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Application of Expert Systems for Personalizing Financial Decisions

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Abstract

Due to the complexity of financial products, consumers with low financial literacy are left behind. However, few practical studies investigated the impact of digital advisory systems to improve customer experience. Configuration systems, as the most popular expert systems, have never been applied as a financial tool. In this study, we explore the application of configuration systems to educate consumers in achieving their financial goals. The results highlight multiple benefits from using the configurator, including greater financial literacy and improved individual financial decision-making.

Keywords: expert systems, configuration management, human-centred design, mass customisation, case study

1. Introduction

Financial products and regulation become more complex every day, while many consumers do not have the financial literacy to understand the implication of this complexity on their own short and long-term life goals. This was highlighted by an OECD report published in 2016 that concluded only 60% of adults had a household budget, and only 50% set long term financial goals (OECD, 2016). However, research has shown that education improves the understanding of market volatility, and attitudes towards investment (Rodrigues *et al.*, 2019). In particular, the COVID-19 pandemic, has further increased uncertainty and volatility in the financial markets, making financially inexperienced individuals even more complex. The available financial regulation has failed to protect consumers from increasingly complex financial products. In practice, much of the consumer protection regulation is translated to disclaimers that the consumers have to sign to get access to financial products or services. Hence, the research field of financial literacy has grown tremendously in recent years (Abdullah and Chong, 2014; Goyal and Kumar, 2021; Taylor and Wagland, 2011; Totenhagen *et al.*, 2015).

Moreover, it was previously found that financial literacy has positive effects on consumers savings decisions (van Rooij *et al.*, 2011), and wealth over time (Lusardi and Mitchell, 2007). Hence, it is possible and effective to educate the consumers and help them to achieve their financial goals. The research within financial literacy has been heavily theoretical or has relied on methods that are designed to fit a large sample size of the population (Rodrigues *et al.*, 2019). There are similar patented tools in the market which will be in access based on request of the customers in especial cases. However, there is no general tool to be accessible for everyone. For example, "Personal capital" is an online financial advisor and personal wealth management company, headquartered in California, with offices across the United States. The company provides financial analytics and planning tools through linking with the user's banks, brokerages, mortgages, credit cards and loans. the level of personalization and graphical visualization is not quite as high. However, it could be argued that the level of complexity shown is also

too high for certain users, as it can be overwhelming with both the numerical data and graphical visualizations at once; the tool is in that sense more tailored towards advanced users.
Studies have investigated the consumers educations about financial theory, such as risk diversification or the theory of complex financial products (van Rooij *et al.*, 2011). Such terminology might be useful, but the consumers first need a rudimentary understanding of their own financial life cycle that is personalized based on their short-term requirements and long-term life goals. Hence, they need to be presented with the impact of very basic financial decisions they could take through a simple user-friendly interface. After implementing a human-centric personalized configuration system, it might be useful to educate the consumers on more complex terminologies, in as far as they relate to the individuals' financial requirements and personal life goals.
Configuration technologies have proven themselves as the leading technology to support the trend of mass customization, providing customers with the ability to customize their products and services to a very high degree (Shafiee *et al.*, 2017, 2018; Shafiee, Wautelet, *et al.*, 2021; Wu *et al.*, 2021). Defining product/service specifications in an error-free way for customer-centric products can sometimes be difficult due to specific interdependencies or incompatibilities across the product parts creating high complexities (Kristjansdottir, Shafiee, Hvam, Bonev, *et al.*, 2018; Kristjansdottir, Shafiee, Hvam, Forza, *et al.*, 2018; Nahrkhalaji *et al.*, 2019). However, product configurators have proved themselves apt to deal with such complexity in most scenarios (Piroozfar *et al.*, 2019; Shafiee, Piroozfar, *et al.*, 2020; Wang *et al.*, 2019, 2020; Zhang, 2014). Moreover, in other complex areas, such as the planning of robot-based automation solutions, it has been shown that configurators have great potential to make knowledge-intensive activities accessible to a wide audience (Schäffer *et al.*, 2020, 2021).
More specifically, PCSs (Product Configuration Systems) lead to shorter lead times for generating quotations (Haug *et al.*, 2019; Shafiee, 2017; Trentin *et al.*, 2012), fewer errors (Heiskala *et al.*, 2007; Sviokla, 1990; Trentin *et al.*, 2012), increased ability to meet customers' requirements regarding product functionality (Piroozfar *et al.*, 2019; Shafiee, Piroozfar, *et al.*, 2020), the use of fewer resources (Forza and Salvador, 2006), optimised product designs (Gronalt *et al.*, 2007; Shafiee, Wautelet, *et al.*, 2021; Trentin *et al.*, 2012), less routine work due to automation (Forza and Salvador, 2006; Kristjansdottir, Shafiee, Hvam, Bonev, *et al.*, 2018; Rasmussen *et al.*, 2021; Shafiee, 2017) and improved on-time delivery (Ardissono *et al.*, 2003; Heiskala *et al.*, 2007; Liu *et al.*, 2006; Rasmussen *et al.*, 2021; Squire *et al.*, 2009).
This paper explores the interface between financial literacy and product configuration, attempting to use the practical approach of product configuration theory in the topic of financial literacy. Meanwhile, the authors will use methods such as design thinking to explore the customers' requirement and deliver a sustainable and responsible configurator. This topic has a growing interest, not only within research, but also for the consumers, while there are few practical tools developed for people of low financial literacy to improve their financial decision making.
The remainder of the paper is structured as follows. Section 2 discusses the relevant literature, and section 3 explains the study's research method. Section 4 discusses the results obtained. Section 5 presents the study's implications for research and practice.

