ΠΟΛΥΤΕΧΝΕΙΟ ΚΡΗΤΗΣ
TECHNICAL UNIVERSITY OF CRETE

MSc in Technology & Innovation Management

"Revolutionizing Furniture: A Sustainable Approach to Customized Design and Manufacturing"

A Framework for Sustainable and Personalized Furniture Production by Integrating Advanced Technologies and Client-Centric Solutions

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6 DECEMBER 2024

ABSTRACT

The furniture industry is undergoing a significant transition. This thesis explores a novel methodology for customized and sustainable products, that integrates advanced parametric design, digital twin technologies, CNC automation and design principles to address emerging demands on mass manufacturing and customization.

By bridging the gap between traditional craftsmanship and modern technological advancements, this research provides a potential pathway for achieving scalable customization and environmental responsibility in furniture production.

This work evaluates the feasibility and market readiness for implementing Mass Customization -a manufacturing approach that combines the efficiency of mass production with the personalization of bespoke furniture. Through literature analysis and empirical validation via semi-structured interviews with professionals of the furniture industry in Greece this thesis provides an understanding of the industry's current state, including operational realities and evolving consumer expectations.

The study identifies critical barriers such as labor shortages, technological unfamiliarity, operational complexities and resistance to change. It also highlights the potential for leveraging digital transformation and streamlined parametric workflows to enhance customer engagement. Key findings underscore the transformative importance of digital twin-driven customization platforms, which will allow real-time modifications to furniture specifications while minimizing disruption to production workflows.

This thesis contributes to the academic and practical discourse on transforming furniture manufacturing into a more agile, innovative and environmentally responsible sector by proposing actionable strategies for stakeholders in the sector. It advocates for a holistic approach to integrating technology and client-centric solutions and it sets a roadmap to the future of furniture design and production.

This thesis document has been prepared over a five-month period according to the criteria set by the Technology and Innovation Management master's program at the University of Crete, while the original idea dates to December 2021. This thesis is entirely my own original work.

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WRITERS NOTE

I am a designer and woodworker with a background in architecture and a passion for pushing the boundaries of furniture design and manufacture. I started crafting projects, with limited formal training and tools at the rooftop of my apartment during my architecture studies so that I can bring my design ideas to life. For the basic knowledge of woodworking, I helped with Mr. Tzanetos Angelos, a veteran woodworker, on his projects while for unorthodox techniques I relied on YouTube tutorials, trial and error and participation in international competitions. My early work, such as the bent-lamination monitor stand I designed and manufactured for the "Rockler Bent Wood Challenge" stands as a landmark for my desire to push boundaries, current capabilities and gain practical skills in hand-tool woodworking.

Figure 1 Bent lamination monitor stand, made in August 2019. Entry for international competition "Rockler Bent Wood Challenge". Multiple veneer layers of differing length laminated using mold techniques to form a continuous loop of wood grain used to keep computer accessories in order. Designed and manufactured by Zygoulis Nikolas

In architecture school I learned to think critically and creatively, applying design principles to both architecture and furniture alike. I also became proficient in parametric design software like Rhino3D and Revit architecture, tools that allowed me to explore the intersection of design

and technology. My first furniture that is designed specifically to be completely manufactured by robotic means is the “RC-DC stool”, made to order by the civil engineering office “RC-DC”.

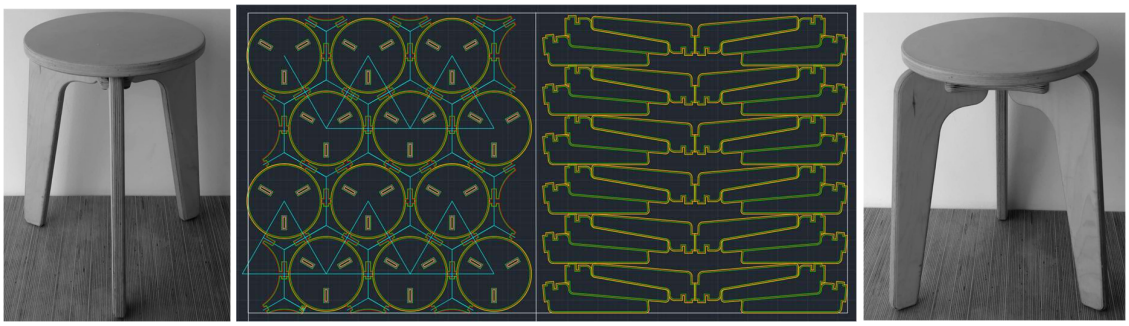

Figure 2 “RC-DC stool”, made in Feb 2020. Commission by “RC-DC office”. By using the advantages of nesting parts in the CNC bed this design yields eleven stools from a single sheet of plywood, making it one of my most efficient design to this date. Designed and manufactured by Zygoulis Nikolas

Figure 3 Prototype rocking chair. made in Feb 2021. One-half scale. Nested MDF parts machined using basic techniques to produce intricate joinery. Designed and manufactured by Zygoulis Nikolas

After architecture school I worked at “Tzoumani Bros”, a small manufacturing plant of 15 people, where I Honed my technical design skills. I learned the intricacies of furniture production, focusing on CNC machining for kitchen and wardrobe construction. I introduced Fusion 360 into the design process, streamlining the manufacturing workflow by automating the generation of Bill of Materials (BOM) lists. There with my own initiative, I experimented with my own designs using their machinery producing prototypes such as a rocking chair, leveraging 2.5D CNC milling techniques to produce complex joinery for functional furniture.

When Covid-19 pandemic hit, I contributed to the creation of “WUDD kid’s toys”, a subsidiary focused on flat-packed, robotically manufactured children’s furniture. This project utilized my previous knowledge on design for manufacture and allowed me to design and prototype a series of 15 unique products. These products are optimized for CNC production, with human hands being involved only in the sanding and finishing process. This experience opened my eyes to the potential benefits of fully automated production, sparking my desire to find the golden ration of traditional and new manufacturing methodologies. (Wudd, 2024)

Figure 4 Wudd kid's toys, designed Apr 2021. Protype design and manufacture for complete furniture and toys line. All products are designed specifically for the manufacturing capabilities of the factory. Designed and prototyped by Zygoulis Nikolas

I also worked with "KPS Group", a company specializing in premium orders for luxury hotels and villas. This experience proved the value of human expertise and craftsmanship in high-end projects, while also expanding my understanding of parametric design and its application in streamlining production at various scales. The most notable project of this time is the parametric table I designed and constructed for myself. It is designed using traditional joinery techniques modernized to suit high-tech manufacturing methodologies.

The beauty of the design is that upon the creation of the digital twin of the furniture its dimensions can be easily modified to create a line of products. Dining tables, coffee tables, credenzas and even benches can be manufactured from a single model. Below I highlight two case studies of completed furniture constructed using the same parametric digital twin model and give examples of different possible dimensions. (Brown, 2022)

Figure 5. Parametric table design, made in Jan 2022. Designed by parametric digital twin methodology and cut by CNC machines.
Top: Outdoor bench with marble top (1200x400x450)
Left: Office table with glass top (1750x800x750)
Designed and manufactured by Zygoulis Nikolas

In addition to my professional experience as a designer, my freelance work gives me a chance to explore experimental designs and fabrication techniques. I often undertake self-initiated projects and commissions to challenge myself creatively and technically. The latest example of pushing the boundaries is the project “Katerina Lamp”, a statement console crafted as a wedding gift. This piece features an angled curvilinear form with continuous wood grain and an embedded infinity mirror. This project required extensive problem-solving with CAD modeling and precision woodworking. To complete this project specialized tools were constructed like a complex 2D paper net -generated from the digital twin model.

Figure 6. "Katerina Lamp", made in June 2021. Statement hallway console with curvilinear form, manufactured using angled kurf bending technique from a single piece of sheet material. Features an infinity mirror providing additional dept to the piece. Designed and manufactured by Zygoulis Nikolas

1 INTRODUCTION

1.1 Proposed Idea

1.1.1 The plan

The goal of this research is to evaluate a new method of design and manufacturing, which merges advanced parametric design in digital twins, CNC automation, and sustainable practices. The purpose of this document is to lay the foundation for the technological feasibility and to assess whether this approach is in demand by the industry.

Rather than developing the exact business model and launching a business immediately, an evaluation of the potential impact, demand and scalability will be made for automated and parametric digital twins. The goal is to identify specific opportunities for such methodology in the industry and determine the readiness of potential clients to accept and adapt to this process.

The core concept revolves around enabling a high degree of customization on existing and new standardized designs. When this process is complete the expected outcome will be a truly sustainable Custom Mass Manufacturing method, also known as “Mass Customization”.

The starting point for this venture is to use software with parametric CAD/CAM capabilities and create flexible digital twin models that can allow furniture dimensions and specifications to be adjusted in real time. The technology to create these models exists and is being used on a regular basis by the manufacturing industry.

These models will guide the design process and simultaneously directly inform the manufacturing workflow by providing data to CNC machines responsible for managing the production of highly customized standard parts. The technology to link software with hardware is also a standardized practice in a modern factory. The result is a seamless design-to-manufacture pipeline, where products like furniture can be tailored to a client's exact specifications with minimal manual intervention by the designer. (Sehyun Myung, 2001)

What I intend to do in the long run is to develop a platform from which the client can in real time modify the existing designs to their liking, see the results of said modifications, and order the exact product they need, while causing insignificant disturbance on the manufacturing side.

By combining advanced CAD/CAM technologies with a sustainable approach, the proposed company named “**M_THICK** studio” will provide flexible solutions for creating both bespoke pieces and scalable designs. The name comes from the parametric material thickness variable I tend to use in CAD, symbolizing the adaptability and precision of the company’s operations.

M_THICK is a forward-thinking furniture design studio that integrates parametric design, CNC automations and sustainable practices to offer high-quality and customizable furniture. At the core of the company is the ability to offer customers the service of adjusting furniture dimensions in real time, while being able to see the changes via modern solutions like 3D renderings, AR models and detailed blueprints before production. The studio is divided in three key areas of operations: a design studio that promotes creativity and innovative designs, a fabrication lab that is used for prototyping and small-scale custom orders, and an R&D hub focused not only on exploring new materials and techniques, but also on developing improvements on workflow efficiency.

1.1.2 The company

The idea for this company is rooted in my experience in the woodworking industry. This company will offer customers the ability to customize the dimensions of their furniture in real time and view the exact ordered piece via 3D renderings, Augmented Reality, and conventional blueprints before their order. This service will be backed by sustainable manufacturing processes that use modern CNC milling manufacturing techniques and a sophisticated website.

I envision a company that can grow and adapt in the uncertainty of today's environment, a company that can be modified to suit the ever-changing parameters of market demand and technological innovations. The name I have chosen for this company is "**M_THICK**", it is the name of the parameter I use in CAD to control the material thickness.

To remain agile the company should have several fields of operations and employ dynamic cellular manufacturing principles that are all interlocked together and derived from the same core need, to produce the finest personalized furniture. All the subsections of this company can either act as individual structures that can branch out to be their own service or link up to support each other and complete bigger projects. (P. Renna, 2015)

The first field of operations will be **the design studio** where designers, like me, will have the resources to design innovative products and solutions. This section of the business will foster creative thinking and provide a platform of which designs can be brought to market. This section will work either on its own initiative or be hired by other companies and individuals. (Barbieri & Muzzapappa, 2024)

The second field of operations will be **the fabrication lab**, that in turn also has a dual purpose. Firstly, will help designs and innovations come alive and will provide the necessary technical

expertise to ensure that the designs are feasible in every scale of manufacturing. Secondly, it will fulfill high margin and prestige orders, so that it provides prestige and financial aid to the company. (Santos, Murmura, & Bravi, 2018)

The last field of operations will be **the R&D hub**, where the company will develop its proprietary workflows. There we will evaluate new ideas and materials and find a way to incorporate them in our main workflows. This field of operations can be adapted according to the current needs of the company. For example, the website linking Fusion 360 with the client will take place here and will be developed by outside contracted experts in Application Programming Interface (API) and website development.

1.2 Motivation

1.2.1 Origin of idea

With a background enriched by a variety of courses and practical experiences in architecture and design, including significant exposure to cutting-edge technologies, I have cultivated a deep understanding of the constructive interaction between architectural creativity and technological advancements.

The above experience and the nature of my multidisciplined abilities have inspired me to imagine of a business model that utilizes smart design options, expert technical CAD/CAM automation, and practical workflows to offer clients semi-custom furniture pieces that fit exactly their space. This is the reason I chose to attend the master's in technology and Innovation Management (MTIM) program at the Technical University of Crete, so that I can equip myself with the necessary managerial tools to make this dream a reality.

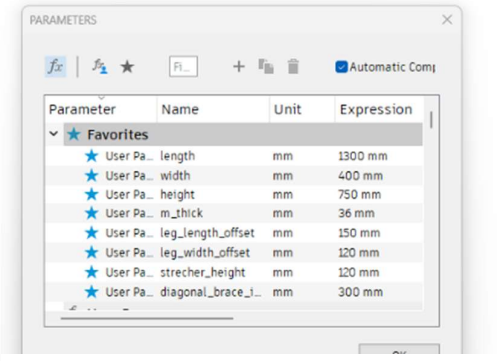

Figure 7 Example of CAD parameter list

Since CAD software like Fusion 360, alternatively SolidWorks or Autodesk Inventor, can be linked to CAM process, the work needed to produce this variety of designs lies in minutes of ticking the overall parameters. Although the design phase of this furniture took longer than just designing a static table, the possibilities unlocked by the initial investment are limitless. The rest of the operations to produce said furniture remain the same, i.e., prepare the stock material based on the Bill of

Materials, load the machine, and oversee it, sand and varnish the parts, and prepare for shipping. (Autodesk, n.d.)

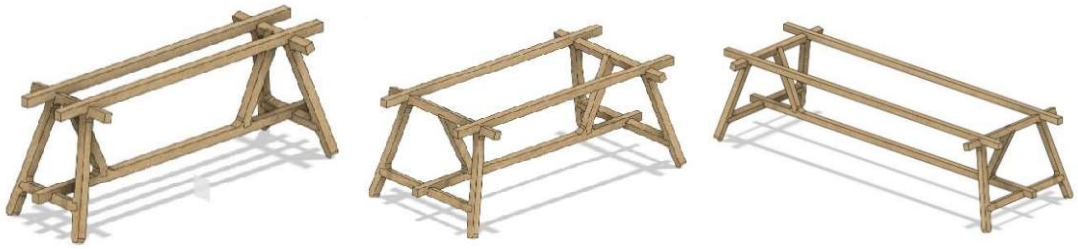

Figure 8 Example of multiple instances of a digital twin CAD model

In addition to this design principle, there is also potential in innovative design that pushes the boundaries of practicality. One distinctive example is the "Katerina Lamp" console I designed and built, a one of a king piece that is next to impossible to manufacture using conventional woodworking tools and exceedingly difficult to manufacture using the techniques I used, making it not viable commercially. Yet using modern CNC machinery with 5axis capabilities this and other similar designs can be reproduced in a matter of hours, rather than working days.

1.2.2 Expected 5-year results.

In 5 years, I expect the company to change and become a **software provider** and **methodology consulting agency**. All the above-mentioned steps will lead to the creation of a seamless connection between the smart factory of the future and the demanding customer of today. It is of extreme value to the company that this methodology can apply to every manufacturing product and not only woodworking furniture. Other sectors like custom packaging, metal working, specialized sporting equipment and so on can be incorporated into M_THICK.

At this stage of my thesis, it is difficult to calculate the steps needed to achieve this, but I have prepared a diagram highlighting the possible flowchart for the order prosses of a mass produced yet custom dimensions furniture product.

1.3 Business Model Canvas

Key partners

- Large scale furniture manufacturers.
  Collaborating with large manufacturers to design and prototype furniture lines. They handle mass production, while we manage initial development.
- Small manufacturers and Family-owned workshops.
  We support small-scale workshops by offering blueprints, design services, and organizational guidance to improve efficiency and modernize their operations.

- Independent designers and architects.
  Partnering with designers to offer them prototyping, production, and technical support to bring their ideas to life.
- Material suppliers.
  We collaborate with suppliers so that they integrate our organizational capabilities into their workflow. By collaborating with them they gain efficiency in fulfilling orders made with our technology, while we gain seamless material supply for our operations.
- Technology providers.
  CAD/CAM and API software providers for solving potential problems, Software developers (API) for developing proprietary code for seamless CAD-CAM-Customer experience, CNC machine and consumables providers that ensure smooth fabrication procedures.
- Marketing and exhibition partners.
  We work with marketing professionals and furniture exhibitions to display our work.
- Legal and accounting.
  We hire professional external collaborators to consult and manage our Intellectual property and accounting issues.

Key activities

- Design and development.
  We create innovative, customizable furniture designs using parametric CAD workflows, yielding digital twins for efficient prototyping and production.
- Prototyping and R&D.
  We build prototypes using our modern manufacturing workshop equipped with CNCs, 3D printers, and laser-cutters, offering rapid iterations and testing. We offer this platform to larger manufacturers as well as to individual designers.
- Small scale production.
  We execute high-end, custom furniture orders for selective clients. We focus on limited-edition and premium furniture that larger manufacturers avoid.
- Licensing and Royalty management.
  We manage licensing agreements for our designs.

Key resources

- Design studio & prototype facility.
  We have a modern, well-equipped studio, used for prototyping and small-scale production. We have CNC machines, 3D printers and conventional tools.
- Parametric CAD/CAM software.
  We are using commercially available advanced software like Fusion 360 or SolidWorks that we have set up with direct integration to the manufacturing machinery.
- Skilled Design, engineering and manufacturing team.
  We employ skilled people, and we offer them an environment where they can unleash their talent and further develop their skills.
- IP portfolio.
  We have an expanded portfolio of innovative and protected registered designs, utility models and trade secrets.

- Network of designers and architects.
  We will form a community of collaborators who contribute and benefit from our business model.

Value propositions

- Customization at scale.
  We offer parametric design solutions that allow for rapid and high level of customization, while maintaining efficiency in mass production.
- Prototyping and design expertise.
  We can accelerate the design-to-market process with fast and accurate prototype development.
- Flexibility for premium orders.
  We can handle effectively high-end and difficult orders that other manufacturers may avoid, giving clients quality bespoke pieces.
- Collaboration platform.
  We provide independent designers with the tools needed to turn their ideas into reality.
- Consulting.
  We offer technical drawings, 3D models and production guidance to other similar businesses looking to modernize their operations.
- Licensing for scalability.
  We offer ready-to-produce designs that manufacturers can immediately scale up, removing the need for their internal R&D.

1.3.1 BMC Table

<table>
<tr>
<td rowspan="2"><u>Key Partners</u>
• Large scale furniture manufacturers
• Small manufacturers and family-owned workshops
• Independent designers and architects
• Material suppliers
• Technology providers
• Marketing and exhibition partners
• Legal and accounting</td>
<td><u>Key Activities</u>
• Design and development.
• Prototyping and R&D
• Small scale production
• Licensing and royalty management</td>
<td rowspan="3"><u>Value Proposition</u>
• Customization at scale
• Prototyping and design expertise
• Flexibility for premium orders
• Collaboration platform
• Consulting
• Licensing for scalability</td>
<td><u>Customer Relationships</u>
• Collaborative design and prototyping
• Ongoing partnership with manufacturers
• Premium client services
• Consulting and support
• Personalizes design services</td>
<td rowspan="2"><u>Customer Segments</u>
• Large manufacturers
• Small manufacturers
• Furniture exhibitions
• High-end customers
• Designers and architects</td>
</tr>
<tr>
<td><u>Key Resources</u>
• Design studio
• Prototyping facility
• CAD/CAM software
• Skilled team
• IP portfolio
• Network of designers</td>
<td><u>Chanels</u>
• Direct B2B relationships
• Online platform
• Onsite demonstrations
• Industry tradeshows
• Portfolio and case studies
• Word of mouth</td>
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<tr>
<td colspan="2"><u>Cost Structure</u>
• Initial investment
• Personnel costs
• Material costs
• Marketing and sales
• IP and legal
• Maintenance
• Consumables
• Software and technology</td>
<td colspan="2"><u>Revenue streams</u>
• Design fees
• Prototyping services
• Licensing
• Small-scale production run
• Consulting</td>
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2 LITERATURE REVIEW

2.1 Analysis Of Business Environment

2.1.1 Greek industrial manufacturing

Modern society has been through a prolonged period of uncertainty, which has been termed as “permacrisis”. This uncertainty leads to a change in consumer needs and expectations, which directly affects the industry. Consumers seem to prioritize their needs differently and expect more from the products they buy and from the companies that produce them. To meet these challenges, Greek industry needs to develop flexible strategies as well as strong and efficient production processes. (ΣΕΒ, 2024)

In particular the fragmentation of the productive base makes it difficult to achieve scale and extroversion, limiting the ability of firms to grow and cooperate. Even though labor costs in the manufacturing sector of Greece remain competitive compared to other EU countries, the remain much higher than in other sectors in Greece. Firms also find it difficult to recruit skilled labor, a situation exacerbated by the demographic characteristics of the country. (ΣΕΒ, 2024)

Increasing energy costs in Grece translates to more than double the costs for Greek industry compared to EU, a situation that does not seem to de decreasing in the upcoming years. Many companies have already started to turn to renewable energy sources and innovative solutions to save on resources. Sustainable development though recycling programs and the adoption of environmental criteria is also a strategic priority for many industries, as it not only enhances reputation but also helps reduce production costs. (Panagiotopoulos P, 2024)

Digital transformation, by definition, has a key role in the modernization of industry. Larger companies have already developed high levels of digital maturity, but it seems that smaller companies are lagging. Moreover, to achieve the above, the industry is increasingly supported by European and National financial instruments, enabling companies to modernize their production processes. (Sidney, 2023)

Finaly, following a survey conducted by SEV, the external challenges of the industrial enterprise are highlighted, with the main issues being human resources, disruption in the supply chain and increasing cost of raw materials. In the coming years, the issue of the lack of skilled labor is expected to intensify and grow to include finding unskilled labor. At the same time, among other challenges, research and development of new products and new product design,

are emerging as top internal challenges. It is worth noting that these data relate to all industrial enterprises in Greece and not to individual cases. (ΣΕΒ, 2024)

2.1.2 The woodworking sector

The term "cabinetmaker" means a profession that serves basic needs and is carried out by a skilled craftsman. It requires the knowledge, skills and abilities necessary to work with wood and wood products to create furniture and structures. Examples of such furniture and structures include dining room, living room, kitchen, kitchen, kitchen, toilet, bedroom, office, shop, restaurant, bar, school, cinema - theatre, ship, hospital, church, balcony and outdoor furniture. (EOPPEP, 2024)

The profession is classified as an activity in the priority sectors "MATERIALS - CONSTRUCTION" and "CREATIVE INDUSTRIES" of the National Smart Specialization Strategy 2021-2027. The operation of the business requires the issuance of an operating license in accordance with current planning and electromechanical legislation, while no special license is required for the exercise of the profession. (Foti, 2021)

At the professional, sectoral and institutional level, the business environment of the cabinetmaker's business needs to be improved. Among other strategies for the development and evolution of the profession, the improvement of skills, digital, business and operational knowledge is identified. The need to reduce production costs while improving quality with environmentally friendly operations is also identified. Finally, it is crucial to differentiate products and services from large companies to enhance the competitiveness and market share of smaller companies. (Foti, 2021)

With a brief description of the analysis of Mrs. Foti Daphne, the four main areas where there may be elements of innovation in the current state of the profession are identified and are briefly mentioned below. (Foti, 2021)

Product and service innovation.

It is the introduction of new, competitive products to the market and results mainly from innovations in the appearance and properties of raw materials. This field also includes innovation related to after-sales services. In this way, the professional cabinetmaker maintains and increases his turnover and at the same time maintains constant contact with his customers. (Foti, 2021)

Process innovation.

