of low cost construction worker, predominantly migrants from rural India. The productivity of this model has been very low compared to international norms, due to lack of focused training attributable to the migratory nature of labour and their low education level.

India faces an increasing affordable housing shortage of approximately 27 million units. It is impossible to meet this demand using the manual construction techniques used so far. Furthermore, the cost of manual construction labour is increasing exponentially, mainly due to various successful government schemes that have provided livelihood to workers in their place of origin.

This reduction of the migrant workforce, the resulting need for mechanisation, and foreign investment in India's technology industry due to the global economic recession, has triggered significant R&D and innovation activities in India. Future R&D in India will be more focused on precast and prefabrication technologies, as well as in the improvement of labour productivity, as means to meet the considerable housing shortfall. Many precast plants have been established across India.

The combination of significant water, fuel and energy shortages, and India's commitment to climate change initiatives, will also drive R&D towards sustainability and climate change initiatives. In fact, investment in green energy technology has recently started to grow at a fast pace.

R&D in the construction sector in India is likely to see manifold growth in the coming years. Unlike in the past, R&D by the private sector is likely to be a prominent share in this growth.

Authors: Suzanne Wilkinson and Charles Ma (New Zealand)

Abstract: The construction industry in New Zealand is predominantly made up of SME's and therefore the private investment in R&D is small and limited. Investment in construction R&D is through the recently (2012) formed Ministry of Business, Innovation and Employment (MBIE) which provides contestable funding on targeted research themes – such as Infrastructure or Manufacturing, both suitable for construction research funding. Research in the construction sector tends to be driven by the Building Research Association of New Zealand (BRANZ) and the former Department of Building and Housing (now part of MBIE). Probably the best way to describe BRANZ, when comparing to international organisations, is that BRANZ is equivalent to a National Research Institute, and as well employing internal scientists, BRANZ provides for external contestable funding on themes from the construction sector research agenda. This chapter discussed the size and configuration of the New Zealand construction industry. An overview of New Zealand's R&D investment in construction will be provided. Past successes in the construction sector research as measured on a number of indices, such as transferability to industry, multi-sector publications, dissemination and uptake will be examined. The chapter will finish with a discussion of the future options being considered for R&D investment for the construction sector, and how this is likely to impact the sector.

Authors: Marit Støre Valen, Knut Samset, Ole Jonny Klakegg, Torill Meistad and Anita Moum (Norway)

Abstract: The Norwegian construction industry (AEC) constitutes the country's second largest industrial sector by value creation after the oil industry and the third largest by revenue. Due to the importance of infrastructure to development of society, expectations are high for continued improvements, and the growth of the AEC industry is largest in the rural regions. For many such municipalities the AEC sector represents the largest source of revenue. Currently, the activity level is high and the industry is facing a number of challenges, due to population growth, increasing urbanization, and new requirements in order to meet climatic challenges. The high cost level and backlog of maintenance of existing infrastructure imply further challenges for the industry to improve performance and develop new knowledge to continue improve products and production processes.

A recent white paper provides an overall policy to meet the need for buildings for future generations. Improving expertise, legislation and research are key instruments. The policy encourages collaboration between government and industry, in accordance with our tradition. Key stakeholders in the R&D system are the Ministry of Local Government and Regional Development, the construction industry's organizations of enterprises, the Norwegian University of Science and Technology and the Norwegian Research Council. The policy is followed up by a policy instrument called Bygg21 that focuses on

developing common strategies for: (i) R&D and innovation; (ii) education and professional development; and (iii) implementation and dissemination of knowledge and experience.

The chapter presents some major programs for research and development within the Norwegian construction sector that have made considerable impact in terms of new knowledge and practices. This includes the Concept Program focusing on front-end management of large public investment projects, the Construction Cost Program focusing on quality and competence enhancement in the value chain, and the Wood Program intended to enhance the knowledge and motivation of using wood as constructing material and increase the use of wood in urban construction.

Three case stories illustrate the dynamics of industrial development and the contributions from research and a new policy in innovation and knowledge transfer within the construction industry. The first case relates to wood as building material. The second case showcases development of urban green living, and the third case illustrates recent initiatives towards energy producing buildings. Policy to promote innovative building projects is also part of the dynamic, as shown through Cities of the Future, involving the 13 largest cities, and the energy research centre for Zero Emission Building (ZEB).

The chapter draws conclusions on how R&D ideas can be translated into tangible industry results. Mutual goals and collaboration between industry and government has proved to be crucial, as well as measures to provide financial and expertise support. Also, hearings between industry and other stakeholders, and long term programs have proved useful to implement changes.

Authors: Anna Kadefors and Jan Bröchner (Sweden)

Abstract: Swedish industry has many multinational firms and in the construction industry, a small number of leading contractors hold strong positions. However, professional service firms are weaker than in most countries.

Today, there is no strong government policy for the development of the construction industry or for public clients as innovation leaders. In the process leading to joining the EU in 1995, the centralised government construction client function was fragmented and construction branches of the infrastructure authorities were separated from their client functions. Around year 2000, the Swedish Council for Building Research was closed and a new organization for research funding emerged. The general research policy intends to strengthen Sweden as an industrial and service nation, as well as a welfare society. High international quality is emphasised, and research initiatives are encouraged to focus on areas that are of importance for human wellbeing and industrial competitiveness. No official statistics for Swedish construction research and innovation exist.