2. Related works

This research has been conducted due to the gap in the literature associated with the interface between personal financial theory and product configuration. As the complexity of global financial products has grown, personal choices of financial products have only shifted further from individuals to more institutionalized organizations (Cumming and Groh, 2018). Sufficient research or progress within this area could aid in bringing more control back to the users over their own financial planning. The following subsections introduce financial literacy systems and configurators to demonstrate the need of financial configuration model within finance (Forza and Salvador, 2002).

2.1. Financial literacy services

Recognizing that many individuals possess low financial literacy and lack basic knowledge of economic principles, certain studies have looked to educate consumers on financial literacy (Lusardi and Mitchell, 2007; van Rooij *et al.*, 2011). All these studies have concluded that, through a concentrated effort, individuals are able to improve their financial literacy. However, the methods used have often been

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generic, e.g., standard quizzes, instead of providing personalized solutions. Furthermore the definition of financial literacy has been quite high level, focusing on things such as risk diversification or the theory behind complex financial products such as derivatives (Abdullah and Chong, 2014; Goyal and Kumar, 2021; Taylor and Wagland, 2011; Totenhagen *et al.*, 2015).

The responsibility to understand financial products often ends up falling on the consumer, as the predatory practices of financial industries are often under regulated (Fraser, 2017). As globalization has made more investments available to individuals, it has increased the burden of researching and selecting the right investments. This is something that is inherently easier for individuals with high levels of financial literacy (Lusardi and Mitchell, 2007), and thus disproportionally affects individuals that don't have the required educations. Individuals lacking the necessary level of financial literacy therefore have a harder time with financial planning and asset management decisions, which has negative impacts on both the society and individuals.

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Providing users with a personalized financial configuration system could entice them to increase their financial literacy by focusing on how the related concepts could affect their own financial situation. This would be useful while dealing with the increasing complexity of financial systems and allow users to become more proficient at various financial practices such as cash flow management, credit management, savings and investments (van Rooij *et al.*, 2011). People with lower scores in financial literacy have consistently been shown to make poor investment decisions (Lusardi and Mitchell, 2007).

2.2. Configuration systems

To the best of the authors knowledge, research and practical implications on product configurators within financial services is limited or non-existent. Despite these differences, certain aspects of research on mass customization within products, and the benefits and challenges of product configurators could still be applicable to configurators for services (Haug *et al.*, 2019, 2019; Shafiee, 2017; Shafiee, Wautelet, *et al.*, 2020).