It concerns the introduction of new ingredients mainly in the production process. An important part in this field is the electronic CAD/CAM technology, automation of production with CNC systems and process control systems MIS (Management Information System), MRP (Material requirements planning), JIT (Just in Time). The driving force in the above innovations is the reduction of production costs, harmonization with quality standards and minimization of energy consumption. (Foti, 2021)

Innovation in organization and operation.

It relates to the introduction of new methods and procedures in the practices of the profession. It is likely to be achieved by participating in exhibitions, attending training courses and making use of academic research and university staff. Individual firms are also likely to develop synergies to adapt to their rapidly developing environment, or to complete large projects. These are based on individual initiatives and are not exploited by all the companies in the sector. (Foti, 2021)

Marketing innovation.

The introduction of a new method of promotion and advertising involving changes in product design, packaging, positioning, promotion and pricing. Usually, the variations in the way products are sold are related to the use of the internet, through which the business is promoted, and customers are informed. The trends for innovation in marketing, subject the entrepreneur furniture maker to utilize modern means of promotion and constantly adapt to new market data. (Foti, 2021)

A change agent is defined as any phenomenon or development that may affect the profession. Change agents can have a wide range from institutional changes to climate change. The factors on which the firm can act and assess its impact will be mentioned below, while factors for which it is practically impossible to take care of, such as the country's micro-political environment, will not be mentioned. (Foti, 2021)

2.2 Analysis of Existing Terminology.

2.2.1 Mass customization

As consumer demand for customization rises across all industries, the relationship between manufacturers and clients is evolving. Customization allows consumers to directly influence the design process, making it a crucial aspect for competitiveness. This personalization trend can lead to shorter supply chains and reduces inventory. Customization of products can be a strategy that enables higher-cost producers to compete with lower-cost imported products by bringing consumers closer to manufacturers and allowing customers to directly influence their product, effectively "bypassing" traditional design and retail processes. (Matthew S. Bumgardner, 2020)

Many products in the current furniture market are customizable, this customization is limited to a semi-custom basis, giving the option to select features, like wood species and finish while maintaining a predefined design. (Matthew S. Bumgardner, 2020)

Mass Customization (MC) is a methodology with which the personalization of customized products is combined with the efficiency of mass production. It is increasingly relevant in today's market as companies that adopt this strategy can quickly customize their products for individual customers or niche markets. With this capability, the delays and complexity associated with forecasts and inventory management are mitigated as both customized and standard products are offered on a Build-to-Order basis (Suzic Nikola, 2014).

Operational efficiency and the satisfaction of individual customers is of the essence and companies must form strategies for them. The critical moments in establishing mass customization are product variety, product price and product time of delivery. The variety of customization offered by the company is determined on their capabilities and can be based on product families with a modular or scalable design. Product platforms and strategy formation can happen wither with a top-down approach, meaning to modify the company's actions to suit the product, or bottom-up approach, meaning that the product and the extend of its customization is based on the capabilities of the firm. (Suzic Nikola, 2014).

2.2.2 Eco-design

Eco-design refers to the integration of environmental considerations into the product design process. Products designed this way serve their functional purpose but also minimize negative environmental impact throughout their lifecycle. It involves selecting sustainable

materials, ensuring product durability and ease of recycling, as well as considering the environmental impact from their production to their disposal. (Matthew S. Bumgardner, 2020)

Eco-design practices include using recyclable materials, low energy consumption, reducing waste during production, promoting repair and upgrading, and exploring clean production techniques. Even though implementation can be challenging due to perception of complexity and the additional steps introduced into the traditional design processes, it can enhance a company's competitive advantage by adjusting its market positioning. New markets can be opened when more companies from different sectors integrate these processes while aligning with consumer demand for sustainable products. Also, in the long run companies can benefit from reducing resource consumption, waste and potential regulatory compliance penalties. (Matthew S. Bumgardner, 2020)

2.2.3 Factory 4.0

The era of Industry 4.0 has already arrived and many factories are using Cyber-Physical Systems to manage their real production processes. These systems help to optimize efficiency by enabling data analysis, supporting automation and data analytics. Some of the key features of the factory of the future include real-time performance monitoring, better control of physical processes, and full integration of the business with suppliers and customers. In all of this, the use of new technology and IT has a significant stake, so companies need to fully understand the potential of digital transformation and strategize accordingly. (ΣΕΒ, 2024)

Digital transformation allows flexibility in the face of market changes, enhancing business resilience. Leveraging digital initiatives such as the Internet of Things (IoT), data analytics and automation offers industries the ability to optimize operations, reduce operational costs and increase efficiency. Digital transformation is not only limited to improving existing systems, but also accelerates product and process innovation. Faster introduction of new products to the market is key to maintaining business competitiveness. Tools such as 3D printing, simulation and virtual prototyping help industries to speed up the design and testing phases, enhancing the overall efficiency of the new product development process. (Nunes, Pereira, & Alves, 2017)

Another benefit is to minimize the impact of a shortage of unskilled staff. Digital work instructions guide workers in performing complex tasks, reducing errors that can result from lack of experience. Through access to information and the creation of templates, workers enhance their skills and can make more informed and well-informed decisions. (ΣΕΒ, 2024)

2.2.4 Manufacturing excellence

Manufacturing excellence can be seen as a response to these challenges. It is a tool that helps companies with a systematic strategy. It offers a war in which systematic improvements are adopted and integrated into businesses resulting in better adaptability to today's demanding industrial environment. It represents a strategy that aims to continuously improve every functional area of organizations and uses tools such as innovation at every level and the systematic elimination of every inefficient process. The result of this process is that organizations reduce errors and improve efficiency and quality, leading them to exceed their limits and achieve high performance with the corresponding resources. (Furlan & Vinelli, 2018)

There are several critical success factors that every organization that wants to achieve industrial excellence needs to focus on. First and foremost, any industrial excellence program should be directly linked to the long-term strategy and objectives of the company. This will ensure that any improvement initiative, by any member of the organization, is also in line with business priorities. In the same success factor and before the organization takes steps towards industrial excellence, management needs to set realistic and measurable goals, thus ensuring that the expectations and efforts of all parties involved are aligned and within the realm of possibility.

It therefore seems that commitment from top management is absolutely critical, as it must clearly define and communicate its strategy and vision. It must also actively support any initiative but also provide appropriate resources and the necessary guidance to the company's staff. The staff of the company, on the other hand, is another key success factor, as it is the backbone of any organization. It needs to be up to date, to welcome the demand for change and to be systematically trained in skills, new tools, techniques and methodologies to be qualified to cope with new market trends. The success of the program depends largely on the quality of the training but also on the relevance of the subject matter and the practical application of the above to the habits of the organization. (ΣΕΒ, 2024)

Finally, change requires the right culture in the organization, which will promote the active participation of employees, giving them the opportunity to contribute to the transformation process and take responsibility for its completion. Of course, everyone's efforts should be recognized and rewarded with tangible or intangible rewards. From the above, the need for effective communication throughout the organization emerges. Developing and implementing an internal and external communication plan is essential to ensure transparency and alignment

of efforts. This transformational change has the answer to the difficulties faced by the entire Greek industry. (ΣΕΒ, 2024)

2.3 Analysis Of Similar Examples

A very interesting approach is the" Close to the Customer", or CTC concept, that Paolo Pedrazzoli and his team suggested in 2016. They developed an innovative production paradigm, implemented within the furniture sector, to enable local and flexible manufacturing of green personalized products in terms of their features offered, place of fabrication, time to deliver and cost. Their ultimate envision is a "green factory behind a glass pane", located directly near to the clientele area of operations, where they can witness and be part of their personalized furniture. They designed a lean and compact system that guarantees performance in both customer service, with rapid delivery times and high level of customization and production efficiency, with automatic data generation and tracking. (Paolo Pedrazzoli, 2014)

To achieve this vision, they suggest several main factors and their innovativeness. A **formalized design approach** that empowers "design to manufacturing in one step", a **mini-factory production system model** that can be easily and quickly integrated in factories and be directly driven by the formalized design process, and a **woodworking machining system** to empower the "Close to customer" concept. The integration of the above different modules into a holistic project is the most challenging aspect of the endeavor. All these factors may contain innovation within themselves, yet the true innovation of the project is the exploitation of the sum of technologies in an innovative business model that delivers value through flexible and personalized products. (Paolo Pedrazzoli, 2014)

The formalized design refers to the tools and engineering needed to be developed or incorporated to make design compatible with manufacturing methods and does not refer to the superficial definition design such as modern, traditional, eclectic, or minimalist. These tools and engineering are meant for a holistic design approach. The goal is to foster a simplified transition from CAD to CAM, with a reduction to the complexity allowing the simultaneous generation of both product design and reliable manufacturing data that will lead to up to 50% increase in effectiveness. (Paolo Pedrazzoli, 2014)

The Mini-factory Production System Model is designed to be compact and easily interactable in green factories. It is the derivative of the formalized design approach and contains the manufacturing part of the paradigm. It contains the logistic structure, the supply chain

management and the means of operations. This system can be the basis for implementing the CTC model strategy in diverse conditions around the EU. (Paolo Pedrazzoli, 2014)

The woodwork machining systems refers to the means of manufacturing and their relationship with the customer. This system will be empowered with an advanced Human Machine Interface (HMI), high flexibility and safety standards, various automations and will run continuously as in a flow-like production environment, optimized for small batches and Just in Time (JIT) production. This module is also responsible for tackling the issues of running industrial machinery close to the customer such as dust extraction and noise control. (Paolo Pedrazzoli, 2014)

The ideal location of a CTC mini factory is near the consumer. The sales and production areas are both easily accessible by people. The process begins when a client enters the area, where with the help of an employee they customize the furniture using a user-friendly configurator of predefined designs driven by a parametric portfolio. Once they conclude a design and its properties and the client is satisfied with the offer, the order is generated and sent to the manufacturing plant, where all machining data are automatically created. The complete process is always monitored to keep the client informed and to increase the efficiency of the system. This flow of information throughout the product's life cycle from conception until delivery is what can allow lean fulfilment of orders in short times. (Paolo Pedrazzoli, 2014)

The system's ability to control information also makes possible the use of minimal levels of inventory within the factory, while relying on a short supply chain. Local raw material suppliers and rapid delivery of materials by couriers are exploited so that the factory's warehouse only needs enough materials to complete just a few orders. Using an automated warehouse CTC factories can process materials in an efficient manner, while a packaging area at the end of the line is used for outbound delivery to the courier or directly to the client. The assembly phase of the furniture is up to the client, who might choose to assemble the furniture themselves using well documented instructions, through a kit for Do-It-Yourself, or choose to have the furniture assembled by an operator. (Paolo Pedrazzoli, 2014)

3 EMPIRICAL VALIDATION

3.1 Design And Objectives

For assessing the feasibility of the initial idea, the opinion of industry experts will be sought after. Semi-structured interviews will be conducted with people in important positions that will express their perspectives of market demand and feasibility of the endeavor, while maintaining a focused framework. Given the exploratory nature of validating a new business model for mass customization of furniture, a semi-structured interview will provide an opportunity to uncover insights from the industry that may not have been anticipated. (Tegan, 2023)

The main group of people that will participate in this survey will be linked with the Key Partners and Customer Segments sections of the BMC. The opinions of small and of bigger manufacturers, designers, material suppliers and independent commercial shop owners will be valuable in assessing the current situation and market demand.

The questions will be formed through a strategic, layered approach and will be common for all participants disregarding their field of operations. The formation of questions will draw from previous surveys from ΣΕΒ and ΙΜΕ ΓΣΕΒΕΕ but also be tailored to the specific theme of this thesis. The target duration for every interview is set to 25 minutes, while the span of the interview questions is set to fit in a single A4 sheet of paper.

Questions will aim to determine whether there is demand for mass customization methodologies and the industry's opinion on its feasibility. They will also aim to determine the need of woodworking factories in cooperating with design studios for the creation of new methodologies and products. It is important at this stage of development of the proposed business model that no information leading to replicating the results by potential competitors be leaked. A set number of participants will be 2 people for every category of the BMC, leading to a sample of 10 interviews. This is the proposed number of participants and can change according to the participants' responses and availability. (Baker & Rosalind, 2012)

3.1.1 Interview Forming

Business environment

- Describe your role and how it relates to furniture production or sales
- What is the value proposition of your company?
- What are the 3 main difficulties of the external environment your business has faced in the last 3 years?
    - (3 short answers)
- What do you think are the 3 main difficulties your business will face in the next 3 years?
    - (3 short answers)

Competitive advantage

- What are 3 key success factors in your sector?
    - (3 short answers)
- What are the 3 failure factors in your sector?
    - (3 short answers)
- How do you measure success in your business?
    - How do you know your manufacturing and sales are where you want them?
- How important is R&D in your business?
    - (Scale 1-5, briefly explain)
- How familiar is your organization with technologies like CNC automation and parametric design in furniture production?
    - (Scale 1-5, briefly explain)

Market demand and feasibility of Mass Customization

- How familiar are you with the term Mass Customization?
    - (Scale 1-5, briefly explain)
- How often do clients ask for specific specifications?
    - (Scale 1-5, briefly explain how you cater to this)
- What are the 3 most frequently requested customization options in your business?
    - (3 short answers)
- Is there a benefit for integrating efficient customization options for your products?
    - (Scale 1-5, briefly explain)
- What challenges do you foresee in offering customization options to your clients, either from a production, market, or technical standpoint?
    - (3 short answers)
- If the customization of products is possible and easy, would your company gain a competitive edge over the competition?
    - Scale 1-5 (5 good, 3 neutral, 1 not good)

Outlook

- How do you foresee the furniture industry to evolve in 5 to 10 years?
- What 3 future developments or innovations that could enhance manufacturing and sales efficiency do you anticipate?
    - (3 short answers)

3.1.2 Player Identification

To find players to participate in this survey there are multiple ways to continue. First the existing professional networks will be used. Companies that have been known to operate in a way that can prove valuable to this thesis will be contacted, or asked to suggest other players form their networks. These companies will be noted with the "contacted due to existing network" notation in the list of participants.

The second way to find major players in the furniture industry will be through an extensive internet search. This way aims to identify new players that promote their visibility through online platforms. Companies found in this way will be evaluated on their overall image and their relevance of their products to this thesis. These companies will be noted with the "contacted due to relevance of operations" notation in the list of participants.

The third way to find players will be a door-to-door strategy in the region of Chania, Crete. This way aims to identify smaller players and family-owned shops in a regional basis. Again, these companies will be evaluated on their image and relevance of their products. These companies will be marked with the "regional contact" notification in the list of participants.

A fourth and final way to identify players will be through a contact with SEV (Hellenic Federation of Enterprises), where noteworthy companies will be suggested to participate in this thesis interviews. These companies will be marked with the "contact through SEV" notation in the list of participants.

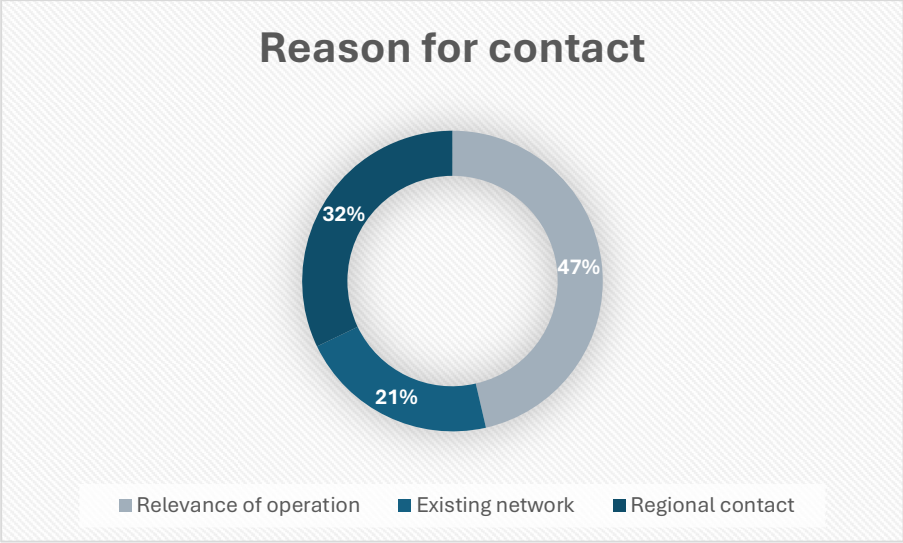


Figure 9 Reason for contact with potential interviewees

A list of 56 potential players was identified. The spread of the companies selected is shifted more to the manufacturing side because it was initially thought that the people responsible for making the actual products would offer a more spherical insight in the demand for customizable furniture as well as access the technical feasibility of such an effort. 30 manufacturing companies of various size were chosen based on the characteristics described above.

For accessing the technical feasibility and better understand "what it takes" to achieve dimensional customization, 6 technology providers were selected. These people are expected to share their thoughts on the machinery and the software, as well as to provide information about the current state of the woodworking industry. To share their thoughts on the matter 7 suppliers were also chosen due to their proximity to various woodworking businesses.

Finaly 11 retail stores and 2 designers were identified and approached so that they could share information regarding the demand for such furniture. Due to their constant proximity to the end-clients they can offer an educated opinion for the market demand for such methodologies.

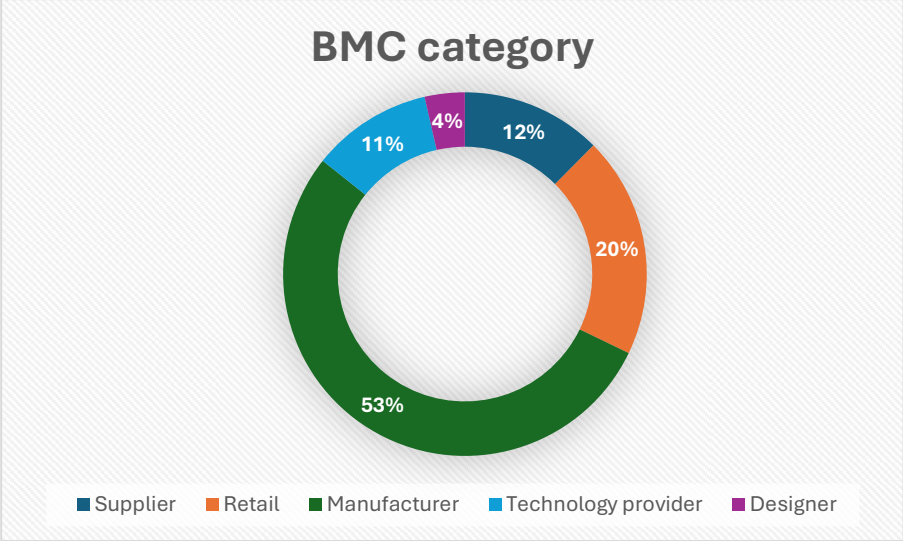


Figure 10 Business Model Canvas category for selected interviewees

3.1.3 Contact with companies

After the identification of potential interviewees, initial contact was made either via phone call with the companies outside the Chania region, or via an on-site visit for the companies within practical reach of Chania. This first approach was an informal contact to find out if the participants would be willing and available to participate. Following the first contact and email was sent to all who replied positively outlining the thesis topic as well as the interview questions so that participants have time to prepare if needed. In this email prof Carayannis was

added as a cc reference so that he could coordinate the meeting if needed or accommodate any potential request by the interviewee's company.

All contact with the potential companies was noted in an excel spreadsheet under the column "Notes". The date of every communication, as well as the actions agreed upon via phone call are all kept in this log. Some of the companies replied swiftly with a positive reply, so we scheduled a meeting at a time of their choosing. Some of the companies, however, did not reply in a timely manner, so a second phone call was made to inquire about their availability.

As a rule, companies that did not reply within three working days did not participate in the interviews either by declining the offer or not responding by any means. The number of participants that agreed to participate was 19, while 37 either declined or did not respond by any means. A third category was also formed, consisting of people who were eager to participate but we could not conduct the interview in time. This section of the list of participants with 8 companies can potentially be used in following professional and academic endeavors.

Lastly, a fourth category was formed with people that participated in the interviews yet were not willing to be recorded. There are 2 instances in this section, both in the manufacturing sector. Even though they were very eager to help by informally participating, answering questions and guiding through their production facilities, they did not want to be recorded.

In all, of the 56 contacted companies, 37 declined of failed to respond, 8 were willing but could not perform the interview before the deadline, 2 were not willing to be recorded and 9 accepted the invitation and participated on record.

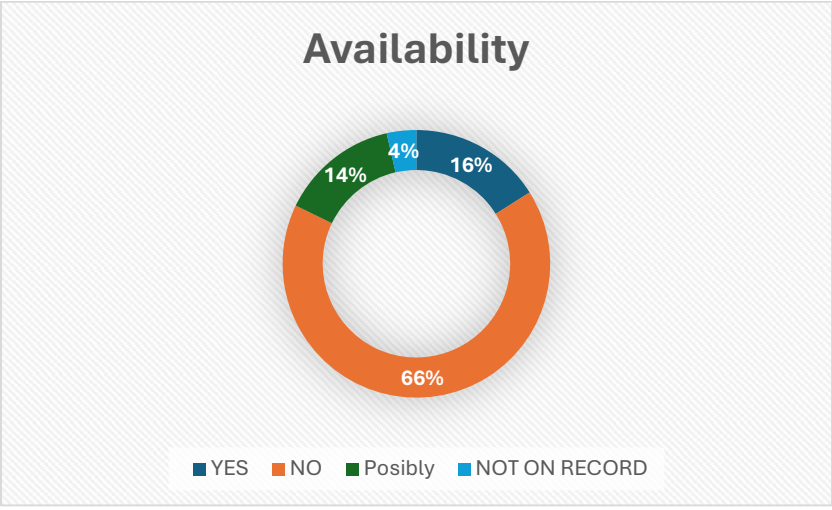


Figure 11 Availability of interviewees

3.2 Data Collection

The companies chosen for this thesis were companies that have a positive image inside the woodworking and manufacturing sector. This information was based upon the researcher's own knowledge as well as recommendations made to him by other participants. All interviews were conducted in the Greek language, as it was most convenient for the participants. They were then transcribed in Greek in a separate .doc file and translated in English so that they can be used in this thesis.

All the interviews were recorded, with the permission of the interviewee and were shared with professor Carayannis, to keep a record for further analysis and proof of execution. An Excel file was formed, where the first column acts as a prompt for the data of the hole row of the sheet, while each following column was dedicated to a single company/ interviewee. The names of the companies and their employees have been redacted so that anonymity of participants can be achieved.

All the audio data were processed within days of each interview and were written bellow each question with the prompt "original response a, b, c…" so that they are not affected by any later modification. This operation was tricky as the answers had to be short and the original context of the interviewee's response should be kept, while some of the interviewee's responses were elaborate and lengthy. For this step the researcher tried to be as objective as possible, while still translating based on the context of the hole interview. Also at this stage, a grade was given to every interview, ranging from HIGH to LOW, regarding the relevance of the company, interviewee, and their ability and confidence to understand the main topic of the thesis. For example, an interviewee that insisted after the interview recording that soon all furniture would be 3Dprinted, was marked with a LOW relevance, as though it may be true, it is far from the reasonable reality of the future, which has led the researcher to doubt the interviewees credentials.

3.3 Data Processing

After collecting data from 6 interviews an initial analysis was conducted. The prompts “Q(x) Common denominators” were added bellow each question so that relevant responses by different interviewees could be grouped. This prompt receives a YES or NO value, indicating that this specific opinion was expressed by the interviewee.

The common denominators are formed based on the topics discussed during the interviews. For a common theme to arise at least 2 interviewees should have talked about this specific theme. It is notable that in some cases an interviewee had not replied with this specific theme in this specific question, yet he had mentioned in a previous question something of relevance to the theme. For these instances the prompt YES was picked as the common denominator reflected the individual’s notion. (Press, 2024)

If the interviewee did not explicitly express an opinion matching the common denominator, it does not mean that he does not believe in it, merely that he did not mention it. During the shorting of replies his response is noted with a “NO” prompt, yet this is only used for ease of the data analysis. For the statistical forming performed on the next section these answers will be noted with the prompt “not specified”, as it seems better.