There are four government authorities that currently dominate the funding of construction research projects: (i) Formas for the areas of environment, agricultural sciences and spatial planning; (ii) the Swedish Transport Administration; (iii) the Swedish Energy Agency; and (iv) VINNOVA, the Agency for Innovation Systems. SBUF, the Development Fund of the Swedish Construction Industry, is the largest source of private sector grants. Public funding tends to support high quality basic research or development and innovation projects. Up to 50 per cent cash or in-kind private investment is required for public support of development and innovation projects. SBUF is financed by approximately 5,000 contractors, based on agreements between construction labour market organisations.

Three cases of industry-university funding schemes are discussed. Although generally supportive, a 2011 evaluation of the Formas-BIC collaboration program raised issues of scientific dissemination, project size and the integration of implementation in research. The Energy Agency CERBOF program has been evaluated and the report states that collaboration between industry, universities and public authorities has worked well, but also highlights problems relating to scientific publication and private co-financing. An ongoing assessment of the *Bygginnovationen* program considers productivity effects in an innovation systems perspective. VINNOVA has shown more interest in impact studies, although recognising in a recent analysis that a timescale of decades is often needed, and that government supported projects cannot be isolated from a broader industrial context. A review of research supported by the Energy Agency called for a more holistic perspective, to ensure that all important links in the innovation chain may receive funding.

The trend in Swedish government R&D funding is that large-scale collaborations are supported, either on a national scale or as trans-disciplinary groups. The funding landscape is however complex and partly contradictory. Recently, the government has decided to provide more generous funding for Formas-supported built environment research.

Authors: Geert Dewulf, Emilia van Egmond and Massi Mohammadi (The Netherlands)

Abstract: Despite various government programs and subsidies, global competition, and the growing awareness of the fact that innovation is essential for improving the business performance; R&D investments and the adoption of innovative technologies are still lagging behind other sectors. The construction sector is still tradition-bound and the production chain relations are ad hoc and project based. Globally, various studies have been published relating the low level of innovation in the industry. The former, stresses the need for close collaborations among partners in the value chain to generate an effective integration of innovative products (Rose and Manley, 2012).

According to Eurostat, investments are lagging behind other European countries and R&D investments have decreased in recent years in the Netherlands. Furthermore, the Dutch government is primarily focused on investing in hard infrastructure such as roads and bridges rather than in research or innovation. This attitude is supported by the major firms suffering the financial crisis. Moreover, despite the fact that the construction industry represents 10 per cent of the GNP, the focus of the Dutch research and innovation agenda is not on construction but on themes such as nano science, health and IT.

On the one hand, the financial crisis might be the reason for the temporary reluctance of the industry to invest in innovation and research and the decreasing public budget. On the other hand, the government focus on a limited number of "*top programs*" has increased the level of public spending in construction research these developments. However, there is also a structural resistance to invest in research and the slow emergence of sustainable innovation programs. Due to the fragmentation of the Dutch construction industry and the focus on specific projects rather than on long-term programs, the adoption of innovations and perhaps more importantly the integration of lessons learned from innovative projects to other projects and programs is being hindered.

This chapter will use the concept of Strategic Niche Management (SNM) to explain the barriers for the emergence of sustainable research and investments programs. Various pilot projects and experiments

are taking place and are often launched or supported by public clients and government programs. However, institutional factors have a negative impact on the adoption pace in the industry.

Various innovations are taking place in The Netherlands and these niches. For example, pilot projects by the Dutch Highways Agency are characterised by a great degree of freedom and few regulations. This chapter will analyse the barriers for a sustainable innovation regime on three different cases:

- two product innovations: the adoption of innovations in the Dutch steel structure conservation production chain, and the adoption of *domotica* innovations, and
- the evolution, development process and lessons learned from a major public private research innovation program.

The chapter is structured as follows: the first section will provide a general description of the Dutch industry and R&D policy. The following sections will provide a description of the analysis framework and will discuss the three cases studies. Two case studies will analyse the barriers for product innovation, and the third case study will analyse a public private innovation program illustrating the institutional context and barriers for sustainable innovation in construction. Finally, conclusions and lessons learned for innovative programs will be made based on the case studies.

Authors: Sarah Slaughter, Douglas Thomas and Robert Chapman (United States of America)

Abstract: The built environment, including buildings and infrastructure, provides the basis for civil society and commerce, and investment in these assets through construction is a key economic engine of the USA, equalling approximately 3 per cent to 5 per cent of GDP. Construction-related R&D can improve the effectiveness and efficiency in this industry, and current USA annual expenditures in this area are approximately USD2 billion, with the USA federal government providing USD500 million to USD700 million. Funded research is equally balanced between basic/applied research compared to development/demonstration research expenditures, with industry focusing on the latter stages, academia focusing on the former, and federal agencies balanced between the two. Recent studies have analyzed the challenges for the construction industry, including an underinvestment in R&D, which currently equals 0.2 per cent of the value of construction put in place, and reductions in productivity of the construction workforce. Other efforts have identified opportunities for significant and rapid improvement. Selected case studies demonstrate the impact that construction-related R&D in the USA have had – and will have – on the nation, and provide the basis for developing a vision for future endeavours.