Design thinking is also utilized throughout the development of the configurator. Design thinking steps in general are outlined as (Shafiee, Haug, *et al.*, 2020; Wautelet *et al.*, 2019):

a) Exploring the problem space: An intuitive understanding is developed through observing current use cases and synthesizing the knowledge of various stakeholders.
b) Exploring the solution space: Simultaneously, the possible solutions are considered, sketched and prototyped within the necessary constraints to obtain tangible alternatives.
c) Iteratively aligning both spaces: The tangible alternatives serve as a means of communicating the understanding of the problem between the knowledge experts, end-users and domain experts. This helps to refine and revise the final solutions.

Hence, the iterative process in close alignment with stakeholders is vital, so that functionalities and user interfaces are not incomprehensible from the end-user's point of view.

We will use two different frameworks to develop the prototype. The first framework was developed (Shafiee *et al.*, 2018) for scoping and managing the knowledge of configuration systems, including the specifications and their corresponding processes. It thus provides a structured step-by-step approach for determining the scope of the configuration system, the requirements of such a system, defining, collecting and ultimately managing the knowledge of the system. The first framework steps are:

1. Determining the scope of the configurator.
2. Knowledge acquisition.
3. Modelling and knowledge validation.
4. Documentation and maintenance.

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For configuration systems it is of vital importance to develop a project scope early, and continuously revise it as new information appears. If the project scope is too wide, it may not be feasible to complete the configurator within the project deadline, while a too narrow scope could mean vital features are not implemented. While other frameworks were used for the development of the configurator, a framework by Shafiee was used (Shafiee *et al.*, 2014, 2018) in scoping the configurator, that considered five key areas as outlined in the scoping below:

- Aims & purpose for the configuration system
- Identification of stakeholders and their requirements
- Definition of the IT architecture
- Products and product features to include in the configuration system
- Project plan including resources, timetable and modelling approach

2.3. Customizing the current financial advisory services

Prior to developing a financial configuration tool, it is of course useful to analyse any currently existing options. To the best of the authors knowledge, there is no scientific research on the topic of financial advice configuration systems, making it a new research topic. In general, configurators are mostly used to configure products from the perspective of a single company (Schäffer *et al.*, 2020). Some commercial options do exist, but they have generally limited uses and do not seem to be relying on product configuration theory directly. All the tools were generally found to have a very low level of accessibility, as they were either hidden behind paywalls, or only accessible in certain regions – no current tools were available on a global scale, though a large limitation to this is also varying financial regulation across countries. The most developed tools are targeted to individuals with high levels of capital and are furthermore not focused on increasing the financial literacy of its users.

3. Research method

All consumers could generally benefit from the increased financial literacy that a financial configuration system could provide. However, the configurator is primarily aimed at people with limited financial education. The system is furthermore also aimed at inhabitants of Scandinavia, or even more specifically Denmark, as there are certain local laws and regulations that need to be taken into consideration. However, many of the principles discussed are still applicable on a global scale. As the project scope was later narrowed towards pension schemes, the system was further aimed at middle-aged people nearing pension age. However, it could also be argued that it would be best to reach younger people and teach them about the importance of saving for their pension early on, when smaller economic decisions will have a greater long-term impact.

3.1. Data collection

The calculations and data processing was based on an initial Excel sheet. Both salary and expenditures were assumed to increase consistently at an inflation rate of 1% - these calculations were however set-up in a way that the inflation rate could be changed either overall, or for each year. Three types of portfolios were considered for general investments and pension savings – based on the Danish Council of Return Expectations (Council for Return Expecations, 2020). Taxation on salaries in Denmark relies on three main areas: labour market contribution tax (Arbejdsmarked-bidrag, or AM), state tax (split into bottom and top tax), and communal tax. Additional exemptions exist for various things, though that level of complexity was not considered for this project.