3.4 Overview of Interviews

This section of the thesis focuses on obtaining statistical information of the data collected through the interviews. The purpose of this analysis is to provide a visual representation to identify patterns, trends, insights and challenges appearing throughout the interviews. Each question of the interview will be presented with the visual aid of bar charts followed by a detailed commentary.

The analysis begins by quantifying the frequency of responses for each question, using the determined “YES” and “NO” prompts. For each question then a bar chart is generated to provide an easy-to-understand visualization of the distribution of responses. These charts are then used to highlight areas of agreement for this specific question among participants.

This first identification and visualization of common recurring themes this section of the thesis sets the stage for the discussion in later sections. The insights derived from the interviews will be used to inform recommendations to the proposed business model.

3.4.1 Responses to Research Questions

In addition to the visual analysis of the responders, this chapter contains a written description of the interpretation of the data. Each chart contains the number of responses on the Y axis, the common themes of the question on the X axis and stacked bars, colored blue for the positive answers or red for the not specified answers. The first and last question will not be analyzed.

❖ **Q2: What is the value proposition of your company?**

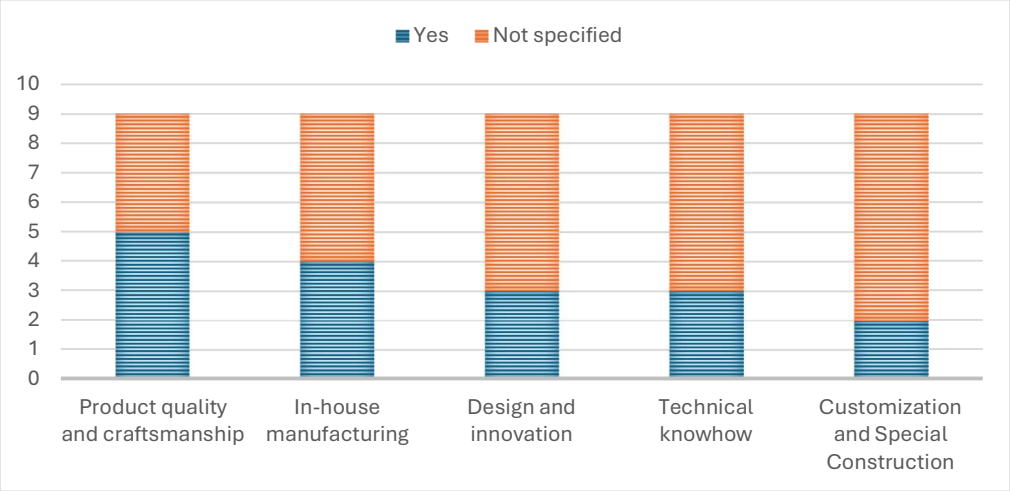


Figure 12 What is the value proposition of your company?

"**Product Quality and Craftsmanship**" and "**In-House Manufacturing**" were slightly more acknowledged than other factors, highlighting the importance in the quality of produced products which in most cases is achieved through in-house manufacturing, where the quality control standards can be adapted to perfectly reflect the company's ethos.

"**Design and innovation**" as well as "**Technical Knowhow**" is also stated in the replies, reflecting on the need for constant evolution of skills within a company. Finaly come participants stated that they gain value through the "**Customization And Special Construction**" of their products.

The above themes can be useful to this thesis, as they prove the need for creating in-house methodologies to achieve superior product quality, while also highlighting the need for constant innovation and evolution of the technical knowhow of a manufacturing enterprise.

In contrast it shows that the customization of the products can offer added value to a company's operations, yet the insignificant percentage of the answers tells us that it may not be necessary

for success. This is a contrast on the core value proposition of the proposed thesis business plan and should provide a topic for later discussion.

- **Q3: What are the 3 main difficulties of the external environment your business has faced in the last 3 years**

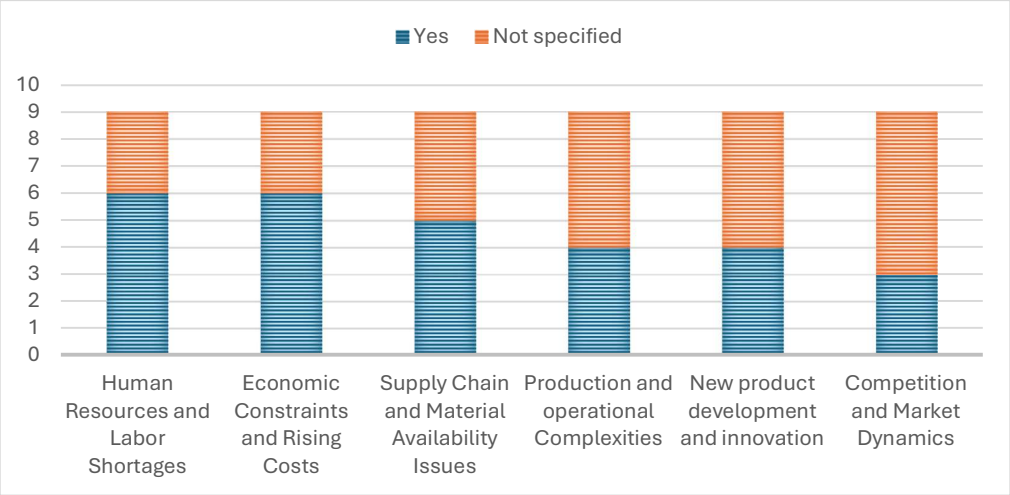


Figure 13 What are the 3 main difficulties of the external environment your business has faced in the last 3 years:

"**Human Resources and Labor Shortages**" together with "**Economic Constraints and Rising Costs**" seems to be the predominant difficulties the sector has faced these last few years. This reflects on a significant and ongoing struggle to find and maintain a skilled labor force, while facing financial pressure from rising costs of operation. "**Supply Chain and Material Availability Issues**" where also talked a lot in the interviews, highlighting the impact of global supply chain disruption on day-to-day workflows.

In contrast, "**Production and Operational Complexities**", "**New Product Development and Innovation**" and "**Competition and Market Dynamics**", were also reoccurring themes yet in less significance than HR, economic constraints and supply chain issues, indicating that these issues may be less universal and more relevant to specific business types.

The predominant factor in this question is human resources shortages, where almost all participants agree that is an issue that has and will continue to plague the sector. This factor will also play a crucial role in the upcoming discussion this thesis will address.

❖ **Q4: What do you think are the 3 main difficulties your business will face in the next 3 years?**

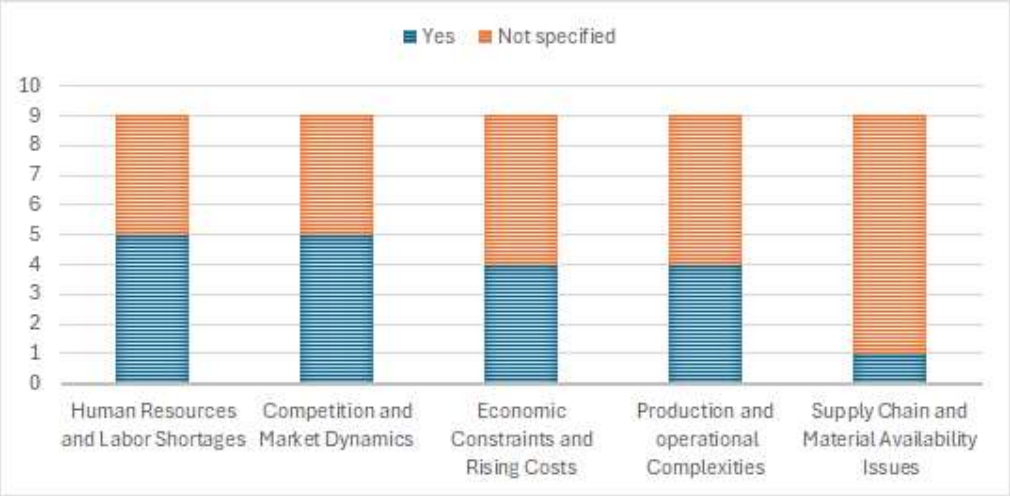


Figure 14 What do you think are the 3 main difficulties your business will face in the next 3 years?

The chart for Q4 identifies the key challenges participants anticipate facing in the next few years. "**Human Resources and Labor Shortages**" continues to be the most agreed upon difficulty of the future, reflecting on an ongoing straggle to attract and retain skilled workers. There is a definite industry-wide issue in Human Resources, exacerbated by demographic trends and a limited pool of adequately trained professionals.

A more significant emphasis on "**Competition and Market Dynamics**" is visible in Q4, suggesting that businesses anticipate a more competitive environment in the future, potentially driven by evolving market conditions and increased demand for innovative products. "**Economic Constraints and Rising Costs**" are still anticipated to be a major difficulty, yet with a lesser importance, indicating that businesses are beginning to adapt to rising costs.

"**Production and Operational Complexities**" remain a stable difficulty both in past and future operations, suggesting a need for better business and operational organization. A notable shift occurs in "**Supply Chain and Material Availability Issues**", where it diminishes to an almost unimportant factor. Also "New Product Development and Innovation" cited in Q3 is absent in Q4, suggesting a shift towards external challenges over internal R&D.

❖ **Q5: What are 3 key success factors in your sector?**

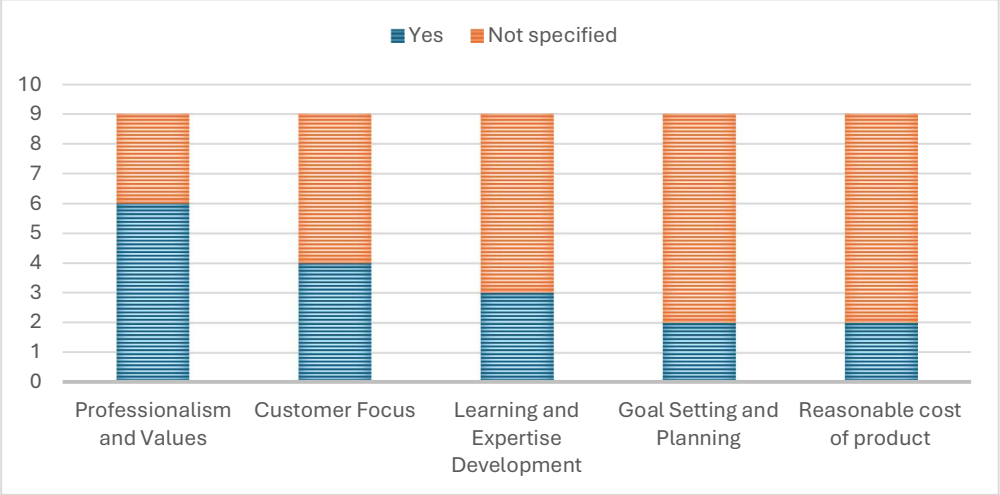


Figure 15 What are 3 key success factors in your sector?

The question aimed to identify the top three success factors critical to achieving growth and sustainability in the furniture industry. Participants were asked to highlight the elements they believed were most essential for their business success.

"**Professionalism and Values**" was the most cited success factor, with 6 participants emphasizing its importance. Businesses that promote professionalism are perceived as trustworthy and capable of supporting customer retention and a good market reputation. Aligning with the need to prioritize customer needs a common theme on the interviews was "**Customer Focus**", pointing out that understanding market demand and delivering tailored products is a key contributor to business success.

One more success factor that interviewees pointed out is "**Learning and Expertise Development**", a factor that also aligns with the results of the previous questions. It can be deduced that a business with an adaptive and knowledgeable workforce can better navigate the inevitable market challenges. Finaly, "**Goal Setting and Planning**" and "**Reasonable Cost of Product**" were also highlighted, showing the need for a clear strategic vision and competitive pricing strategies.

The analysis of this question concludes that professionalism, skill development and a customer-centric approach is the foundation for success in the furniture industry. Also, strategic planning and maintaining competitive pricing strategies are important for achieving operational efficiency and market competitiveness. It is worth noting that Product Quality is not included in the common themes, as it is taken for granted through the value proposition.

❖ **Q6: What are 3 failure factors in your sector?**

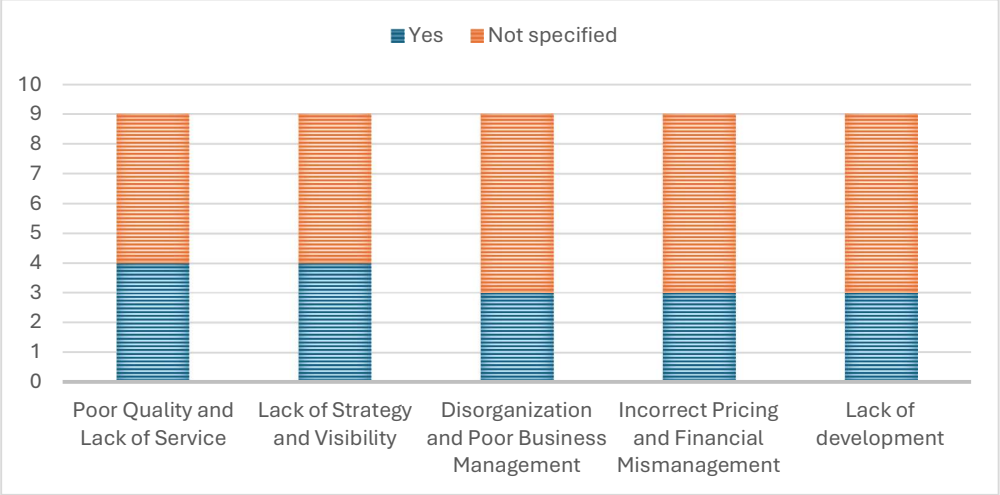


Figure 16 What are 3 failure factors in your sector?

This question is asked to identify factors contributing to business failures. It was specifically asked after the success factor so that a direct comparison of idea concepts can be made.

"**Poor Quality and Lack of Service**" was identified as a failure factor, aligning with the assumption that it is taken for granted in the success factors. Poor performance in these critical areas impact negatively customer retention and overall business reputation.

Similarly, the themes "**Lack of strategy and Visibility**", "**Disorganization and Poor Business Management**", "**Incorrect Pricing and Financial Mismanagement**" and "**Lack of development**" aligns with the "Goal Setting and Planning", "Learning and Expertise Development" and "Reasonable Cost of Product" themes identified in the previous question.

This analysis reveals that business failure is often linked to deficiencies in core operational procedures. Companies that fail to define strategic goals and actively promote their brand struggle to remain competitive. Also, issues connected to operational inefficiencies, inadequate financial oversight and stagnation in innovation can prove key obstacles that erode profitability and limit the ability to adapt to new market developments or introduce new offerings.

❖ **Q7 How do you measure success in your business?**

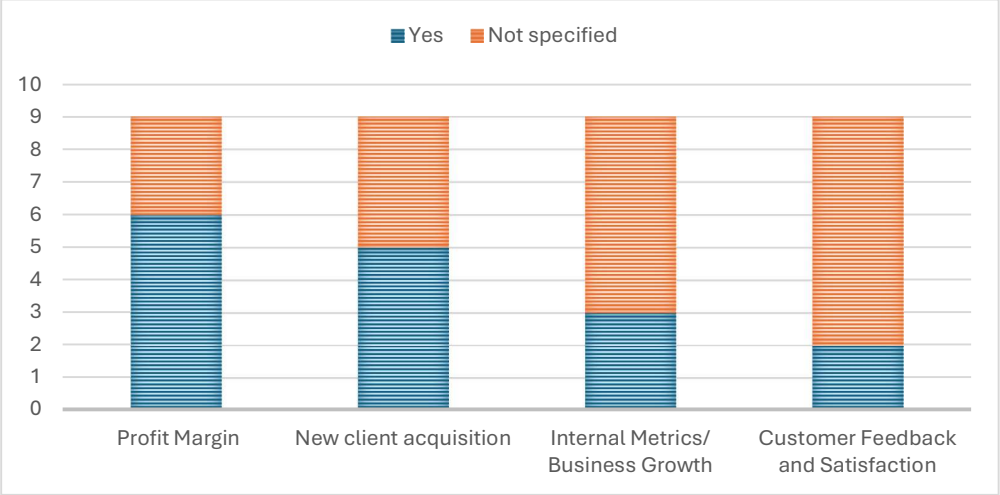


Figure 17 How do you measure success in your business?

"**Profit Margin**" emerged as the most significant indicator of success. This is a reasonable outcome, since generating economic value is among the main objectives of every business. Profit margin underscores the importance of financial performance and profitability and aligns with previous interview themes. Also, the theme "**New Client Acquisition**" also aligns with long term viability as attracting new clients is viewed as a critical driver of growth and market presence. The "**Customer Feedback and Satisfaction**" theme is a derivative of the long-term viability, where existing clients and their loyalty is a driving factor for new client acquisition.

It is worth noting that these factors are the tip of the iceberg, since at least 3 participants stated that they rely on more metrics for success. These metrics are combined to form "**Internal Metrics/ Business growth**" and can contain internal metrics such as sales figures, efficiency benchmarks or team development goals.

Overall, the findings for the success factors indicate that businesses prioritize profitability alongside customer acquisition and retention as the primary measures of success. This can present a conundrum, as new client acquisition requires significant investment in marketing, quality control and new product development, hindering short-term profitability.

❖ Q8: How important is R&D in your business?

Table 1 How important is R&D in your business?

Manufacturing company 1	Manufacturing company 2	Manufacturing company 3	Manufacturing company 4	Manufacturing company 5	Technology provider 1	Technology provider 2	Retail 1	Designer 1
100%	80%	80%	90%	70%	N/A	90%	100%	80%

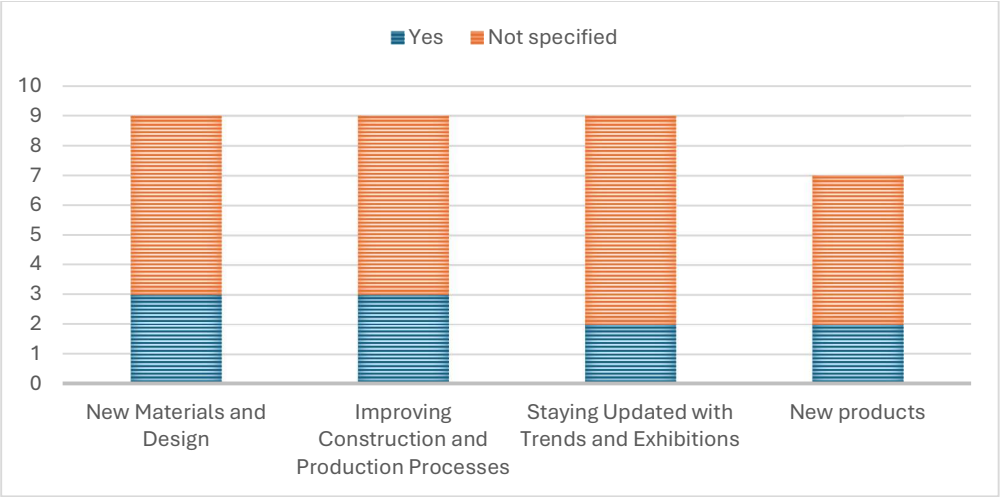


Figure 18 How important is R&D in your business?

The responses on a percentage scale reflect the high importance of R&D, with values ranging from 70% to 100%. These high percentages reflect a general consensus on the criticality of research and development as well as to new product development.

This question was mainly asked to measure the importance of R&D and while interviewees were not expected to delve deeper into the question, some of them did. This way, even though we can create common themes the reliability is little.

Most of those how delved deeper emphasized "**New Materials and Design**", "**New Products**" and "**Improving Construction and Production Processes**", themes that point to the need for continuous development of product quality and operational efficiencies by determining new materials and methods.

❖ **Q9: How familiar is your organization with technologies like CNC automation and parametric design in furniture production?**

Table 2 How familiar is your organization with technologies like CNC automation and parametric design in furniture production?

Manufacturing company 1	Manufacturing company 2	Manufacturing company 3	Manufacturing company 4	Manufacturing company 5	Technology provider 1	Technology provider 2	Retail 1	Designer 1
80%	30%	50%	0%	100%	Irrelevant	irrelevant	70%	10%

It is worth noting that for this question the familiarity of technology providers is marked as irrelevant, as obviously they are 100% familiar with the technology they promote, yet this familiarity is out of the scope of the question, which aims to discover the level of familiarity of the manufacturing sector with modern manufacturing methodologies. Even though the scope of the question covers a very big field, it can be used for a shallow analysis.

The average of relevant responses amounts to 52% familiarity for the manufacturing companies. By viewing the received percentage for the familiarity of the furniture industry the results are mixed, showcasing a sharp contrast between high levels of adoption and complete disregard for such methodologies.

In general, smaller factories like manufacturers 2 and 4 are reluctant to integrate such methodologies due to operational barriers, costs and lack of technical expertise. It is notable though that even though smaller manufacturers may lack the resources to get into CNC machining, they can use 3D CAD for visualization and 3D printers for rapid prototyping.

Also, larger factories with the necessary resources to obtain CNC capabilities seem to vary in the degree of automation. Only one of the interviewed companies has confirmed the outmost need for complete automation through CNC machinery and advanced software. The other 2 factories have obtained the necessary machinery due to pressure from the market. After the interviews it is made clear that due to reasons not disclosed, they are unwilling to integrate modern manufacturing methodologies to their workflows.

This failure to keep ahead of cutting-edge capabilities is alarming yet seems to align with the research done in Literature Review section and the outcome of the interviews, where the Greek manufacturing industry is lacking behind compared to the European. This topic will be further discussed in later sections of this thesis.

❖ Q10: How often do clients ask for specific specifications?

Table 3 How often do clients ask for specific specifications?

Manufacturing company 1	Manufacturing company 2	Manufacturing company 3	Manufacturing company 4	Manufacturing company 5	Technology provider 1	Technology provider 2	Retail 1	Designer 1
100%	10%	60%	70%	100%	60%	70%	60%	40%

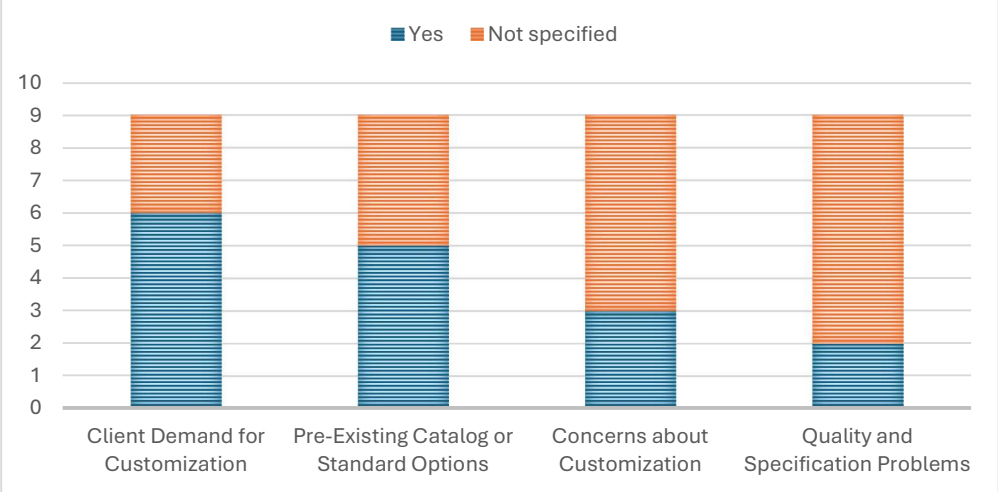


Figure 19 How often do clients ask for specific specifications?

This question aims to determine whether the customization of products is something that market demand needs. Findings like the theme "**Client Demand for Customization**" point to a significant emphasis on customization by client demand, aligning with the broader themes of this thesis, witch focus on mass customization and sustainability in furniture design and production.