4. Developing the configurator

It was chosen to develop a web-interface based using Excel VBA programming. This Excel sheet is a simple web-interface that builds a more user-friendly interface on top of an underlying Excel sheet, that is provided to serve as the engine. The system allows the users to provide various limits on the various inputs and outputs the user might be able to receive, and works well with other systems or APIs, feeding the outputs into these

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systems (Shafiee, Wautelet, *et al.*, 2021). As such, more graphical visualizations can be built on top of this engine, though the underlying system still relies on the logic within the Excel sheet.
Within Excel, there are a few limitations to what Excel allows, though this is currently being expanded. For example, it currently does work with neither Visual Basic programming nor pivot tables. The initial interface shown to the user when testing, requesting inputs on the left-hand side, and providing the relevant outputs on the right-hand side. The more visual API interface that was built on top of the Excel web interface – showcasing the pension portfolio over time, see Figure 1 and Figure 2. The graphical visualization changes actively as the inputs below are edited.

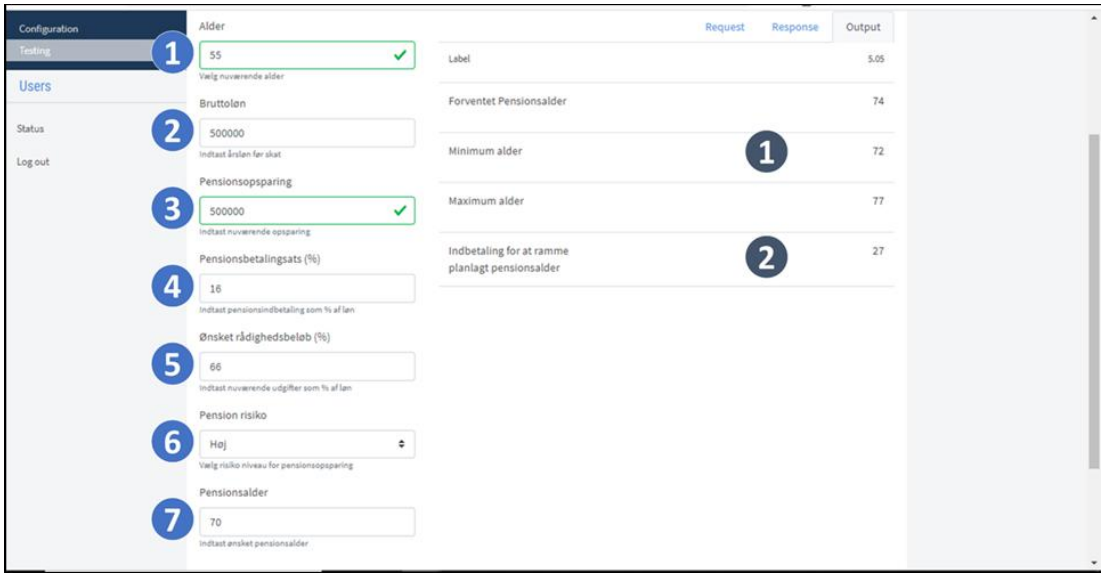

Figure 1. Configurator testing interface; Inputs: 1) Age 2) Net salary 3) Pension savings 4) Pension payment rate 5) Spending 6) Investment risk 7) Expected pension age; Outputs: 1) The range of expected pension age 2) planned retirement payment amount.