Also, this question shares the insight that regardless of the need for customization, existing solutions offered are contained to a "**Pre-Existing Catalog or Standard Options**" meaning that at least for the time being the demand for such customizable furniture is relieved by the existing fixed dimensions for the mass-produced items or by the custom order on a specialized manufacturer like company 4.

During the interviews some opinions were expressed at this stage and appear under the themes "**Concerns about Customization**" and "**Quality and Specification Problems**" hinting to significant barriers for adopting customization options in mass production. Overall, the thesis's argument that customization is a key driver of competitiveness in the furniture industry is validated by these results, while also highlighting the existence of ongoing adoption challenges.

❖ **Q11: What are the 3 most frequently requested customization options in your business?**

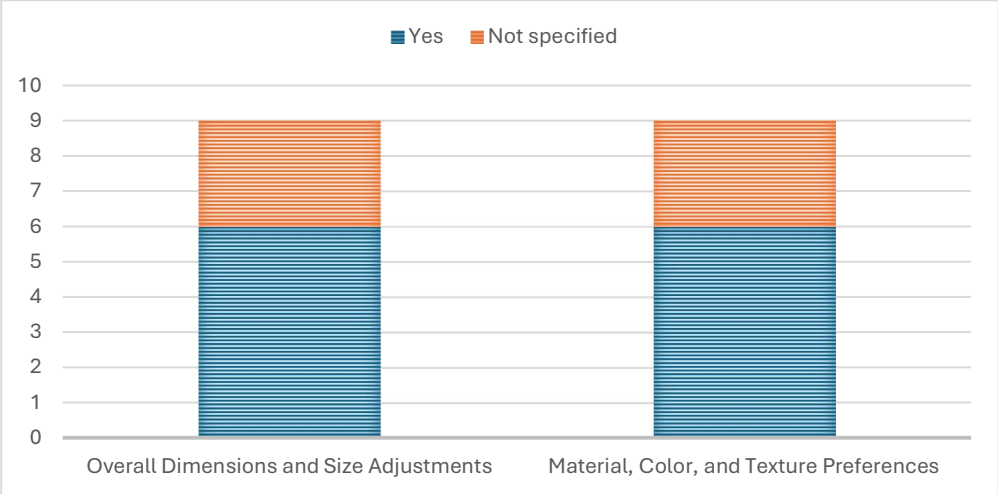


Figure 20 What are the 3 most frequently requested customization options in your business?

This question aimed to find what the most common types of customization requests in the furniture business are. Two main themes that emerged, "**Overall Dimensions and Size Adjustments**" and "**Material, Color, and Texture Preferences**", are in a tie. The responses varied in context, but all of them aligned with either one of the above responses. It is important to note that this separation is not done in random, as even though to the end customer the result is similar, i.e. customization option, it is a completely different story for the manufacturer.

Material, color and texture can be a difficult thing to configure in ready-made options that are stored in the shelves as complete products, i.e. an IKEA table. Yet if the manufacturing of a standard product is made to order it is a very simple modification. Instead of processing one material, like a red fabric, you can process the other material, like a yellow fabric. Similarly, instead of cutting this specific code of melamine sheet, you cut the other and instead of painting with blue color you paint with clear varnish. There result is the lack of complexity from having to change the manufacturing process.

On the other hand, to change overall dimensions you need to change the dimensions of some critical parts of the construction. For example, if you make a credenza 5cm smaller, you can not use the cut-lists and hole locations of the larger credenza. Normally you would have to recalculate all the necessary parts and drilling operations. This is proven by almost all interviewees to be an extremely complicated challenge that will introduce an added risk and lead to certain efficiency decrease. This topic will be discussed again on later sections.

❖ **Q12: Is there a benefit for integrating efficient customization options for your products?**

Table 4 Is there a benefit for integrating efficient customization options for your products?

Manufacturing company 1	Manufacturing company 2	Manufacturing company 3	Manufacturing company 4	Manufacturing company 5	Technology provider 1	Technology provider 2	Retail 1	Designer 1
20%	20%	N/A	40%	N/A	20%	100%	N/A	N/A

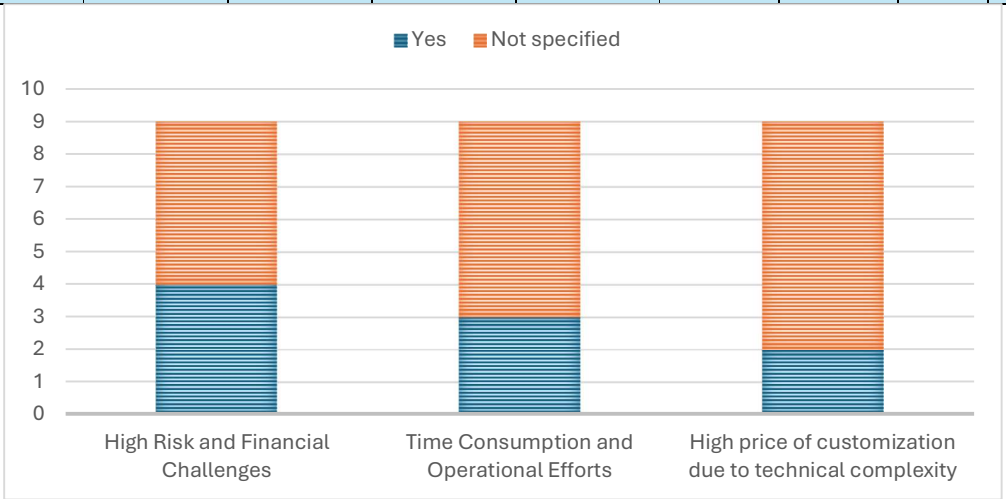


Figure 21 Is there a benefit for integrating efficient customization options for your products?

This question was aimed to assess whether businesses see benefit in integrating customization options to their workflows, and aimed to identify the specific internal production benefits that may have existed. It is important to note that this question was not well defined, leading to many of the participants not replying directly. The majority of those who did reply, did not see any benefit in integrating such options to their workflows.

This is a strange result since most of those who did not see any benefit on offering customization options, did in fact offer customization of their products to some extent. Also, it is a strange reply since, from previous questions, we have established that customization is in high market demand and that customer satisfaction is a priority for most businesses.

By analyzing the responses, we can deduct the themes "**High Risk and Financial Challenges**", "**Time Consumption and Operational Efforts**", and "**High Price of Customization due to Technical Complexity**". This response was expected to some degree due to the lack of technology integration in the manufacturing sector, yet not in this magnitude. For this reason, the next question was formed.

❖ **Q13: If the customization of products is possible and easy, would your company gain a competitive edge over the competition?**

Table 5 If the customization of products is possible and easy, would your company gain a competitive edge over the competition?

Manufacturing company 1	Manufacturing company 2	Manufacturing company 3	Manufacturing company 4	Manufacturing company 5	Technology provider 1	Technology provider 2	Retail 1	Designer 1
0%	100%	0%	90%	30%	0%	20%	100%	N/A

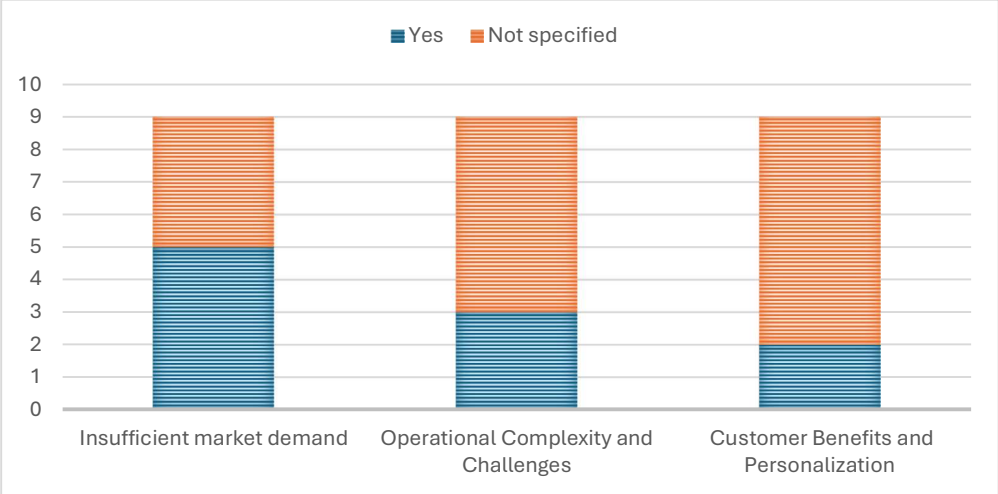


Figure 22 If the customization of products is possible and easy, would your company gain a competitive edge over the competition?

This question aimed to clarify the previous one, by removing the doubt for the technology and the complexity of customization. The focus here is to quantify the competitive advantage of a company utilizing customization methodologies.

Again, there was a pushback stating, "**Operational Complexity and Challenges**", though this is rendered incongruous, since the question stated "if it was possible and easy". One insight that can prove valuable to the thesis is the opinion that there in "**Insufficient Market Demand**" for such methodologies. This opinion contradicts the results of Q10 and Q11 where we have established that customization is something that is in market demand.

One possibility for this negative response is the perceived technical complexity in combination with the need for radical reorganization of the operational procedures needed for the offering of customization options. These factors pose a big barrier and when considering the effort and resources needs to be surpassed, most people will automatically disregard the concept. On a bright sight for the thesis the theme "**Customer Benefits and Personalization**" emerged, albeit in small numbers.

❖ Q14: How familiar are you with the term Mass Customization?

Table 6 How familiar are you with the term Mass Customization?

Manufacturing company 1	Manufacturing company 2	Manufacturing company 3	Manufacturing company 4	Manufacturing company 5	Technology provider 1	Technology provider 2	retail 1	Designer 1
10%	30%	50%	0%	N/A	60%	70%	N/A	N/A

The term mass customization is generally not known by the interviewees, excluding technology providers. What is interesting is that even the concept of mass customization is strange to most manufactures, and they think that its implementation on their products is impossible and not important.

What stands out is that this opinion is shared even by manufacturer 5, who is actually implementing mass customization methodologies. His business plan revolves around parametrizing his furniture cabinets regarding the construction method, overall dimensions and material efficiently. This observation can provide valuable information for this thesis, as it points to the lack of correct terminology in the sector. Also, it points out that it is extremely difficult to translate methodologies and knowledge from one subsector of the industry to one other. Also, it may point to the actual difficulty level of the thesis endeavor.

❖ Q15: What challenges do you foresee in offering customization options to your clients, either from a production, market, or technical standpoint?

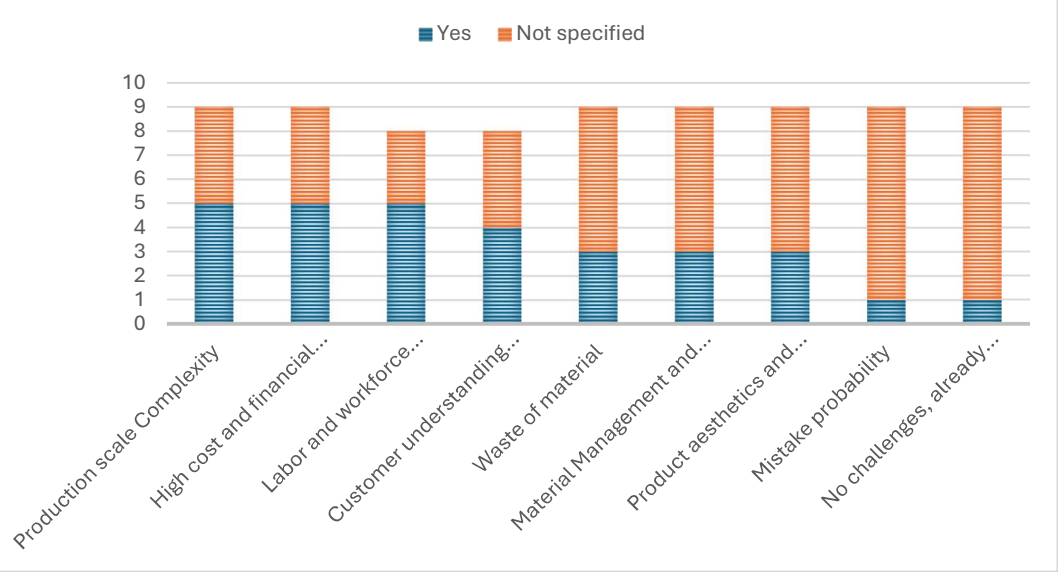


Figure 23 What challenges do you foresee in offering customization options to your clients, either from a production, market, or technical standpoint?

This question aims to unravel potential challenges on offering customization options, with focus on production, market and technical aspects. The following 8 themes arise which mainly talk about manufacturing challenges, the client's creative ability and material management.

"**Production Scale Complexity**" theme is derived from the responses linked to problem in scaling operations. The main concern here is that customization, mainly of dimensions, disrupts the traditional batch manufacturing process. It highlights the need for a flexible production line with an increased reliance on digital tools.

Industry experts tend to agree that the thesis methodology is only capable of small scale, bespoke manufacturing. Also, interviewees identified the need for complete redesign every time a customized dimension must be made. While the above statements may be true for traditional customization methodologies, the proposed thesis argues that this is exactly the problem it aims to solve. This theme can act as a validation for the importance of developing flexible manufacturing methodologies.

One more opinion that is stated under this theme is that this methodology is **challenging during peak production periods**, since a company cannot prepare material and products in the off season to help production during peak seasons. This insight is correct, and further analysis on a way to solve this problem can be proposed in the discussion section.

"**High Cost and Financial Constraint**" theme is linked to the economic investment need for such methodologies. Investment in advanced technology, skilled labor and material flexibility can strain budget and put pressure on the business. This problem is particularly visible in smaller enterprises that lack both financial capacity and human resources.

The cost of implementing this thesis methodology from the ground up is substantial and will be a topic suggested for further analysis. Even though the cost and financial constraint can seem enormous, it is worth noting that the tools needed for implementing this dimensional change on furniture are the same tools that are used to create them now.

"**Labor and Workforce Challenges**" is linked with the availability of skilled workers. It is a well-established fact that human resources are limited in industry and that skilled workers are hard to find and retain. Customization requires specialized skills in design, production and client communication. This is a difficult task to train or hire workers adept at handling the complexities of customized orders. This theme will also play a crucial role in the upcoming

discussions, as the thesis proposition aims to remove strain from human resources and automate the interaction of design-production-client communication.

Two more highly valuable insights are "**Customer Understanding and Expectations**" and "**Product Aesthetics and Practicality Challenges**", where misalignment between what clients want and what businesses can offer is a common challenge. It is noted that customers often have high expectations for customization, but are limited in understanding of ergonomic, technical, or production constraints. This limitation of understanding of basic furniture design and manufacture from the public can sometimes compromise the balance between product design and functionality. Also changing the dimensions of some furniture can mess up the analogies resulting in a product that is not aesthetically pleasing.

This theme proves that handing the complex topic of dimensionally flexible furniture products can have serious consequences. A great effort should be made to illustrate design changes as per the request of the client, so that their expectations are managed. It is important to note that this theme does not apply to all customers, as more often than not, an interior designer or an architect is responsible for selecting specific furniture and can accommodate the communication with their client. Lastly the themes "**Waste of Materials**" and "**Material Management and Inventory Issues**" have been identified and are linked to material management. The main concern with changing dimensions in furniture is that the yield from the main material sheet would be smaller. This consideration can be split in two categories, the first is when the furniture is shortened and the second is when it is lengthened. When it is shortened, obviously the material yield from a sheet cut with the same sequence of cuts would be smaller but it would certainly fit the predetermined raw material assessment. On the other hand, if the predetermined material assessment is done with regards the best yield possible from raw stock, lengthening the product would result in more material usage.

The other issue highlighted in this section is inventory management. This theme is directly linked to "Production Scale Complexity" and the challenges presented during peak production periods. Since you cannot know the final dimension of a furniture it seems to be impossible to organize the inventory of parts or prepare material during the downtime. This is a very valuable insight into the manufacturing process of customizable furniture and can provide a critical point for reflection on the discussion section.

❖ **Q16: How do you foresee the furniture industry to evolve in 5 to 10 years?**

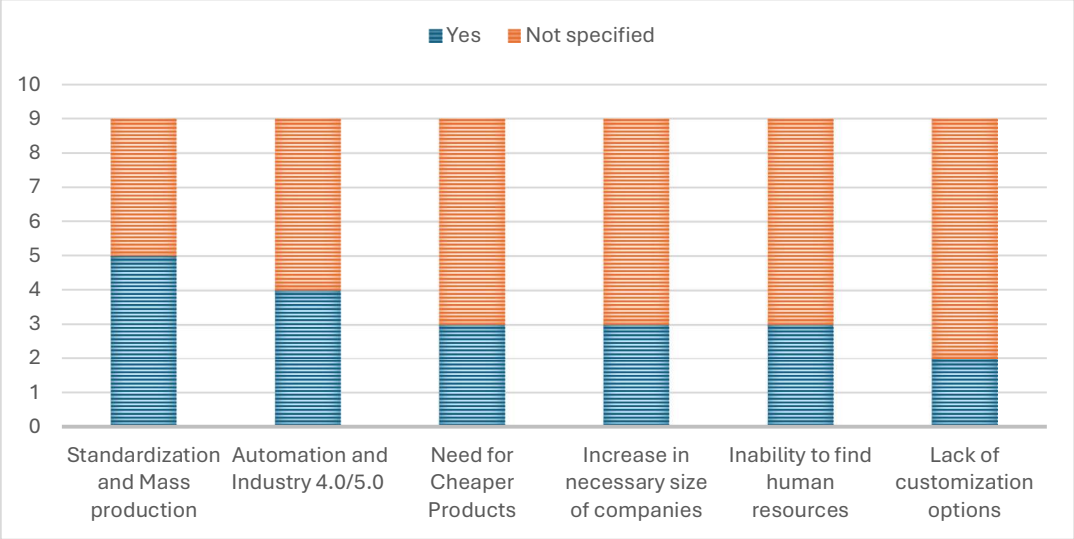


Figure 24 How do you foresee the furniture industry to evolve in 5 to 10 years?

This question aims to understand how the industry sees the future. It is also one of the last questions of the interview and a chance for the participant to summarize their thoughts.

The themes "**Standardization and Mass Production**" and "**Need for Cheaper Products**" shows that affordability, scalability and efficiency will play a crucial role in the future and that the furniture industry will be heavily influenced by companies seeking to meet increasing global demand for affordable furniture. Also "**Automation and Industry 4.0/5.0**" technologies are expected to be pivotal in improving precision and operational efficiencies.

The above two themes align with the broader industry trend on reducing production costs and maximizing output. In addition, an interesting subproduct of the above themes is the need to "**Increase in Necessary Size of Companies**", arising from the increasing reliance of production efficiency on expensive machinery, economies of scale and government policies that disproportionately benefit larger corporations.

The "**Inability to Find Human Resources**" and retain skilled and trained personnel identified by L.R. and interview questions Q3 and Q4 is expected to continue. Finaly, a small amount of people suggested that due to the push for automation and mass production a "**Lack of Customization Options**" will appear. This point to a possible trade-off between efficiency and personalization. These insights reinforce the importance of strategic innovation and adaptability of companies.

4 COMPILATION AND ANALYSIS

4.1 Compare and Contrast Analysis

4.1.1 Recurring themes

4.1.1.1 Labor and Workforce Shortages

This topic is agreed upon by all interviewees and is also supported by the literature review. The lack of skilled employees is cited as a major challenge both in the past and for the future. In the literature review, there was one more relevant topic regarding human resources, the lack of unskilled employees in the future. This topic was not discussed in the interviews performed in this thesis, but is correct, since the pool of this thesis was not as big as the ones in L.R.

This shortage of human employes is expected to pose operational difficulties, such as scaling production, but also hinder the ability to continue operations for smaller businesses that heavily rely on human participation to complete their products. This combined with the rising cost of operation is likely what will lead to the condensation of several smaller companies into one larger.

4.1.1.2 Customization Demand

A consistent theme that arose throughout the interviews is the acknowledgement of client demand for customization. Participants repeatedly emphasized that customization in dimensions, material and construction methodologies and quality is important to end-users.

However, all participants seem to agree that affordable furniture and customizable furniture are not on the same spectrum. In the current state of manufacturing, one will always have to choose between price, design, quality and customization, as the operational complexity of having all the above puts significant financial constraints as it lifts the expertise level, organizational complexity and the cost of the required machinery.

While talking with the participants, it was made obvious that the factories of today must innovate and adapt new technologies to remain relevant. Their insights also point to the difficulty that smaller organizations face during their search and adaptation for new automated production lines, like securing funding and finding personnel able to work in this new environment.

4.1.1.3 Shift Towards Mass Manufacturing

Participants also point towards a shift from customized work made specifically for every customer to a mass production environment, where a client chooses rather than designs.

Also, technology providers, as well as manufacturers, stated that the sheet material part of the industry, like kitchen and wardrobe manufacturing, has already been automated and is able to cater to specific dimensions request by the client with great success in Greece and EU, yet there is still the need for a highly educated designer-programmer to perform this task on behalf of the client. This manipulation of the standard construction is done using advanced and dedicated software with Enterprise Resource Planning capabilities. The implementation of such methodologies seems to be a standard in EU industry, while Greek factories vary in the degree of implementation. The dedicated 3D CAD/CAM software is connected to the CNC machinery and follows every part of the assembly throughout its manufacturing cycle. Every part has an identification number, that informs the machinery and the operators of the required operations that need to happen. This leads to increases in efficiency and quality control.

As per the words of the general director of "Technology provider 2", no kitchen is the same, so they need to offer their clients (the factories producing these furniture) the ability to customize their orders. While this ability exists, it contradicts the trend of switching to mass production, meaning that even though kitchens will become more and more standardized, there will be an option for customizability. This trend of switching to mass production can be explained by the words of the owner of "Technology Provider 1", an experience technician of CNC machines, who said that this customization is already in effect, though in expense of productivity. In a mass production environment, a factory can process up to 500 sheets of material daily, whereas their productivity in custom manufacturing drops to 100 sheets processed. This limitation is in my opinion a target many large manufacturers will be able to overcome as they become more acquainted with the necessary software and invest in intelligent-automated machinery.

4.1.2 Contradictions

4.1.2.1 Mass or Customized production VS human resources

After conducting the interviews, the results were mixed. On one hand many players agrees that customers need special furniture, constructed just for them, meaning that customers like to choose and modify the options available to them. On the other hand, the same players agree that in the future automation will take over the industry, shifting from the personalized fabrication of today to a prefabricated reality of IKEA. This is proven by the interviews

conducted both with bigger and smaller manufacturers that either offer standardized designs or manufacture specific requests. All the players also agree that the furniture industry is burdened by the lack of specialized employees.

What seems to be noteworthy is that most manufacturers do not seem to be able to understand this change and adapt to it, meaning that even though they see this happening right now they can not provide a solution for their business. This inability to understand this new trend can be explained in part due to the sheer amount of workload they face, and the rapid evolution of technological means in production and marketing. What is also made clear by the interviews is that the Greek furniture industry is lacking in terms of technological competency, skillful employes and an environment of mutual support between enterprises.

It seems that the future of the woodworking industry in Greece relies heavily on individual initiative with minimal state support. Of course there are exceptions, yet it is agreed upon by all interviewees that technological growth is most likely to appear in bigger organizations that have the economic power to invest in such new tools.

When the question of whether their company would gain a competitive advantage over the competition, if they could offer customization options efficiently (Q13) was asked, most manufacturers could not see any advantage. Also, in many conversations the notion was that an automation in this specific niece area of furniture sales is not needed as market need is covered by existing standardized solutions. If the need for such a change in dimensions is imperative, it would be cheaper to redesign said furniture for said new dimensions, rather than thinking ahead of time for the rare possibility of it happening.

All the above factors seem to enhance the gap between mass production, customized production and the lack of human resources. It is strange that the new technologies can offer substantially much more productivity making human resources less important, at least in quantity of employes, yet most manufacturers seem to be unable nor willing to invest in such technologies.