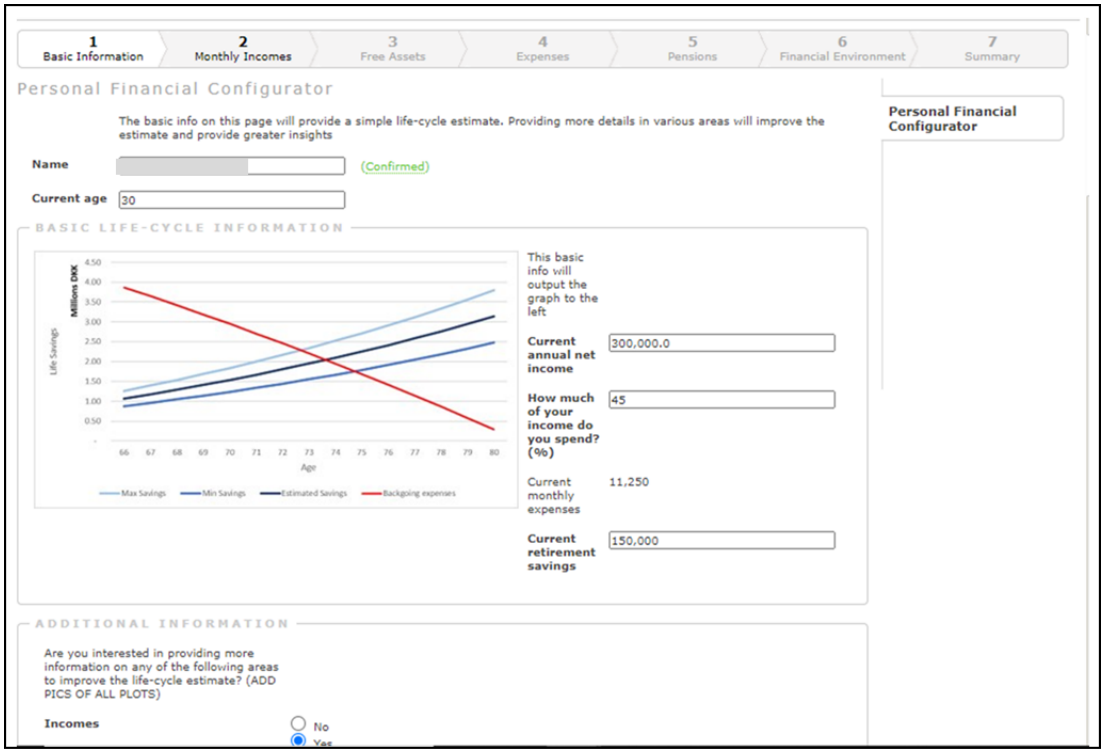

Figure 2. User Interface page with basic information

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4.1. Feasibility

After considering further prototype development, all users were asked questions. The questions were asked from an individual standpoint. The questions are outlined in Table 1. Though the exact financial goals varied significantly across interviews, all users showed interest in being provided with more clarity on whether these goals were feasible – and what financial changes they could make to ensure they were feasible.

The level of financial literacy also varied significantly across users, as some users requested a simplified interface, while others were requesting greater levels of detail. This highlights the need for product configuration theory early in the prototype, questioning users on their level of financial literacy, and providing them with the corresponding level of complexity in the system. This could be in the form of simple multiple-choice questions. Furthermore, the prototype should also encourage greater interaction through using sliders for the various input parameters, in addition to auto-fill forms. This could even be done through integration with banking applications. Through the use of spreadsheets, certain documents could also be auto generated as outputs for the users to further edit and adjust over time.

If such a system could be developed successfully, it has been shown both through scientific research that the benefits to users would be numerous. Ranging from improved investment opportunities, increased budgeting and decreased financial stress throughout the user's life cycle. Through implementing configuration theory, even users of high financial literacy could improve their understanding of new concepts.

Table 1. Questions for feasibility test

Questions	Compilation of interview answers
1. Which financial goals do consumers have during their financial life cycle?	Various spending goals such as purchase of primary or secondary housing properties, purchase of car, saving for vacations. Maintaining certain living standards through pension, varying significantly across interviews from lower to current to higher standards. Having kids, providing savings or inheritance for them.
2. What level of financial details are end-users able to comprehend?	Comprehension among users varies greatly and will also depend heavily on the interface and content presentation. While many end-users might be familiar with and understand the terminology, they are often unaware of the impact of various parameters on their portfolios
3. How should the model interface be designed for ease of use and understanding of end-users?	For certain users, visual and graphical representation helped with understanding, particularly to show the impact of various parameters. Other users requested further details, in form of the underlying spreadsheets and calculations. Interactive elements through scales or an overall control panel would engage users to test various parameters. Providing initial suggested inputs, and the ability to auto-fill remaining parameters based on current inputs.

4.2. Usability

In addition to asking about feasibility, the domain experts were also interviewed on the usability of the prototype. Interviewees were first asked five standard usability questions based on Nielsen (Nielsen, 1992; Shafiee *et al.*, 2017); the averages of the results are outlined in Table 2. Considering that there was little variation among results, it should be noted that interviewees were also shown different versions of the prototype as it was under development.

The first question was asked in terms of actual time, while a scale of 0-100% was provided for questions 2-4, to make it easier for the interviewees. Most interviewees still noted the difficulty in answering these

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questions due to the lack of directly competing or comparable systems. This further highlighted the novelty and importance of the research topic.
This is also a good reason for applying design thinking and involving the stakeholders to a high extent throughout the prototype development. Interviews were conducted concurrently with the development of the prototype, and edits were consistently made based on this user feedback. Users were found to have many varying goals, ranging from different levels of comfort in retirement, to differing savings goals ranging from real estate investments to travelling budgets.

Table 2. Questions for usability test

Questions	Round of average
1. How much time is required to learn the current system?	5 minutes
2. How much time is saved in using the system compared with conventional methods?	81%
3. How easy would it be to re-learn the system? (After longer periods of non-use)	83%
4. To what extent are calculation errors reduced by using the system?	88%

5. Conclusion

It has been shown that there is a growing demand for improved financial advisory tools, imposed by increasingly complex financial products and services. This demand has only grown through financial crises, as the most vulnerable individuals have been further left behind (Goyal and Kumar, 2021). Configuration theory seems to be a suitable approach of dealing with this financial problem. Hence, considerations need to be made in ensuring people with varying levels of financial literacy can be enticed to use the tools. This can be achieved through utilizing a human-centered approach around design thinking, ensuring that users of all levels are engaged through sufficient interaction with the interface (Shafiee, Haug, *et al.*, 2021).
Several financial tools already exist, and some of them seem to apply certain product configuration aspects and with limited access for public. However, there is still very little scientific research on such tools (Fraser, 2017). Moreover, most of these tools have very low levels of accessibility and are not necessarily reaching the individuals that need them the most (Lusardi and Mitchell, 2007). None of these tools seem to vary their content based on financial literacy either, rather being targeted towards individuals of high incomes that are likely already aware of most financial aspects, and currently manage their own investment portfolios.
It is demonstrated that it is possible to build a financial product configurator with high levels of feasibility and usability through utilizing product configuration theory with a strong focus on human-centered development around design thinking. Hence, we developed and implement the system in several iterations and based on the comments and opinion from users. Additional work would be required to expand the financial analysis within various areas, such as incomes, housing assets, investments in the market and more, to ensure the accuracy of the life cycle analysis. Additional interviews should be conducted with the aim of targeting people of lower education levels and socioeconomic status, as this was a large gap in the current interviewee pool.
The current system developed was shown to be fairly limited from different aspects. All users are presented with the same view, which was shown to break down at high incomes. Moreover, most interviews and tests were conducted on people in higher income groups. Many users questioned the lack of their other financial assets, such as real estate or investments such as stocks or bonds. The importance of including these aspects for a thorough life cycle analysis should be highlighted. Any excess money that does not go towards expenditures or pensions will still be saved by the individuals, either as a free asset, or going towards investments such as stocks or bonds. Moreover, transferring the approaches to investment and financial advice for small and medium-sized manufacturing companies could also be a promising further development. Additional work would be required to expand the financial analysis within various areas, such as incomes, housing assets, investments in the market and more, to ensure

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the accuracy of the life cycle analysis. These areas would likely need to be designed and developed concurrently to ensure the interrelationships are considered thoroughly.

More work would also need to be put into the interface design and system design, ensuring high levels of visual and graphical representation, while still allowing the users to edit the various features and see the impact on their life cycle. Additional interviews should be conducted with the aim of targeting people of lower education levels and socioeconomic status, as this was a large gap in the current interviewee pool. Though exceptions exist, this should also correlate to more individuals with lower financial literacy - the general target group of the ideal financial configuration system. Another interesting point could be to conduct additional research on younger individuals, as these are most prone to change their financial habits, and also have the most potential to still impact their financial life cycle. Such research could start with university students but could even be expanded to high schools or middle schools – though the complexity of the content would need to be adjusted accordingly.

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