4.1.2.2 Kitchen VS Credenza

One more contradiction made clear by the interviews conducted, is noted with the interview of “manufacturing company 1”, who stated that they choose not to offer their standard furniture lines in different dimensions, since they study the manufacturing process in great detail only for the dimensions that are deemed important. He stated that they choose not to alter their

furniture first as it would ruin their aesthetics, and secondly because an act like changing the overall dimensions of furniture changes their internal structure, meaning that they have recalculate everything from the ground up. He stated that in complex furniture like sofas and credenzas this is extremely difficult, and their past efforts to accommodate special request have led to massive inefficiencies on their production floor, forcing them to deny any alternative other than the one displayed at their exhibitions.

The aesthetic part of the above statement is subjective, and it is up to each designer or customer to decide if they find some furniture aesthetically and ergonomically pleasing. On the mater of complexity of fabrication in altering the internal structure of furniture it is made clear that this is a reality in sheet material furniture like kitchens and wardrobes. This is a gray space in furniture manufacturing, as on one hand you can have cabinet furniture in every possible dimension necessary, powered by common CAD-CAM, ERP software and advance robotic manufacturing technologies, while on the other hand a credenza that is fabricated with the same materials and tooling is very difficult to adjust.

The difference may lay in the methodologies of fabrication, as kitchen design and manufacturing companies face the problem of every kitchen not being the same, forcing the factories to invest in adjustable tools and methodologies. In contrast, sofa and credenza manufacturing is relying on aesthetically pleasing solutions, meaning that manufacturers are forced to invest in design rather than in adjustable manufacturing methodologies. The tools used in every case are what allows flexibility, while design can accommodate any potential changes.

This insight is critical for the continuation of the proposed project, as it proves the necessity for design in the current market, as well as the necessity of lean manufacturing methods in the modern factory. A holistic approach with manufacturing methodologies from different sections of the woodworking industry should be implemented to produce a radical system that can help industrial factories with modernizing and adapting to the new reality of the market.

4.2 Matrix of findings

Table 7 Matrix of findings

	Themes	Insights	Challenges Identified	Implications for Business Model
	Operational Challenges			
1	Labor and Workforce Shortages	Severe shortage of skilled workers, expected to worsen over time.	Limited ability to scale production, reliance on manual processes.	Focus on automation via parametric design to reduce dependency on skilled labor on the factory floor. Design each manual process to be as simple as possible to make training easy
2	Financial Constraints	Small and medium-sized businesses struggle to invest in new technologies.	High financial barriers to entry for automation and customization solutions.	Search for cost-effective solutions with modular technology. Set a small initial investment threshold for software and machinery of 10.000 euros.
3	R&D Importance	Recognized as critical, but implementation is inconsistent.	Resource constraints and lack of dedicated R&D teams in smaller enterprises.	Create and participate in collaborative innovation hubs and share R&D resources within industry clusters
4	Operational Complexity	Customization disrupts traditional manufacturing workflows, especially if scale is needed	Difficulty scaling during peak production periods, challenges with material inventory and waste.	Implement clear and easy to follow methodologies. Search for ERP systems to connect the parametric designs with adaptive production lines.
	Market Dynamics			
5	Customization Demand	High demand for customization in dimensions, materials, and construction.	High operational complexity, increased costs, lack of existing scalable methodologies.	Focus on solving Operational Challenges to provide customer with affordable customization.
6	Market Understanding	Clients demand customization but often lack understanding of design constraints.	Misalignment between client expectations and manufacturing realities.	Develop easy to follow User Experience. All parameters the end client sees have to be as simple as possible. Create detailed but simple guidelines/rulebooks to

				manage client expectations.
7	Product Aesthetics and Practicality	Customized dimensions can lead to aesthetic and ergonomic issues.	Balancing client requests with functional and aesthetic design principles.	Promote designs that are adaptable. Design with parametric methodology in mind. Always confirm changes with client.
8	Client-Centric Visualization	Clients demand interactive tools to view and approve designs.	Lack of tools for real-time customization visualization; disconnect between client expectations and deliverables.	Promote the use of extended reality and other visualization tools to manage client expectations in real-time and enhance client decision-making.
	Workflow Management			
9	Technology Adoption	Limited familiarity with advanced manufacturing technologies like CNC and parametric design.	High initial costs, lack of training, and resistance to change in small-to-mid-sized firms.	Does not affect the business plan. Failure for adoption for technology from competing businesses is an advantage.
10	Material and Inventory Management	Changing dimensions impacts material yields and inventory management.	Increased material waste, inefficient use of resources, challenges in pre-production material preparation.	Create standardization of stock materials. Design for largest dimensions of furniture and create cultists that shrink rather than demanding additional material. Design specification of parameters to suit standardization of stock
11	Shift Towards Mass Production	Trend toward standardized mass production, especially for affordable furniture.	Risk of losing competitive edge for smaller manufacturers unable to match scale.	Does not directly affect business, as it follows this trend, adding the customization capability. Will offer competitive advantage if successful.
12	Industry Outlook	Predicted growth in automation, standardization, and Industry 4.0 practices.	Smaller firms' risk being left behind without technological advancements.	Position the business as a transition enabler. Consider mid to long term and how to transition to consultancy and end-to-end solutions

5 CASE STUDY

Since no practical president for furniture designed with the proposed methodology could be found, a virtual development of an example of said furniture is deemed necessary. Keeping in mind the various problems identified through the interviews, this example will be simulated using low-cost machinery to act as a feasible practical example and a proof of concept.

In this example, prototype designs of the researcher's creation can be used so that no copyright infringement problems arise, or sample furniture from the existing furniture lines of an interviewed company so that the example can be as realistic as possible. A mixed methods approach will be used, to keep the example as relevant as possible to the current market trends, while taking creative freedom on the manufacturing methods, so that this example can be easy to implement using basic materials and machinery.

This chapter can provide the vital steppingstone and president for validating the proposed methodology in a virtual and academic environment, at least as a feasible concept for further development.

To validate the thesis, this example will cover and explain the basic CAD design processes that are needed to create parametric digital twin models. It will also integrate all CAM processes needed to complete said furniture, and the necessary data so that multiple factories can work together. Finaly it will try to evaluate the simulated methodology in terms of manufacturing time. This process will be completed within the software environment and be presented in a way of screenshots.

5.1 Design criteria

This example will be considered successful if:

1. The design process can produce furniture that can alter dimensions in at least 4 critical parameters, i.e. length, width, height and material thickness.
2. The design incorporates at least 2 different materials, i.e. wooden frame structure and marble top. The aim for this constraint is to force the example to need at least 2 different factory environments to work together from afar, so that the proof of concept accommodates subcontracting parts of the manufacturing to other businesses (a problem identified by the interviews)
3. The CAM virtual simulation works on a range of dimensions and can be adjusted to the new parameters given in a timely manner with minimal designer input.

4. Augmented reality files should be exported for every instance, as of to show potential clients the true size of alternative dimensions (indicated as a problem for the methodology by several interviewees.)
5. The CNC machinery used for this experiment cost bellow 10.000 euros and can reliably produce all parts of the assembly.

5.2 Design selection.

The sideboard named M514 Franko designed and manufactured by Anesis will be selected for replication. It has been selected as the minimalistic geometry is replicated easily enough, while keeping technical complexity, and aligns with the scope of this experiment. (Anesis, n.d.)

The structure of M514 Franko consists of the cabinet body made of veneered MDF (Medium Density Fiberboard) and the solid oak lower frame with a unique “cross” shape visible beneath the cabinet. This furniture is offered with an optional ceramic top.

The storage compartments, containing simple shelving, are enclosed by four doors that feature a handle-less design, with a recessed groove cut into the door panels. These grooves are integrated with the solid oak lower frame to add to the aesthetics.

The entire piece is offered in various finish options including various stains and lacquer finishes. This furniture is delivered fully assembled and in three size variations in length, while there is no option to change the height nor the thickness.

5.3 Constraints and Assumptions

This example includes the analysis and discussion of the sideboard named "M514 Franko", designed and produced by Anesis Comfortable Designs. All rights to the initial design, images and related materials are owned by Anesis. The inclusion of this product in this thesis is made solely as an example of the "state of the art" in Greek manufacturing industry and its use is for academic and non-commercial purposes intended to demonstrate this thesis methodology in furniture design. The internal structure and manufacturing discipline used in this example is of my own creation, since I have not seen the actual piece nor its true manufacturing process. (Billah, 2018)

The CNC machinery that will be used to simulate this example has a Machine Work Area X/Y measuring 1500mm x 1500mm. (RatRig, n.d.) Since all necessary parts must be produced inside this work area, the overall maximum length of the parametric furniture will be determined by the limitation of this basic machinery. The longer piece of this assembly is the bottom frame stretcher. It is assumed from the start that it will be machined from a 140mm wide solid oak beam. The maximum dimension of material stock is 1981mm as shown in the diagram.

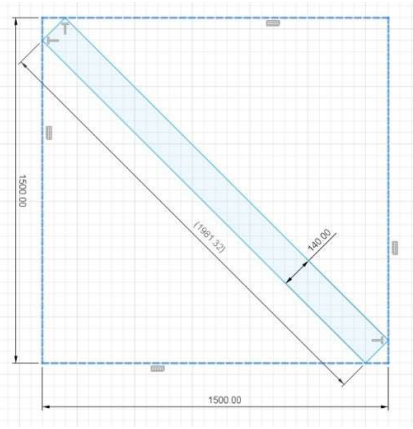


Figure 25 Maximum allowable dimension of raw material for case study

For simplicity of the example, the "Lamello Cabineo 12" joining method will be used (Lamello, n.d.). Also, it is considered that all necessary complimentary machinery are available. All edge banding, if applicable, will be performed after the CNC milling operations. Sanding, finishing and assembly is done in the current way.

5.4 Design process

The first step requires some foreshadowing and is to determine the outline using parameters (fx). The specific materials that will be used are set as new parameters and an indicative value is assigned. For this sideboard the parameters shown in the next table are set.

Name	Unit	Expression
length	mm	2200 mm
height	mm	780 mm
width	mm	550 mm
base_height	mm	240 mm
cover_thick	mm	19 mm
inside_thick	mm	16 mm
ceramic_thick	mm	12 mm

Figure 26: Parameter list

Right away it is possible to determine what is the maximum size that is possible to be manufactured using the tools at hand. Contracting basic sketches using the parametric values it is identified that the largest part will reach its maximum allowed length of the furniture is 2650mm in length. In this size of the furniture the individual door width will be 652mm, which is normally avoided but for this example it is acceptable. By stretching the sketches and setting the minimum door width to 400mm we can derive that the minimum allowed length of the furniture is 1650mm.

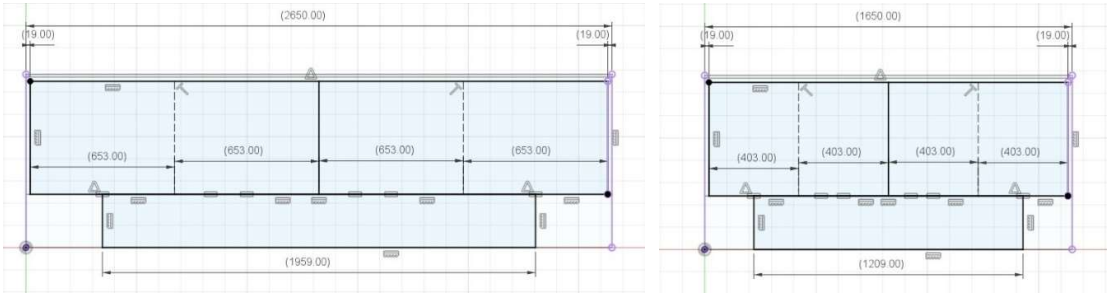


Figure 27 Maximum and minimum length

Since the only parameter that is limiting this furniture is well defined, the rest of the dimensions and construction can continue. Width wise, there is no apparent problem so it will be up to the end customer to define. The construction method chosen for this instance is a grooved back construction with a middle divider.

For this example, the nominal width is 550mm, but it can vary from 350mm up to 600mm. This limitation is put due to specific construction details like the shelving pin location and the offset of Cabineo 12 connectors that will be modeled next. Note that this is done due to time constraints linked to this thesis, but in an operational scenario one should not be limited to static parametric modeling. Instead, they should opt to design smart parametric models that can adapt to any scenario.

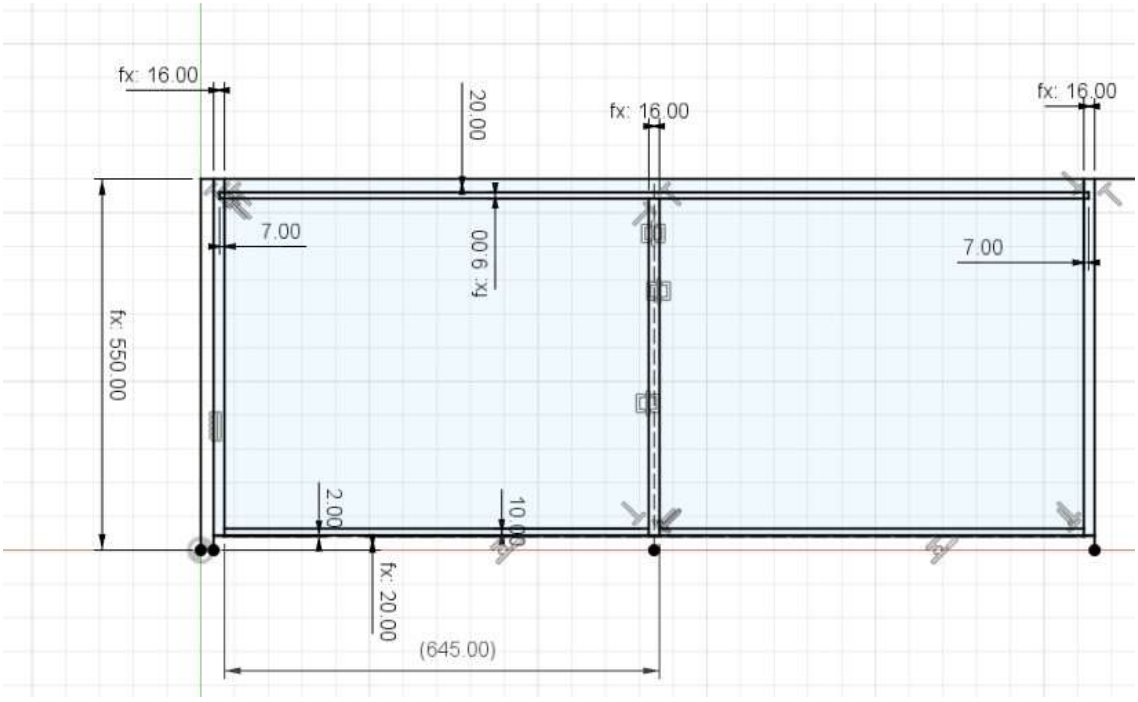


Figure 28 Cabinet width

Note that the width (currently displayed as 550mm) is the only parameter that rules the sketch. All other dimensions are relative to the previous sketches and this parameter. In this sketch the specific construction method can be seen with the grooved 9mm back panel and the stopped middle divider. After modeling screw pilot holes and clearance for the back panel, shelving pins and hinge predrilling and predrilling for connecting the cabinet with adjacent parts we have concluded with the basic cabinet construction.

After creating all parts, necessary hole locations, joinery methods and linking them to the height parameter the result is a custom cabinet that its dimensions are fully controlled by the parameter list. The result is the following.

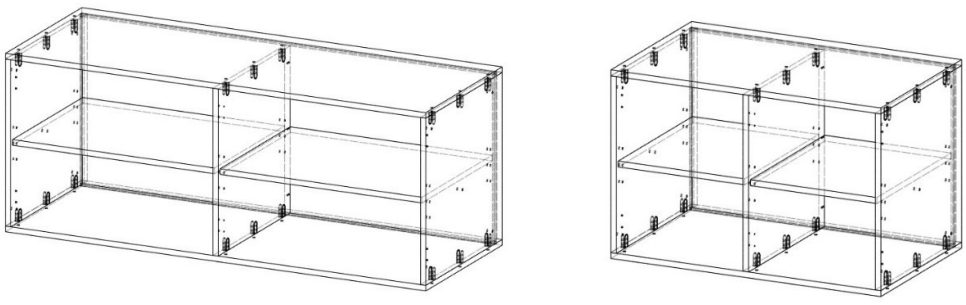


Figure 29 Basic cabinet with joinery for the two extreme length dimensions, 2650mm and 1650mm

After designing the basic cabinet, we must accurately calculate the geometry of the handless design. The design seams to be a continuation of the solid wood base, so this is designed next. Here we can set new parameters for the dimensions of the lumber. A conservative 38mm is selected as the initial value. Additionally, a manufacturing parameter is set now regarding the dimensions of the tooling bit we will use. A router bit of 10mm is set as a parameter, so that it can be changed quickly if we decide to manufacture using a larger diameter bit later. This is important to think of before hand as the joinery of the base will be designed to be cut solely on the CNC machine. Also, the base is symmetrical, so only half of the furniture should be drawn.

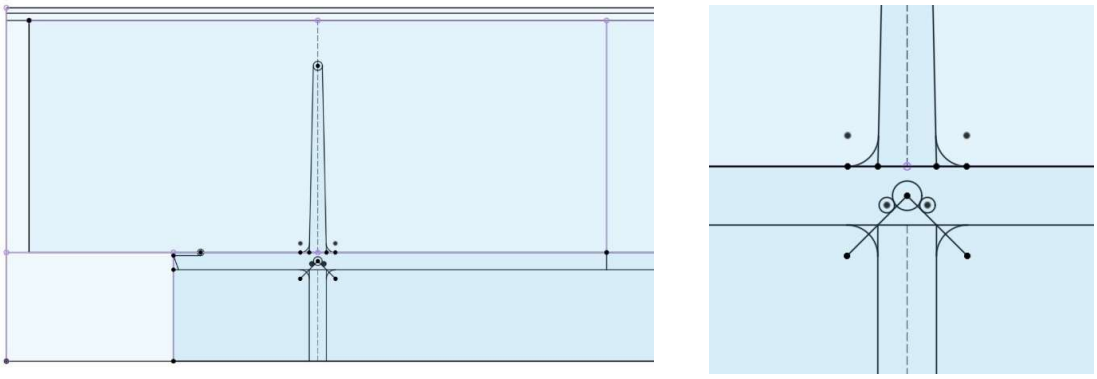


Figure 30 Frame and door "Cross" detail

Since we have established the exact geometry of the door we can model it. Again, since the design is symmetrical, we can design once and duplicate. The door will be made of two pieces, the door panel and the wooden insert that will be glued in place after finishing. For simplicity we will consider that this small panel is 6mm fixed, a parameter will not be set. After modeling the door and the panel and installing the necessary hinge attachment point and joinery methods, we have the following result.

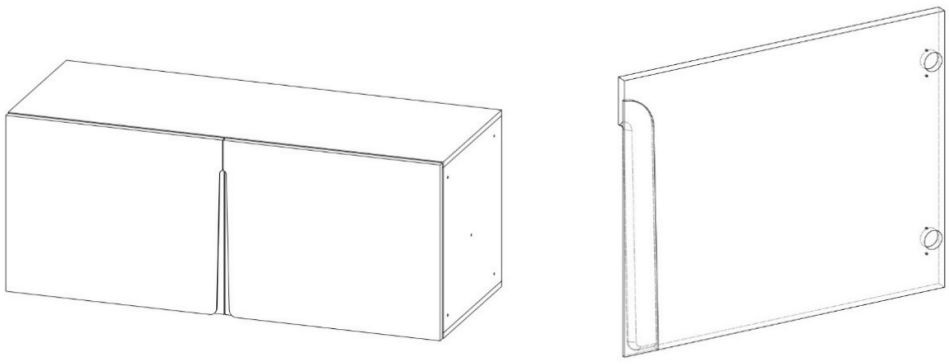


Figure 31 Cabinet doors and detail of single left door, displayed in dimensions for 2650 overall length.

By repeating the existing cabinet model lengthwise and modelling the rest of the decorative panels (curved side panels and top panel) we have finished with the basic upper construction of this furniture, and it is ready to prepare for manufacturing. It remains to model the solid wood base and the ceramic top. Note that during this process various more parameters have been used, either to add customization options to the client or to guide our manufacturing process. When all modeling is completed, one more table of parameters will be displayed so that the reader can have a better understanding of this process.

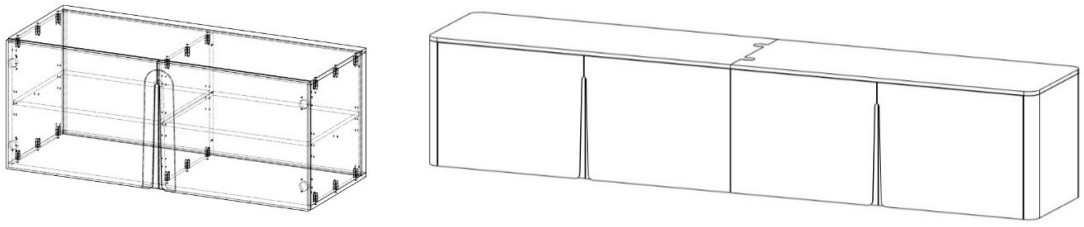


Figure 32 Wireframe view of basic cabinet, and complete view of upper assembly displayed in 2650 overall length.

Following a similar design methodology and using the existing analogies set by the previous sketches, the bottom leg frame is modeled. This specific frame is designed to be cut completely with 3 axis CNC machining. Most of the joinery is designed to interlock with adjacent pieces reducing the assembly time. Note that achieving the mitered joinery required by the example piece is complicated for simple CNC machines and will be glued up manually. The separate pieces for this frame have the required clearance for the machining operations and the cutting tools. The ceramic top is modeled in the same way. Finaly the all the pieces are combined.

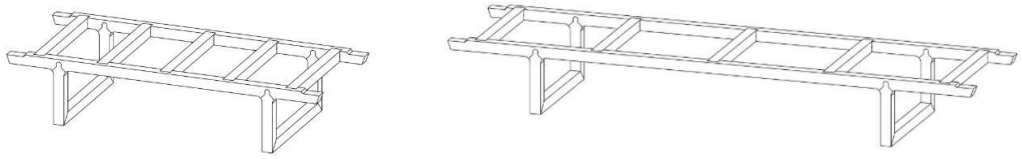


Figure 33 Solid wood frame for the two extreme length dimensions, 2650mm and 1650mm

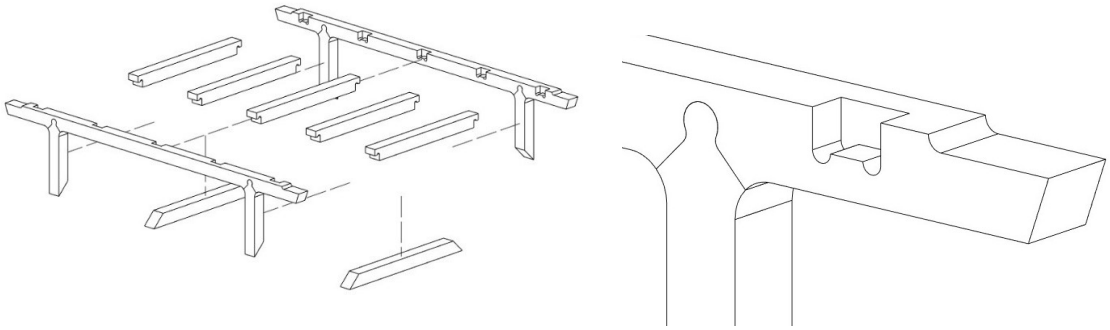


Figure 34 Exploded view and detail for solid wood frame

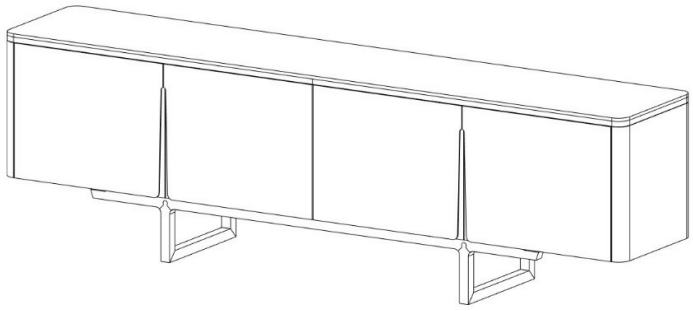


Figure 35 Fully modeled piece, displayed in 2650mm variant

5.5 Complete Parameter List

Having finished the modeling side of the proccess we can finaly view the complete parameter list. The dimensions that can be available to the client are to the top of the list, while some parameters can be kept from them because ether they consern the manufacturing or they are deemed to complicated for a client.

length	mm	2650 mm
width	mm	500 mm
height	mm	780 mm
base_height	mm	240 mm
outside_thick	mm	50 mm
inside_thick	mm	16 mm
ceramic_thick	mm	12 mm
insideBack_thic	mm	9 mm
Door_thick	mm	20 mm
Solid_frame	mm	38 mm
Leg_R	mm	20 mm
Bit_Diameter	mm	10 mm

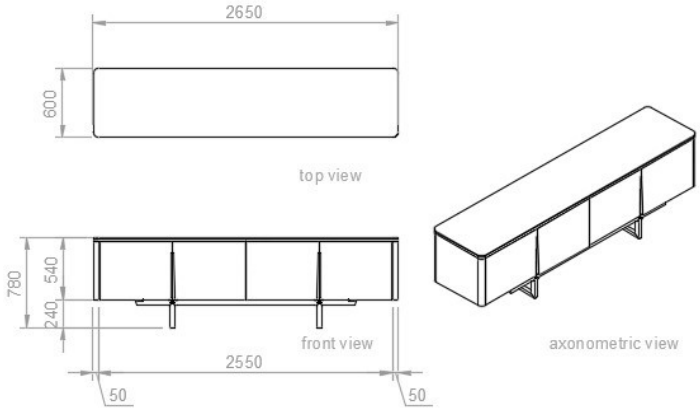
Figure 36 Complete list of parameters

The client can modify the overall length, width and height of the furniture. Aditionaly they can modify the height of the solid wood base of this furniture, and the outside material thickness. These parameters can either be up to the client, or be set up with an equazion by the manufacturer to adjust the furniture proportions, i.e. if the length is smaller than 2m the side panels can be 20mm, otherwise it can be set to 40mm. Acordingly the hight of the base can be adjasted for various height altarations.

Furthermore, the model desinded here has additional parameters that can be changed by the factory depending on the available or desirable materials. For example, if they wish to manufacture the interior structure out of melamine boards the parameter inside_thick can be set to 16 or 18mm, if MDF is needed it can be set to 17 or 19mm and so on. These parameters are inside_thick, ceramic_thick controling the thickness of the ceramic top, insideBack_thick controling the thickness of the backpanel, Door_thick controling the thickness of the door.

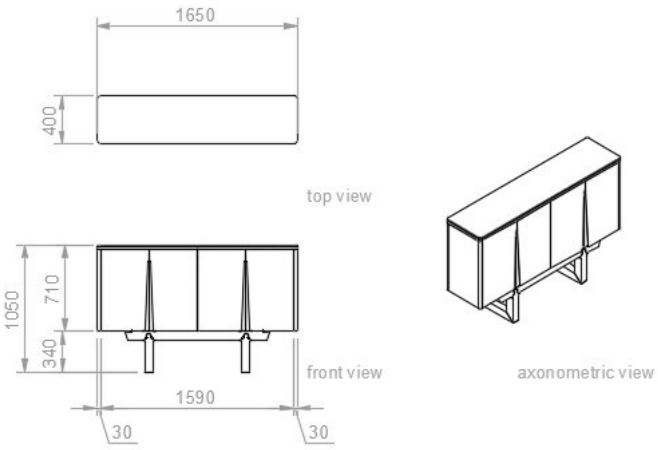
Similar parameters have been set to accommodate the manufacturing of the solid wood frame, where the manufacturer can adjust the thickness of the solid wood material depending on the bach, the curvature of the cross if needed and also the endmill diameter that will be used by the CNC machinery.

5.6 Showcase of different furniture alterations



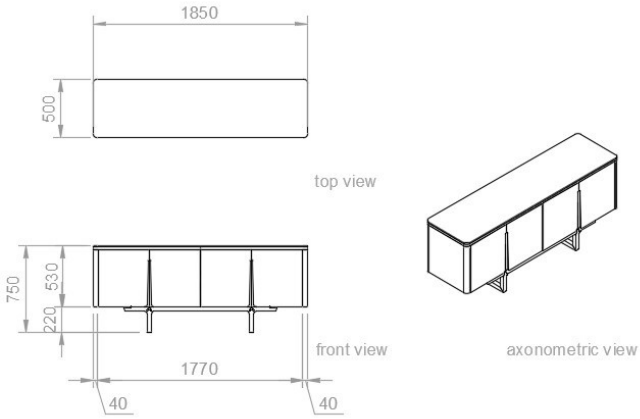
length	mm	2650 mm
width	mm	600 mm
height	mm	780 mm
base_height	mm	240 mm
outside_thick	mm	50 mm
inside_thick	mm	16 mm
ceramic_thick	mm	12 mm
insideBack_thic	mm	9 mm
Door_thick	mm	20 mm
Solid_frame	mm	38 mm
Leg_R	mm	20 mm
Bit_Diameter	mm	10 mm

Figure 37 Configuration 1 with parameter table



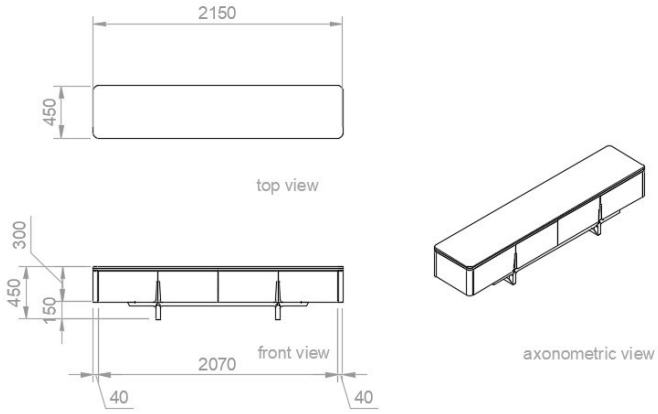
length	mm	1650 mm
width	mm	400 mm
height	mm	1050 mm
base_height	mm	340 mm
outside_thick	mm	30 mm
inside_thick	mm	16 mm
ceramic_thick	mm	12 mm
insideBack_thic	mm	9 mm
Door_thick	mm	20 mm
Solid_frame	mm	70 mm
Leg_R	mm	20 mm
Bit_Diameter	mm	10 mm

Figure 38 Configuration 2 with parameter table



length	mm	1850 mm
width	mm	500 mm
height	mm	750 mm
base_height	mm	220 mm
outside_thick	mm	40 mm
inside_thick	mm	16 mm
ceramic_thick	mm	12 mm
insideBack_thic	mm	9 mm
Door_thick	mm	20 mm
Solid_frame	mm	38 mm
Leg_R	mm	20 mm
Bit_Diameter	mm	10 mm

Figure 39 Configuration 3 with parameter table



length	mm	2150 mm
width	mm	450 mm
height	mm	450 mm
base_height	mm	150 mm
outside_thick	mm	40 mm
inside_thick	mm	16 mm
ceramic_thick	mm	12 mm
insideBack_thic	mm	9 mm
Door_thick	mm	20 mm
Solid_frame	mm	38 mm
Leg_R	mm	20 mm
Bit_Diameter	mm	10 mm

Figure 40 Configuration 4 with parameter table

5.7 Manufacturing Strategy

Having completed successfully all the above steps, we end up with a parametric furniture that contains can contain all the information for the manufacturer. Since we have displayed some options available, it is suitable to calculate the manufacturing of the largest piece, as it will guide all future operations.

Groups of materials will be decided now. The easiest way is to split them by thickness and nest them in the complete work area of the CNC machine available. The better way is to create smaller groups that are less than the work area of the machine so that we can be more agile when the dimensions change. For this example, parametric envelopes will be created, using the existing parameters, that will contain groups of subassembly parts. This is done so that we have the minimum waste of material when changing the dimensions of the furniture piece. This way the yield of every piece that will be used to machine the parts is predictable.

Note that for the scope of this thesis, no calculations will be made for the yield of the stock material from standard 2800x2070mm and 3600x1830mm sheet material boards. This is a much more complicated issue that is solvable yet demands specific attention and creative solutions. For this example, it is accepted that we have a pool of infinite stock material that can be cut to the specific dimensions of this furniture.

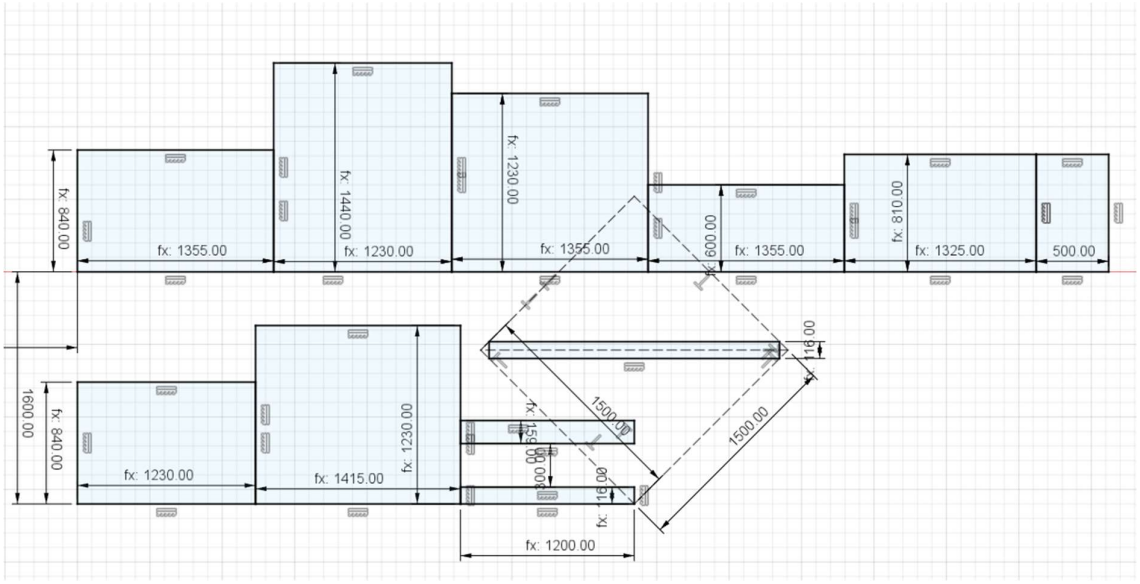


Figure 41 Envelopes created for nesting parts within the work area of the CNC machine at hand.

The envelopes created are as follows. All the dimensions for these envelopes are set using parameters. As an example, the first envelope that will be used to nest the door panels is created using these parameters. The height is calculated by subtracting the height of the base from the overall height and adding 30mm of clearance. Likewise, the length is calculated by dividing the overall length of the base by 2 and adding 30mm of clearance. A

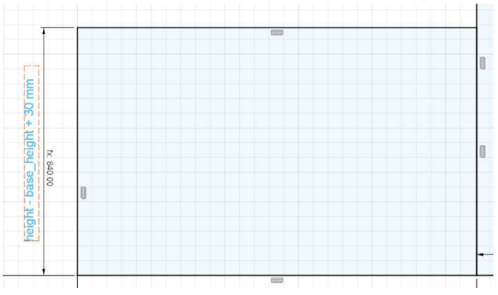


Figure 42 Equations for creating envelopes for door panels

similar approach applies to every envelope that is created.

After creating the envelopes accordingly for every part of the furniture piece and nest all parts, the result is a fully parametric strategy for manufacturing said furniture. All previous alterations showcased in this example as well as new combinations of dimensions are ensured to fit within the manufacturing capabilities. The resulting nested pieces are then assigned a material value so that a Bill of Materials (BOM) can be generated. In the pages that follow all the previous examples will be analyzed in the form of nested parts and BOM lists.

5.8 Showcase of manufacturing strategies

In this section, the cutlists and nesting of parts on the pieces of the cutlist will be shouwcased. Note that the generation of a new cutlist and the update of the nesting is done automaticaly. Unfortunately, due to the limmitations of this thesis timeline a comrehencive analysis for the generation of the G-code need to run the CNC machinery will not be done. Even though this analysis will not be completed, this work is standardized and will continue in the same way as before, meaning that the manufacturer only has to calculate the G-code for one of the configurations and the rest will be automatically adjusted.

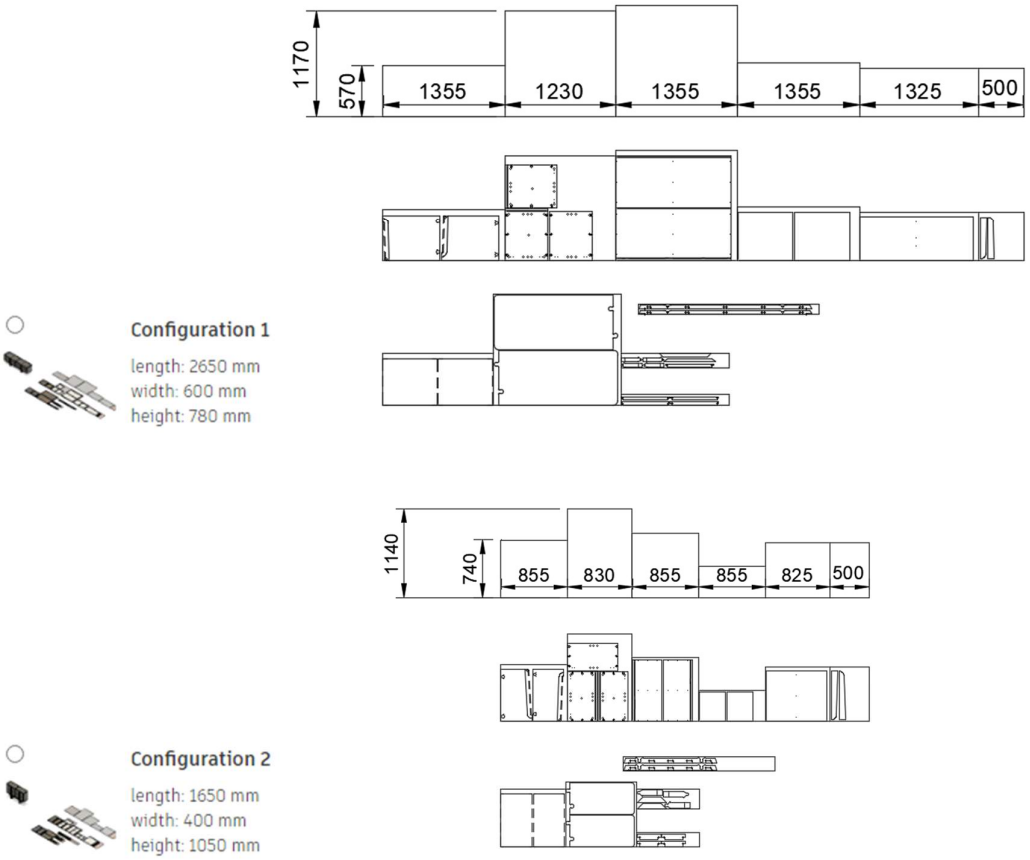


Table 8 Complete part list/cut lists for all four configurations used in the example

Complete Parts List

config 1

Solids

Code	Material Name	Quantity	Width	Width	Thickness
FRAME WIDTH	Solid Timber 03	1	1200	116	38
FRAME LEGS	Solid Timber 03	1	1200	159	38
FRAME STRETCHERS	Solid Timber 03	1	2005.3	116	38

3

Boards

Code	Material Name	Quantity	Length	Width	Thickness
DOORS	Medium Density Fiberboard	2	1355	570	20
DRESS SIDES	Medium Density Fiberboard	1	1230	570	50
DRESS TOP	Medium Density Fiberboard	1	1415	1230	20

4

Laminated Boards

Code	Material Name	Quantity	Length	Width	Thickness
SIDE PANELS	Laminated Cardboard	2	1230	1170	16
TOP BOTTOM	Laminated Cardboard	2	1355	1230	16

SHELVING	Laminated Cardboard	2	1355	600	16
BACK PANEL	Laminated Cardboard	2	1325	540	9
HANDLES	Laminated Cardboard	2	540	500	6
		10			

config 2

Solids

Code	Material Name	Quantity	Width	Width	Thickness
FRAME WIDTH	Solid Timber 03	1	800	180	70
FRAME LEGS	Solid Timber 03	1	800	255	70
FRAME STRETCHERS	Solid Timber 03	1	1941.3	180	70
		3			

Boards

Code	Material Name	Quantity	Length	Width	Thickness
DOORS	Medium Density Fiberboard	2	855	740	20
DRESS SIDES	Medium Density Fiberboard	1	830	740	30
DRESS TOP	Medium Density Fiberboard	1	915	830	20
		4			

Laminated Boards

Code	Material Name	Quantity	Length	Width	Thickness
SIDE PANELS	Laminated Cardboard	2	1140	830	16
TOP BOTTOM	Laminated Cardboard	2	855	830	16
SHELVING	Laminated Cardboard	2	855	400	16
BACK PANEL	Laminated Cardboard	2	825	710	9
HANDLES	Laminated Cardboard	2	710	500	6
		10			

config 3

Solids

Code	Material Name	Quantity	Width	Width	Thickness
FRAME WIDTH	Solid Timber 03	1	1000	116	38
FRAME LEGS	Solid Timber 03	1	1000	159	38
FRAME STRETCHERS	Solid Timber 03	1	2005.3	116	38
		3			

Boards

Code	Material Name	Quantity	Length	Width	Thickness
DOORS	Medium Density Fiberboard	2	955	560	20
DRESS SIDES	Medium Density Fiberboard	1	1030	560	40
DRESS TOP	Medium Density Fiberboard	1	1030	1015	20
		4			

Laminated Boards

Code	Material Name	Quantity	Length	Width	Thickness
SIDE PANELS	Laminated Cardboard	2	1060	1030	16
TOP BOTTOM	Laminated Cardboard	2	1030	955	16
SHELVING	Laminated Cardboard	2	955	500	16
BACK PANEL	Laminated Cardboard	2	925	530	9
HANDLES	Laminated Cardboard	2	530	500	6
		10			

config 4

Solids

Code	Material Name	Quantity	Width	Width	Thickness
FRAME WIDTH	Solid Timber 03	1	900	116	38
FRAME LEGS	Solid Timber 03	1	900	159	38
FRAME STRETCHERS	Solid Timber 03	1	2005.3	116	38
		3			

Boards

Code	Material Name	Quantity	Length	Width	Thickness
DOORS	Medium Density Fiberboard	2	1105	330	20
DRESS SIDES	Medium Density Fiberboard	1	930	330	40
DRESS TOP	Medium Density Fiberboard	1	1165	930	20
		4			

Laminated Boards

Code	Material Name	Quantity	Length	Width	Thickness
SIDE PANELS	Laminated Cardboard	2	930	780	16
TOP BOTTOM	Laminated Cardboard	2	1105	930	16
SHELVING	Laminated Cardboard	2	1105	450	16
BACK PANEL	Laminated Cardboard	2	1075	300	9
HANDLES	Laminated Cardboard	2	500	300	6
		10			

5.9 Design criteria review

After completing the case study, a review of the outcome is necessary. This review will evaluate the successful fulfillment of the initial design criteria and suggest future improvements.

- **Alteration of dimensions.**

This criterion has been accomplished with great success. The furniture produced can alter its dimensions in at least 4 critical parameters, as well as in a plethora of other dimensions critical for manufacturing.

- **Incorporation of different materials.**

Indeed, the design contains multiple materials, like the solid wood frame, the sheet material cabinet frame and doors and the ceramic surface for the top. Unfortunately, due to the limitations of this case study, an example of partnership between two factories could not be performed.

- **Manufacturing simulation.**

Due to the limitations of this study a comprehensive analysis of the CAM procedures could not be calculated. Even though this step was not displayed in its full implementation, the nesting of parts in their designated panels, alongside the cut list generated shows great potential.

- **Augmented reality files.**

This criterion was also not possible to be performed due to the limitations of this case study. The barrier to completing this step was the lack of compatibility for materials between the CAD software and the .usdz file format needed for displaying the A.R. models. Additionally, a rapid and easy methodology for exporting these kinds of files for every alteration of the furniture could not be determined.

This criterion was deemed necessary by the interviews analysis and its failure on this example should provide critical feedback for later implementation of this idea.

- **Adhere to the limitations of inexpensive CNC machinery.**

Indeed, the CNC machine used for this implementation costs bellow 10.000 euros. A smart strategy when designing the furniture meant that the limitation of the work area of the machines found in this price range were bypassed effectively.

6 CONCLUSIONS AND RECOMMENDATIONS

This thesis explored the intersection of advanced parametric design, digital twin technologies, CNC automation and design principles as a potential solution to the growing market demand for customization and sustainable furniture. This thesis used a combination of literature review- to establish the current landscape and correct terminology, empirical validation- to assess firsthand the current state and demand for customization at scale, and a case study- that was deemed necessary for laying the ground plane for future endeavors. This research provides critical insights into the current challenges and opportunities linked with innovative customization solutions in the furniture industry.

6.1 Summary Of Findings

6.1.1 Technological Feasibility

One of the primary objectives of this research was to evaluate the technological feasibility of implementing mass customization. The study found that through technologies such as CAD/CAM integration, digital twins, and CNC automation significant opportunities for streamlining customization arise.

However, it also points to a lack of readiness of the Greek furniture industry to adopt these technologies, confirmed by the literature review and the interviews conducted. Larger manufacturing companies that have the resources and infrastructure to adopt automation seem to fail to leverage the full potential of advanced systems due to limited technical expertise and reluctance to undertake comprehensive redesign of existing workflows.

On the other hand, smaller manufacturers and family-owned workshops which make up to a substantial portion of the Greek industry, often lack economic capital and knowledge to integrate these technologies in a smaller scale. This gap highlights a need for industry-wide initiatives.

6.1.2 Market demand and options for customization

This research highlights a growing demand for customizable furniture. It also highlights an increasing trend for mass produced items that provide financial benefits both to the manufacturers as well as the customers. The most common customization requests by the clients include adjustments to overall dimensions, material selection, and color or texture preferences.

Interviews with industry experts revealed that most companies try to offer customization to their clients by providing a wide range of materials, colors and textures. They use these options as strategic tools for staying competitive and strengthening their value proposition. However, the research also identifies a systemic limitation: while manufacturers cater to aesthetic customization, they fail to adequately address dimensional customization.

Manufacturers of furniture lines predominantly rely on inefficient, legacy operational models that rely on ad hoc solutions to fulfill requests for dimensional changes, or completely deny these modifications to their furniture lines. This systemic limitation on producing static furniture that can only be customized in appearance, forms a distinct trend across Greek furniture manufacturing industry and indicates a significant gap between consumer needs and consumer expectations with operational capabilities. **This gap represents a clear market opportunity for manufacturers willing to invest and develop methodologies in adaptive production lines and parametric design solutions.**

Efficient production of dimensionally altering furniture lines can offer a significant competitive advantage to those that manage to overcome the complexity barriers linked with adaptive production lines. The Greek industry faces several systemic challenges that hinder the adoption of dimensional change of predesigned furniture pieces.

6.1.3 Challenges of the Industry

The most prominent challenge identified through the interviews and literature review is the lack of skilled labor in the furniture industry. This issue not only hinders the efforts for mass customization, but also threatens the day-to-day operation of manufacturing plants. Almost all interviewees suggested that they struggle to attract and retain talent, further constraining their ability to adopt advanced manufacturing technologies.

Adding to the lack of skilled labor, the rising operational costs and limited access to capital for investing in new technologies further hinder evolution of the Greek furniture making industry. Smaller workshops are disproportionately affected, as they often rely on outdated practices and lack the financial means to modernize.

Technological unfamiliarity and resistance to change pose additional barriers. The adaptation to advanced tools such as parametric design and CNC automation is often seen as complex, risky, and disruptive to established workflows. This resistance to change stems not only from financial limitations but also from cultural hesitation to deviate from traditional practices.

6.2 Critical insights

6.2.1 Empowering Clients

As stated in a lot of interviews, clients can sometimes be detached from the reality regarding their needs in furniture. It is made clear that clients can have difficulty in understanding the ergonomics of furniture and can wish for furniture that will not be usable, comfortable, or aesthetically pleasing. Clients also may face difficulty understanding special measurements, making it difficult for them to visualize the changes made to their furniture.

A critical insight for the thesis can be deducted by this challenge. It is the duty of the designer and the manufacturer to guide and protect their clients from this sort of mistake, yet, in the end it should be up to the client to decide if he wishes to buy a product.

It is of the utmost importance that the client is up to date with the design specifications they will buy. Reliable, effective and easy to understand communication methods should be used to inform the client. Through technological means they can be provided with detailed blueprints and renders, derived automatically from the digital twin models. In addition, modern visualization techniques can be generated easily enough, opening the possibility to integrate Extended Reality (augmented and virtual).

6.2.2 Customization in Mass Manufacturing

While everyone predicts that mass manufacturing will take over the market, no one could provide a solution for customized work. Of course, the problems with customization of furniture in a mass manufacturing environment are plenty, yet no manufacturer could even entertain the idea of using mass manufacturing and enhanced customizable methodologies for offering furniture products in the specifications of client and in fair prices.

This is a critical insight into the project as it marks the difficulties of changing mass production systems. It proves that for the thesis idea to work, the complete production line and life cycle of the product development must be designed around adjustability. Examples found in the literature review suggest that innovations in parametric design and flexible manufacturing strategies could bridge the gap and present a clear opportunity for further research and development.

6.2.3 CAD-CAM and CNC compatibility

One more thing that we can learn from technology providers is that the CAD process can happen in a variety of software, ranging from dedicated software for every machinery, basic

CAD with the ability to export in .dxf format, or industrial design CAD/CAM software like SolidWorks and Fusion360. It is established by the interviews that modern CNC machinery will be compatible with whatever software the end user chooses to design.

This is a critical insight for the suggested endeavor of this thesis in offering dimensional parametric furniture to the end customer, as it reassures that any pilot effort made with parametric industrial design software and low-end CNC machinery, will be compatible with the latest and most technologically advanced CNC machines the industry has to offer.

6.3 Recommendations

6.3.1 Further research

This thesis lays the groundwork for a methodology that will allow customers to order standard furniture pieces in customized dimensions, while enabling factories to process these requests effectively. As proven by the research and empirical validation, there is no widely accepted president for methodologies in the furniture industry, making this approach both innovative and challenging.

The first recommendation for implementing this added value concept is to perform an in-depth search of state-of-the-art literature to identify existing examples of adaptive production systems. While specific examples in the furniture industry can be limited, valuable information can be withdrawn from other industries. Automotive, packaging and bespoke consumer goods may have solutions incorporated in their production systems designed to accommodate customization of products without disturbing the manufacturing side. These examples will help this project by identifying efficient operational strategies that are also able to maintain scalability. Additionally, marketing and education efforts can be identified that will be needed to build awareness for the benefits of mass customization strategies.

6.3.2 Strategy forming

An in-depth analysis of the implementation strategy and the business model that will accompany this strategy is mandatory to the viability of the system. Given the complexity of transitioning to adaptive manufacturing, this analysis should include a phased roadmap with clear milestones. Early stages should involve pilot studies on limited and prototype product lines that will allow for incremental refinement of the system. Achieving defined Technology Readiness Levels (TRLs) is critical and will provide measurable benchmarks for progress and risk mitigation.

To promote adoption among small and medium-sized enterprises, the methodology must be designed to accommodate varying levels of technological sophistication. This means creating modular solutions that can be scaled according to resources at hand and market needs of different manufacturers.

6.3.3 Partnerships

Collaboration with computer development experts is also critical so that a seamless link between the manufacturing tools and customer-facing platforms can be created. They will be responsible for guiding the project concerning the website and order process of online customers, as well as for finding a way to link the 3D CAD product design software to these customers.

As shown by the interviews, building a dynamic online platform is another key component. This platform will allow customers to interactively select and modify furniture designs, and receive immediate feedback through detailed renderings, blueprints and AR presentations, as well as accurate cost estimates. This step is deemed necessary as it can bridge the communication gap between designers, manufacturers, and clients, reducing the likelihood of mistakes and managing expectations.

6.3.4 Funding

Securing funding is necessary to continue the development. The development of the methodology proposed will need substantial funding for infrastructure and skilled personnel. While a full-scale implementation of this methodology is expected to have high initial cost for the infrastructure, at the development stage the cost of buildings and equipment can be kept to a minimum as shown in the case study. Funding sources could include government grants, venture capital investments and partnerships with stakeholders that share an interest in innovation within the furniture industry.

An in-depth analysis of the costs associated with this project is necessary. This cost analysis can be conducted for 2 case studies, one concerning the least amount of financial investment needed to perform customization at a small to medium scale, and a second one that will identify the funding needed for achieving true mass customization at scale.

6.4 Development options

This project has a plethora of options for development. A swift analysis of the two most appealing approaches will be made. This analysis considers two hybrid models: a Start-Up + Licensing and a Co-Development + Academic Collaboration. Both scenarios leverage unique strengths and are informed by the findings and evidence of this thesis.

6.4.1 Start-Up + Licensing

The start up model can allow the project to maintain full authority over the methodology's initial development and implementation. A model like this, can allow for rapid iterations and experimentation with different set-ups and provides with the opportunity to refine these elements in a controlled environment. As evidenced by the case study paradigm conducted, tight integration between the design software and the CNC machinery is required, while the cost of the machinery needed does not exceed a reasonable investment amount.

This low initial cost of machinery is a compelling argument for continuing with the start-up model, as it limits the limiting upfront cost of a start-up model. The cost of establishing this company, is comparable to setting up a normal low volume bespoke woodworking shop. The cost of the CNC machinery required is comparable to the cost of the average table saw used by most small manufacturers. This means that even if the initial strategic goal of achieving mass customization methodologies is not reached in a timely manner, the same tools and processes can work to produce low-volume, high-margin product development and manufacturing.

After conducting the test and refinement stages, the technology can be licensed to established manufacturers. This can be in form of teaching the methodologies or providing a ready-made solution (if possible to develop). This way provides a scalable and low-overhead pathway to market expansion. Licensing the methodology offers additional value to any company willing to participate, as the interviews revealed that many manufacturers, especially small and medium companies, face technological and financial barriers that prevent them from independently developing innovative systems and products. By licensing they gain access to proven solutions and efficient methodologies.

Funding for this development option can come from bootstrapping personal funds together with earning co-funding from European Union development funds for acquiring buildings and machinery, while standard salary and stock options can be offered for compensating the development of the APIs and webpage interface.

6.4.2 Co-Development + Academic Collaboration

A second viable option for developing the proposed project is by combining co-development with an industrial partner while continuing the project in an academic environment through a PhD program. This route emphasizes long-term innovation with practical validation.

Partnering with an industrial manufacturer provides immediate access to infrastructure, resources, technical and marketing expertise. Since the interviews suggested a reluctance of manufacturers to overhaul their operations, the co-development route can benefit both the project and the manufacturer by mixing the current methodologies with the innovative one.

The same machinery used in the day-to-day operation can be utilized to prove the proposed project. By partnering with an established partner to create this project is similar to a start-up concept, with the difference of extra technical expertise and increased capital, streamlining the initial stage of development. The downside is that extra effort should be made to draw the objectives of the project as well as the ownership and authority over the project design phase.

On the same time, continuing the project as a PhD offers an opportunity for an in-depth theoretical exploration providing solid foundation for future expansion of this project. The PhD program could also focus on addressing the gaps in technology and methodologies identified throughout this thesis concerning the seamless link of back-end manufacturing systems and customer-facing platforms.

An academic collaboration can also add credibility to this project, opening alternative funding routes through research funding and government grants, since the proposed project aligns with current trends on sustainability and development of industry 4.0 and 5.0 strategies.

6.4.3 Technology Readiness Level

In conclusion, the methodology suggested in this thesis presents an opportunity for transforming the furniture industry. This project is sitting between a 2,3 and 4 TRL as it contains multiple sub methodologies that are proven in a differing extend. The methodology for creating parametric furniture that are adjustable by a designer is proven multiple times reaching a TRL of 4 or 5, yet the technology for linking the customer to the manufacturing is in a primitive state and need further development yielding a TRL of 2 or 3.

The success of this project will depend on careful planning, strategic partnerships and a commitment to continuous improvement.

7 BIBLIOGRAPHY

Anesis. (n.d.). *Franko M514*. Retrieved from Anesis: https://anesis.com.gr/product/franko/

Autodesk. (n.d.). *CAD/CAM Software*. Retrieved from autodesk.com: https://www.autodesk.com/solutions/cad-cam

Baker, S., & Rosalind, E. (2012). *How many qualitative interviews.* NCRM.

Barbieri, L., & Muzzapappa, M. (2024). Form innovation: investigating the use of generative design tools to encourage creativity in product design. *INTERNATIONAL JOURNAL OF DESIGN CREATIVITY AND INNOVATION*, 163-182.

Billah, M. M. (2018). Fair or Free Use of Copyrighted Materials in Education and Research and the Limit of Such Use. *Chicago-Kent Journal of Intellectual Property*, 423-448.

Brown, K. (2022, Dec 12). *Parametric vs. Direct Modeling: Which Side Are You On?* Retrieved from PTC: https://www.ptc.com/en/blogs/cad/parametric-vs-direct-modeling-which-side-are-you-on

EOPPEP. (2024). *https://www.eoppep.gr/index.php/el/professional-outlines*. Ανάκτηση από EOPPEP: https://www.eoppep.gr/index.php/el/professional-outlines

Foti. (2021). Roadmap for the adaptation of the profession "Cabinetmaker". *IME GSEVEE*, 1-83.

Furlan, A., & Vinelli, A. (2018). Unpacking the coexistence between improvement and innovation in world-class manufacturing: A dynamic capability approach. *Technological Forecasting and Social Change*, 168-178.

Lamello. (n.d.). *Lamello*. Retrieved from Cabineo 12: https://lamello.com/products/drilling-system/cabineo-12

Matthew S. Bumgardner, D. L. (2020). Sustainable Practices in Furniture Design: A Literature Study on Customization, Biomimicry, Competitiveness, and Product Communication. *Forests*.

Nunes, L., Pereira, A., & Alves, A. (2017). Smart products development approaches for Industry 4.0. *Procedia Manufacturing*, 1215-1222.

P. Renna, M. A. (2015). Design and reconfiguration models for dynamic cellular manufacturing to handlemarket changes. *International Journal of Computer Integrated Manufacturing*, 170-186.

Panagiotopoulos P, R. S. (2024). Navigating the Greek Energy Crisis through a Multidimensional. *Energies*, 17, 3915.

Paolo Pedrazzoli, F. A. (2014). An Innovative Production Paradigm to Offer Customized and Sustainable Wood Furniture Solutions Exploiting the Mini-Factory Concept. *IFIP International Conference on Advances in Production Management Systems*, 466-473.

Press, R. (2024, March 14). *Education*. Retrieved from REV: https://www.rev.com/blog/analyze-interview-transcripts-in-qualitative-research

RatRig. (n.d.). *RatRig*. Retrieved from Stronghold Pro: https://ratrig.com/cnc-kits/routers/stronghold-pro-advanced-kit.html

Santos, G., Murmura, F., & Bravi, L. (2018). Fabrication laboratories: The development of new business models with new digital technologies. *Journal of Manufacturing Technology Management*, 1332-1336.

Sehyun Myung, S. H. (2001). Knowledge-based parametric design of mechanical products based on configuration design method. *Expert Systems with Applications*, 99-107.

Sidney. (2023). Transnational governance of digital transformation: financinginnovation in Europe's periphery. *New Political Economy*, 227-239.

Suzic Nikola, A. Z. (2014). Customizing Products through Application of Group Technology: A Case Study of Furniture Manufacturing. *Journal of Mechanical Engineering*, 724-731.

Tegan, G. (2023, Jan 14). *Primary Research | Definition, Types, & Examples*. Retrieved from Scribbr: https://www.scribbr.com/methodology/primary-research/

Wudd. (2024, Dec 6). *kids toys*. Retrieved from Wudd: https://www.wudd.gr/?lang=en%2F

ΣΕΒ. (2024). Χτίζοντας το μέλλον για ακόμα πιο ισχυρή βιομηχανία. *ΣΕΒ*.

8 APPENDIX

8.1 Briefing for interviewees

Invitation for Interview on Furniture Customization, Technical University of Crete

My name is Zygoulis Nikolas, a graduate student at the master's in technology and innovation management (MTIM) at the Technical University of Crete. As part of my thesis, I am conducting a survey into **new methodologies for integrating parametric digital twins with CNC automation to achieve Mass Customization**.

Given your expertise and experience in the furniture industry, I believe your insights would be valuable to this research. I would like to invite you to a 25–30-minute interview to discuss:

- Your experience with customization and automation in furniture production
- Market demand and future trends in customizable products
- The challenges and the opportunities of adopting new manufacturing technologies.

The interview can be conducted at your convenience, either via phone, video call, or filling in the word document on your own. If you are located near Chania, I would be glad to conduct the interview in person. I have also cc'd my mentor and advisor, Prof. Carayannis Elias who is overseeing my master's thesis.

About me

I am a qualified Architect, specializing in design and technological integration within the product design and manufacturing sectors. Through academic study and work experience, I have gained a deep understanding of traditional manufacturing, parametric design through advanced software and CNC automation. I am strongly interested in the way digital design and manufacturing can help unlock creative freedom, increase efficiency and provide economic growth
Currently, I am expanding this knowledge by focusing on how innovation strategies and digital technologies can be applied in industries like furniture manufacturing. My aim is to contribute to the evolving relationship between design, automation and customization in the modern market.

Thesis focus

My thesis focuses on exploring new methodologies of design and manufacturing that combine parametric digital twins with CNC automation to achieve Mass Customization in the furniture industry. The final goal of these methodologies is to provide flexibility in furniture design, allowing manufacturers to offer highly customizable products, while reducing production costs and lead times.
This thesis will evaluate both the technological and economic feasibility of these integrations by identifying key technological and organizational factors. It will also determine if there is market demand for such customizable products and whether approaches like these provide a significant competitive advantage.

In the next page you will find the 17 questions of the interview. Please let us know if you need additional information and when you are available.
Thank you for your participation.

8.2 Briefing for interviewees translated in Greek

Υπόψιν Διοίκησης // Πρόσκληση για συνέντευξη σχετικά με την προσαρμογή επίπλων, Πολυτεχνείο Κρήτης

Καλημέρα,

Το όνομά μου είναι Ζυγούλης Νικόλας, μεταπτυχιακός φοιτητής στο πρόγραμμα διαχείρισης τεχνολογίας και καινοτομίας (MTIM) του Πολυτεχνείου Κρήτης. Στο πλαίσιο της διπλωματικής μου εργασίας, διεξάγω μια έρευνα σχετικά με νέες μεθοδολογίες για την ενσωμάτωση παραμετρικών ψηφιακών διδύμων με τον αυτοματισμό CNC για την επίτευξη της Μαζικής Προσαρμογής (Mass Customization).

Με δεδομένη την εξειδίκευση και την εμπειρία σας στον κλάδο των επίπλων, πιστεύω ότι οι απόψεις σας θα ήταν πολύτιμες για την έρευνα αυτή. Θα ήθελα να σας προσκαλέσω σε μια συνέντευξη διάρκειας 25-30 λεπτών για να συζητήσουμε:

- Την εμπειρία σας με την εξατομίκευση και την αυτοματοποίηση στην παραγωγή επίπλων

- Τη ζήτηση της αγοράς και τις μελλοντικές τάσεις στα εξατομικευμένα προϊόντα

- Τις προκλήσεις και τις ευκαιρίες της υιοθέτησης νέων τεχνολογιών παραγωγής.

Στο παρόν email έχω επίσης συμπεριλάβει στον μέντορα και σύμβουλό μου, καθηγητή κ. Καραγιάννη Ηλία, ο οποίος επιβλέπει τη μεταπτυχιακή μου διατριβή. Η συνέντευξη μπορεί να πραγματοποιηθεί στα ελληνικά, ωστόσο καθώς το τμήμα είναι αγγλόφωνο τα αποτελέσματα αυτής θα μεταφραστούν.

Η συνέντευξη μπορεί να διεξαχθεί όποτε σας βολεύει, είτε μέσω τηλεφώνου ή βιντεοκλήσης, οπότε και χρειάζεται να καταγραφεί για την δημιουργία εμπιστευτικού αρχείου στο οποίο θα έχω πρόσβαση μόνο εγώ και ο Κ. Καραγιάννης. , είτε συμπληρώνοντας μόνοι σας έγγραφο Word. Εάν βρίσκεστε κοντά στα Χανιά, θα ήμουν ευτυχής να πραγματοποιήσω τη συνέντευξη αυτοπροσώπως.

Με εκτίμηση,

Ζυγούλης Νικόλας

Διπλ. Αρχιτέκτονας Μηχανικός Α.Π.Θ.

M.Sc. Technology & Innovation Management candidate

0030 6975847845

8.3 Translated Interview Questions in Greek

Επιχειρηματικό περιβάλλον

- Περιγράψτε το ρόλο σας και πώς αυτός σχετίζεται με την επιπλοποιία.
- Ποια είναι η πρόταση αξίας της εταιρείας σας;
- Ποιες είναι οι 3 κύριες δυσκολίες του εξωτερικού περιβάλλοντος που αντιμετώπισε η επιχείρησή σας τα τελευταία 3 χρόνια; (3 σύντομες απαντήσεις)
- Ποιες πιστεύετε ότι είναι οι 3 κύριες δυσκολίες που θα αντιμετωπίσει η επιχείρησή σας τα επόμενα 3 χρόνια; (3 σύντομες απαντήσεις)

Ανταγωνιστικό πλεονέκτημα

- Ποιοι είναι οι 3 βασικοί παράγοντες επιτυχίας στον τομέα σας;
    - (3 σύντομες απαντήσεις)
- Ποιοι είναι 3 παράγοντες αποτυχίας στον τομέα σας;
    - (3 σύντομες απαντήσεις)
- Πώς μετράτε την επιτυχία στην επιχείρησή σας;
    - Πώς ξέρετε ότι η παραγωγή και οι πωλήσεις σας είναι εκεί που θέλετε;
- Πόσο σημαντική είναι η E&A (R&D) στην επιχείρησή σας;
    - (Κλίμακα 1-5, εξηγήστε συνοπτικά)
- Πόσο εξοικειωμένη είναι η επιχείρησή σας με τεχνολογίες όπως η αυτοματοποίηση CNC και ο παραμετρικός σχεδιασμός στην παραγωγή επίπλων;
    - (Κλίμακα 1-5, εξηγήστε συνοπτικά)

Ζήτηση στην αγορά και σκοπιμότητα της μαζικής προσαρμογής

- Πόσο συχνά οι πελάτες ζητούν συγκεκριμένες προδιαγραφές;
    - (Κλίμακα 1-5, εξηγήστε συνοπτικά)
- Ποιες είναι οι 3 πιο συχνά ζητούμενες επιλογές προσαρμογής στην επιχείρησή σας;
    - (3 σύντομες απαντήσεις)
- Υπάρχει όφελος από την ενσωμάτωση αποτελεσματικών επιλογών προσαρμογής για τα προϊόντα σας;
    - (Κλίμακα 1-5, εξηγήστε συνοπτικά)
- Εάν η προσαρμογή των προϊόντων είναι δυνατή και εύκολη, η εταιρεία σας θα αποκτήσει ανταγωνιστικό πλεονέκτημα έναντι του ανταγωνισμού;
    - (Κλίμακα 1-5, εξηγήστε συνοπτικά)
- Πόσο εξοικειωμένοι είστε με τον όρο Mass Customization;
    - (Κλίμακα 1-5, εξηγήστε συνοπτικά)
- Ποιες προκλήσεις προβλέπετε για την προσφορά επιλογών εξατομίκευσης στους πελάτες σας, είτε από άποψη παραγωγής, αγοράς, είτε από τεχνική άποψη;
    - (3 σύντομες απαντήσεις)

Κλείσιμο

- Πώς προβλέπετε να εξελιχθεί η βιομηχανία επίπλων σε 5 έως 10 χρόνια;
- Ποιες 3 μελλοντικές εξελίξεις ή καινοτομίες που θα μπορούσαν να βελτιώσουν την αποτελεσματικότητα της παραγωγής και των πωλήσεων προβλέπετε;
    - (3 σύντομες απαντήσεις)

8.4 List Of Interviewees

Updated list is transferred to EXCEL for easy manipulation.

№	Participant Name	Role	Company/ organization	BMC category	Spesific Category	company size	Region	Reason for contact	Reason for selection	Availability	Interview date	interview means	Notes	Way of reaching out
Interview conducted														
1	Vasilis Tsirkos	CTO	Papadatos S.A.	Manufacturer	Standardized Luxury furniture manufacture	40	Acharnes, Athens	Relevance of operation	Selected because they produce designer furniture lines. They are manufacturing inhouse and have a network for exports in 40 countries	YES	21-10-24	14:00 phone call	17/10 Send email accounting@papadatos.gr , accounting will review, find suitable candidate, and call back . 21/10 talked with Vasilis Tsirkos, willing to help, gave him my number to call when he finds some time today.	papadatos@papadatos.gr / 210 8079 300
2	Tzouvadakis		Tzouvadakis	Manufacturer	Family-owned Woodworking workshop	4	Chania, Crete	Regional contact	Selected because they are a good example of a very small, traditional woodworking company, that is curently run by the 3rd generation	YES	21-Oct	13:00 on site	21/10 visited his shop, conducted the interview right away	In person
3	Tzevelekidis	production manager	Anesis	Manufacturer	Standardized manufacturer of designer tables and chairs	18	Langadas, Thesaloniki	Existing network	Selected because I follow their efforts since 2021. They are regarded as an innovative company in the circles of woodworking industry in Thessaloniki. They cooperate with foreign designers to produce quality products	YES	22-10-24	reply via email	18/10 Reception holds my phone and will forward mail to whom may have time.21/10 talked with Mr. Tzevelekidis, he will do it, propably after 5 some day that suits him. (his number 694517348)	info@anesis.com.gr / 23940 20494

4	Natalino Manzieri	owner	Woodnimac service	Technology provider	CNC tooling reseller	6	Sindos, Thessaloniki	Existing network	Selected as they are leaders in CNC machine integration in factories across Greece with over 150 successfull integrations. They import and install machinery from Italy and Germany. They are regarded as the expert advisors in CNC production by many factories in Greece.	YES	22-10-24	8:30 My call	16/10 Willing to participate, contact again with draft 18/10. Sent mail . 21/10 called back. Set up meeting for 8:30 at 22/1011/11 talked with matzieri for pricing information, is open to disguss yet thinks the projects is too much for a thesis, to big of a field to be explained shortly	woodnimac.service@gmail.com / 6976222051
5	Isakidis Christos	General Director	ISAC Advanced Robotics	Technology provider	CNC tooling manufacturer	17	Kilkis, Thessaloniki	Relevance of operation	Selected because they are the only major woodworking CNC manufacturer in Greece. I have been following their effords since 2022 and admire their ability to promote their machinery and upgrade factories in greece	YES	23-10-24	11:00 Their call	17/10 Called and sent mail. The secretary will notify management and find the right person for the interview. Positive stance by them. 18/10 Called back to set up interview with CEO11/11 called to incuire for pricing, they are open to share data with formal email asking for it, the secretary is called Fotini	info@isac.gr / 2341075889
6	Bitsakis Spyros	Lighting Designer	Illum	Designer	Lighting Design	5	Chania, Crete	Regional contact	Selected for divercity in the interviews. Their opinion yet not extremly relevant can provide insights on a designers' and potential clients' way of thinking	YES	25-10-24	13:00 on site	25/10 visited on site, had an interview with the sales person	
7	Alexiou Alexis	salesperson	Hummel	Retail	Kitchen design	N/A	Chania, Crete	Regional contact	Works with prefabricated	YES	01-11-24	reply via email	24/10 visited on site, was eager to help and will reply via email	info@hummel.com.gr

									kitchen furnishings					
8	Mantourakis Nikos	owner	-	Manufacture r	CNC operator	1	Chania, Crete	Regional contact	Sugested by many small manufacturers, as he is the only one in Chania region open to cut jobs for other businesses with his machinery.	NOT ON RECORD	06-11-24	inperson meeting	6/11 visited on site, was busy and denied to answer any of my questions on record. He had a talk about CNC machining and the Cretan market.Even though no valuable data for this thesis was gained, he was nice enough to explain the basic function of a CNC machine. He has 20 years of experience in CNC fabrication and is the man to go for all cretan small manufacturers for CNC pantorouter cutting.Even though he is the man to go, he does not use sofisticated machinery or software. He is knowledgable about his stuff, yet strongminded and can not provide feedback for the thesis. He is however a good lead for practical help if the sugested thesis project starts in Crete.	
9	Polakis Giannis	Owner	Polakis furniture	Manufacture r	Custom fabrication	4	Chania, Crete	Regional contact	chosen for his good reputation between Chania manufacturers	YES	06-11-24	12:00 on site		2821 080000
10	Kourmoulis Dimitris	CEO	Kourmoulis AEBE	Manufacture r	Nesting kitchen	8	Rethimno, Crete	Existing network	Chosen as he has advanced machinery and methodologies. Meet during a sales pitch for his methodology at a fabrication workshop in Chania.	YES	07-11-24	13:00 on site		697502425
11	Skarakis	CEO		Manufacture r	Hotel furnishings		Chania, Crete	Existing network	Highly regarded as an entrepreneur by professionals. Works with large scale hotel furnishings	NOT ON RECORD	12-07-24	10:00 on site	Visited on site 12/11, was eager to help, gave a tour of the factory and we talked about the idea. Unfortunately, clients came and had to reschedule for later date	
Initial response positive yet interview not concluded														
12			Ambiente cucine	Retail	Kitchen design		Chania, Crete	Regional contact	Orders and imports cabinets from	Posibly	will reply via mail		17/10 In person meet, will send them email to schedule meeting. 21/10 visited on site, told they will reply via	In person meet, info@ambiente-cucine.gr

									Italy. They fit them in place				email11/11 deadline for interviews ended	
13			Porcelana Chania	Retail	Retail bathroom		Chania, Crete	Regional contact	Bathroom materials and furniture	Posibly			17/10 In person meet, will send them email to schedule meeting21/10 visited on site, told to reach out again on Friday11/11 deadline for interviews ended	In person meet, chania@porcelana.gr
14	Deliveraki Eleni	Chief sales	Skarakis Line	Retail	Retail Furniture		Chania, Crete	Regional contact		Posibly	31/10, 9-11:00 on site		24/10 visited on site, was very eager to help, schedulded apointment for 31/10I was not able to make the apointment, Have not talked since11/11 deadline for interviews ended	6973246514
15	Voutsina Tina		Centro	Retail	Kitchen Retail		Chania, Crete	Regional contact		Posibly			25/10 visited on site, eager to help, will answer via email11/11 deadline for interviews ended	chania@centrokitchen.com
16	Kripakis Giannis		Kripakis furniture	Retail	Retail manufacturer / sales		Chania, Crete	Regional contact		Posibly			04/11 found through random woodworker at a suplier, called to schedule, told to talk later08/11 called again, told he hill call later11/11 deadline for interviews ended	
17	Stelios fanourakis	CEO		Manufacturer	furniture production company in Bulgaria			Existing network	Manufactures chairs and tables. Has 11 CNC machines, 3 production lines. Major player with 1.000m3 of solid wood in storage.	Posibly	19/10/24, 19:00 My call		14/10 Suggested by old client of mine. 16/10 Very positive vibe. Willing to tour the factory floor. Possibility for cooperation at a later stage. Sent interview draft on Viber 17/10. 18/10 Contacted again to arrange a meeting. 19/10 could not participate in intervie. schedule for later date.	693 2647919
18			Loukakis handmade	Manufacturer				Regional contact		Posibly			25/10 visited on site, was told to email my Qs and they will see, 26/10 replied via email to agree on meeting27/10 talked via Phone, was told that he will find space in his schedule and call me to meet in person11/11 deadline for interviews ended	6973327303 Thodoris, ztloukakis@gmail.com
19	Stasinopoulou Staurouls		Home design	Designer			Chania, Crete	Regional contact		Posibly			24/10 Visited on site, will review mail 11/11 deadline for interviews ended	homedesign27@yahoo.com
Negative response/ Not good fit														
20	ΣΕΒ		ΣΕΒ	Manufacturer	Manufacturer association			Relevance of operation	Contacted so they can suggest potential interviewees	NO			29/10. Ζήτηση με mail για να μου βρούνε εταιρίες για συνεντεύξεις.	

21	Mr. Manousos	Owner	No name shop in Chania	Manufacturer	Handcrafted furniture		Chania, Crete	Regional contact		NO	NOT GOOD FIT		16/10 Very small and traditional yes had exchibition and experience, possibly not a good fit bue to lack of technology	In person
22			Sato S.A	Manufacturer	(large) Office furniture manufacture and trade			Relevance of operation	Largest distribution network in Greece, CRM in effect	NO			17/10 Talked with sales shop. Instructed to send mail with info and then call 21/10 talked with sales shop again, they do not know anything, was not willing to help, gave me disconected number.	info@sato.gr / 213 0181 600
23			Ntaountakis	Manufacturer	Kids furniture retail		Chania, Crete	Relevance of operation		NO			25/10 visited on site, was not eager to help, was ofensive	
24	-	-	Drakos Furniture	Manufacturer	High quality custom furniture	-		Relevance of operation	Insights in customer special demands	NO	-		18/10 Does not want to participate. Only makes custom work.	697 6769911
25			Xristodoulidis Triantafilos	Manufacturer			Diavata, Thessaloniki	Relevance of operation		NO			25/10 sugested by Ntaountakis	
26			Domogroup	Manufacturer				Relevance of operation		NO			NO ANSWER, CALL LATERNO ANSWER, CALL LATER	info@domogroup.gr /210-68-12-340
27	Παντελής Κωσταντινίδης	Sales	K2 contact furniture	Retail	Designer furniture manufacturer			Relevance of operation		NO	25/10/24, 17:00 my call missed my call, call again		17/10 Instructed to call central office, if they don't do it, he will. Central office refused on account of workload. Interview will be conducted with κ. Παντελή Κωνσταντινίδη. Call him to arrange21/10 secretary answered, Mr. Pantelis was in confrence, took my number, he will call when free. Mr. Pantelis called, set up meeting (his number 6988631631)11/11 deadline for interviews ended	2310 323333
28	Kaloterakis Antonis	CEO	Kaloterakis Design group	Manufacturer	Manufacturer and retailer of luxury household			Existing network	They have exchibition of standardised products and also custom manufacture projects	NO	He will call		14/10 sugested by Lekai Nikos, old coworker. 17/10 Willing to participate, yet not very eager. I gave him my number to call me when he has the time.07/11 visited on site, was extremly rude. Will not participate	28310 28590
29	Katerina Matzieri			Technology provider	Software teacher, CNC software expert, Wood manufacturing consultant			Existing network		NO			14/10 Suggested by Antoniou Sakis, Head production technician at Toumani Bros. Waiting on her number. 29/11 did not have time to participate	

30	Christos Ouslis	CEO	Epiploidees	Manufacturer	Affordable furniture			Relevance of operation		NO			18/10 Talk with Mr. Christos Ouslis at 6932159383 to arrange meeting. Send mail with info. Call Mr. Christos on 22/10 to arrange meeting03/11 contacted again, did not have time to participate	info@epiploidees.gr 2467023277
31			Fragkalis	Manufacturer	Manufacturer custom-made			Relevance of operation		NO			18/10 Reception holds my phone and will forward mail to those who may have time. 21/10 did not answer	info@fragkalis.gr / 2314 012901
32	Antonis Digalakis			Manufacturer	Aluminium profiles and manufacture of aluminium doors and stuff			Regional contact		NO			21/10 Visited onsite, was absent, reception gave me his number to set up meeting24/10 his field of operations is not maching the thesis	6947032561
33	Androulakis Aygoustakis		Aline	Supplier			Moires, Creete	Relevance of operation	Sugested by Scarakis Line, has automated CNC melamine production	NO			24/10 suggested by Scarakis Line. 29/10 talked with reception, hold my phone, will forward mail to director10/11 did not anser	2892023745
34			Aerakis Epipla	Manufacturer			Heraclion, Crete	Relevance of operation	Sugested by Scarakis Line, has semi automated CNC sofa production	NO			24/10 suggested by Scarakis Line. 29/10 talked with reception, told to phone at 2810287008 after 18:00 to find mr Aerakis.10/11 did not anser	2810 232657, 2810287008
35			Holz Tsourounakis	Manufacturer	WinDoors wooden			Relevance of operation	Sugested by Ambiente cucine and Skarakis Line, has automated CNC production of windoors	NO			16/10 suggested by Ambiente cucine, 29/10 talked with secretary, will review mail and get back to me from next month10/11 did not anser	2821 096906
36	Πετρίδης Αναστάσιος	Owner	CNC CAT	Technology provider	CNC tooling manufacturer			Relevance of operation	Manufactures wood and metal CNC tools, commonly found in small businesses	NO			17/10 Positive vibe. When ready call him 21/10 secretary answerd Mr. Petridis was in confrence. Holds my phone and will get me back11/11 deadline for interviews ended	info@cnccat.gr / 211 7707270
37			Stepcraft GR	Technology provider	CNC tooling manufacturer			Existing network	Manufactures affordable semiprofessional wood CNC. Cheapest option for ATC	NO			16/10 Willing to participate, contact again with draft 18/10. Sent mail 21/10 Is outside, will go back to office and call me to arange11/11 deadline for interviews ended	info@stepcraft.gr / 6984 194594
38			Sadimac	Technology provider				Relevance of operation		NO			NO ANSWER, CALL LATER11/11 deadline for interviews ended	info@sadimac.com / 23940 20577

39			Dromeas S.A.	Manufacturer	(large) Office furniture manufacturer			Relevance of operation	Complete development-exclusivity contract for office furniture EU Services	NO			17/10 Send email υπόψιν διοίκησης, Management will review and contact me. (CEO does not speak English). 21/10 secretary said management is away for an exibition can not reply at this stage.11/11 deadline for interviews ended	dromeas@dromeas.gr / 2321099220
40			Kourtis in House	Manufacturer	Importer, house furniture / Custom			Relevance of operation		NO			17/10 Instructed to call central office 210 8066245. They will notify Mr. Kourtis, asked for email to remember 21/10 talked with secretary. My mail is forwarded to marketing department. They will call if interested.11/11 deadline for interviews ended	central@kourtis.gr /210 6250 106
41			Metaxakis Athan ABEE	Manufacturer	(Large) Vertical production process Professional furniture sector B2B			Relevance of operation		NO			17/10 Send mail to info@ , cc sales@ . They will reply via email21/10 secretary asked for a friendly reminder in mail. (resend the mail)11/11 deadline for interviews ended	sales@metaxakis.gr / 210 6628 823
42			Moda Bagno	Manufacturer	High-end Design Furniture trade			Relevance of operation		NO			17/10 Told by reception to send email at reception@modabagno.gr . They will review and arrange 21/10 secretary has forwarded the mail. She will ask management and call me with news11/11 deadline for interviews ended	info@modabagno.gr / 210 8036 700
43			Marmaridis	Manufacturer	Home furniture			Relevance of operation		NO			17/10 Instructed to send email at peristeri@marmaridis.gr , a colleague will revie and call back 21/10 secretary will ask management for news. She took my number, management will call me to arange meeting11/11 deadline for interviews ended	210 5712121
44	Mastorakis	Production manager	Tsigenis Woodcraft	Manufacturer	Horeca and household custom manufacturer			Existing network	Also works with Corian	NO			17/10 Send mail υπόψιν κ. Μαστοράκη (διευθυντής) 21/10 Management has seen it, call after 2am to talk with them11/11 deadline for interviews ended	info@tsigenis.gr /2810 373370
45			Tsaousoglou	Manufacturer				Relevance of operation		NO			17/10 Try after 27oct, they go to exhibition this week11/11 deadline for interviews ended	info@tsaoussoglou.com / 210 67 74 100
46			Mexil	Manufacturer	Professional contract furniture			Relevance of operation		NO			17/10 Send mail. Secretary will notify management.21/10 I wait for their reply. Secretary will notify them that I called again11/11 deadline for interviews ended	info@mexil.gr 2310 383000

47			Diafano Chania	Retail	Retail		Chania, Crete	Regional contact		NO			24/10 visited on site, was busy propably will not participate11/11 deadline for interviews ended	chania@diafanostores.gr
48			Entos, Chania	Retail	Retail Furniture		Chania, Crete	Regional contact		NO			24/10 visited on site, was very busy will review mail.11/11 deadline for interviews ended	g.bozi@sato.gr
49			Manias Collection	Retail	Retail Furniture		Chania, Crete	Regional contact		NO			24/10 visited on site, was eager to help, will review mail and reply11/11 deadline for interviews ended	maniascollection2@gmail.com
50			Afoi Vrodaki	Retail	Retail Furniture		Chania, Crete	Regional contact		NO			24/10 visited on site, send email, they will review and talk again11/11 deadline for interviews ended	info@afoivrodaki.gr
51			Panagiotakis	Supplier				Existing network		NO			3/11 contacted in person, told to send mail they will reply via email11/11 deadline for interviews ended	Located in Chania, contact in person
52			Afoi Chiou	Supplier				Existing network		NO			28/10 contacted via phonecall did not have time	27310 44704
53			Alfa Wood Group	Supplier				Relevance of operation		NO			17/10 Send mail. Secretary will notify management.27/10 I wait for their reply. Secretary will notify them that I called again11/11 deadline for interviews ended	2410 561200
54			Mesogeiaki S.A.	Supplier				Existing network		NO			27/10 Send mail. Secretary will notify management.NO ANSWER, CALL LATER	23940 23770
55			Steropal	Supplier				Relevance of operation		NO			18/10 Reception holds my phone and will forward mail to those who may have time. 21/10 did not answer	info@steropal.gr / 23940 32222
56			Eltop	Supplier				Relevance of operation		NO			27/10 Send mail. Secretary will notify management.	info@eltop.gr / 210 5565570

8.5 Original Interview Response Matrix

General information	Manufacturing company 1	Manufacturing company 2	Manufacturing company 3	Manufacturing company 4	Manufacturing company 5	Technology provider 1	Technology provider 2	retail 1	Designer 1
Company	Papadatos SA	Tzouvedakis Home	Anesis comfortable designs	Polakis Furniture	Kourmoulis AEBE	Woodnimac service	ISAC Advanced Robotics	Hummel-Manousakis	Illum Lighting
Field of operations	Manufacturer	Manufacturer	Manufacturer	Manufacturer	Manufacturer	Technology provider	Technology provider/ technology manufacturer	Retail Kitchen	Lighting Design
Relevance on my topic	HIGH	medium	HIGH	medium	HIGH	HIGH	HIGH	Medium	low
Size (people)	40	4	18	4	8	6	17	unknown	3

Name of interviewee	Tsirkos Vasilios	Tzouvedakis Dimitris	Tzevelekidis Akis	Polakis Giannis	Kourmoulis Dimitris	Natalino Manzieri	Isakidis Christos	Alexiou Alexis	Bitsakis Spyros
Position	Production manager	Owner	Production manager	Owner	Owner	Owner	General Director	Sales man	Sales person
Date of the interview	21-10-24	21-10-24	22-10-24	06-11-24	07-11-24	22-10-24	23-10-24	01-10-24	25-10-24
Means of interview	phone call	On-site	Written reply	On-site	On-site	phone call	phone call	Written reply	On-site
data prosecing date	21-Oct	21-Oct	23-Oct	NOT YET	NOT YET	26-Oct	26-Oct	07-Nov	27-Oct
interview file	Papadatos Tsirkos	Tzouvedakis	Written response in mail	Polakis Giannis	Kourmoulis Dimitris	Woodinimac Manzieri	Isac Isakidis		Illum Lighting
Q1: Describe your role and how it relates to furniture production or sales	Manufacturing company 1	Manufacturing company 2	Manufacturing company 3	Manufacturing company 4	Manufacturing company 5	Technology provider 1	Technology provider 2	retail 1	Designer 1
original response a	is the connection between Production and Management	Owner of family business	machine acquirement, production methodology, cost, design manager	Owner, responsible for order of materials, fabricating, communicating with the client.	owner of Kourmoulis ABEE, focusing on kitchen and wardrobe manufacturing as well as specialized constructions. The company aims to transition to B2B wholesale operations, employing 8 people.	Has 25 years of technical experience in CNC machines. Installs high end machines in Greece	Is the general director, deals with marketing, accounting, production and development	Customer service, design and costing	sales of lighting material, Design of lighting solutions
Q2: What is the value proposition of your company?	Manufacturing company 1	Manufacturing company 2	Manufacturing company 3	Manufacturing company 4	Manufacturing company 5	Technology provider 1	Technology provider 2	retail 1	Designer 1
original response a	High quality furniture	Handmade furniture	Handmade furniture	good reputation through quality of work	Provide mass production with customization options to local carpenters	N/A	helps factories increase in productivity via CNC machines	quality of service	Has specialized architectural lighting products
original response b	Works with Italian designers	Special constructions	Unique design	fair price for end customer and responsibility as a businessman	Give other woodworkers ready made products to install	N/A	Easier and simplified methodologies for production	Reliability	N/A
original response c	Manufactures inhouse	Knowhow	Works with designers	Positive social media presence	Modify the construction method and dimensions of their products to suit specific client, without additional costs	N/A	N/A	N/A	N/A
Q3: What are the 3 main difficulties of the external environment your	Manufacturing company 1	Manufacturing company 2	Manufacturing company 3	Manufacturing company 4	Manufacturing company 5	Technology provider 1	Technology provider 2	retail 1	Designer 1

business has faced in the last 3 years									
original response a	material supply/manufacturing quality	Personnel difficult to find	Covid	lack of human labor, no young people joining the industry	The biggest challenge is the workforce—lack of skilled workers is the only major issue	Lack of educational institutions for providing high end manpower. Industry can not find educated people that can design and manufacture furniture through all the technology.	Human resources, Difficult to find and train high quality personnel	Cost increases	supply chain problems
original response b	timeline of manufacture and delivery of their furniture	Informal economy	Lack of human resources	rapid increase of cost of materials	production complexities	Lack of financial support from Greek government. Standards for acquiring funding are correct (industry 4 and 5) but suit bigger companies, rather than SMEs.	Hard time increasing customer base	Lack of products	N/A
original response c	Prototyping of new products	High cost of running business	Insecure economic environment	rapid increase of operating costs	economic fluctuations	Due to lack of personnel, Demand is high and companies poach high-end employs from each other	Development of new products	Informal economy	N/A
original response d	N/A	N/A	N/A	N/A	N/A	Not enough new people in the industry. Usually the children of factory owners tend to advance, while there is a lack of new people interested in the woodworking industry	Economic/ institutional challenges	N/A	N/A
Q4: What do you think are the 3 main difficulties your business will face in the next 3 years?	Manufacturing company 1	Manufacturing company 2	Manufacturing company 3	Manufacturing company 4	Manufacturing company 5	Technology provider 1	Technology provider 2	retail 1	Designer 1
original response a	communication with people	Personnel difficult to find handymen	Lack of human resources	Lack of human labor. Foreign people will be brough to fill the gap	labor shortage will lead to hiring unqualified workers	New people seek easy money, it is rare to find people that are truly interested in advancing knowledge. People are Static knowledge wise.	Lack of human resources	Downfall of building economy	Supply chain products

original response b	When a lot of problems arise it is difficult to face them	Internet shopping	Insecure economic environment	Existing craftsman will eventually retire making the lack of human recourses more significant, rising salary costs	increased competition for jobs will lower standards	N/A	Development issues, capital liquidity issues, product development	Rise of costs	Bigger need for products will enhance problems in supply chain
original response c	N/A	High cost of running business	Lessening of consumer economic power	Material costs	N/A	N/A	Competition from abroad	informal economy	N/A
-									
Q5: What are 3 key success factors in your sector?	Manufacturing company 1	Manufacturing company 2	Manufacturing company 3	Manufacturing company 4	Manufacturing company 5	Technology provider 1	Technology provider 2	retail 1	Designer 1
original response a	set goals	experience	Correct values	quality of product	Success is a result of overcoming obstacles quickly	N/A	Rapid delivery	Responsibility	Technical expertise
original response b	organize goals	expect the future	Willingness to learn	reasonable cost	Persistence, resilience and adaptability	N/A	Customizable product for customer need	Quality of products	experience
original response c	work towards goals	financial planning	Professionalism	punctuality to timelines	Staying committed in challenging situations	N/A	Technical support and specialization	Reasonable cost for the consumer	network of suppliers
Q6: What are 3 failure factors in your sector?	Manufacturing company 1	Manufacturing company 2	Manufacturing company 3	Manufacturing company 4	Manufacturing company 5	Technology provider 1	Technology provider 2	retail 1	Designer 1
original response a	opposite of success	low quality of service	Lack of strategy	Failure to calculate production costs	Incorrect pricing	N/A	Lack of R&D	Bad quality of products	Client can not understand the circumstances of delays
original response b	N/A	lack of visibility	arrogance	Disorganization of business	Failure to calculate real production costs	N/A	Lack of understanding of competitors, especially foreign ones that may be ahead	Bad marketing	N/A
original response c	N/A	N/A	Black market/ informal economy	N/A	Pour financial management and lack of organizational skills	N/A	Lack of Brand awareness	Bad administration	N/A
Q7 How do you measure success in your business?	Manufacturing company 1	Manufacturing company 2	Manufacturing company 3	Manufacturing company 4	Manufacturing company 5	Technology provider 1	Technology provider 2	retail 1	Designer 1
original response a	profit margin	profit margin	Profit margin	positive reaction of clients	Success is measured by sustaining the business during slow periods	N/A	Profit margin	operate based on entrepreneurial instincts	Happy clients

original response b	product sales success (acceptance from market)	N/A	Happiness	Through client acquisition	making enough profit through peak seasons to reinvest in equipment and cover operational costs	N/A	Has 15 different internal statistics	N/A	Word of mouth success
original response c	set fair price for their products	N/A	growth rates	Profit margin	N/A	N/A	N/A	N/A	N/A
Q8: How important is R&D in your business?	Manufacturing company 1	Manufacturing company 2	Manufacturing company 3	Manufacturing company 4	Manufacturing company 5	Technology provider 1	Technology provider 2	retail 1	Designer 1
scale	100%	80%	80%	90%	70%	N/A	90%	100%	80%
original response a	new materials	new construction methodology	N/A	There is a continuous need to find better methodologies and tools	The company has modernized its machinery, yet no formal R&D initiatives are mentioned	N/A	Continuous incremental innovation to enhance the product	N/A	You have to follow innovation, trends and fashion
original response b	new design	Find new products and markets	N/A	New materials to keep clients happy	N/A	N/A	adapt completely new technologies to their products to enhance life cycle	N/A	Continuous enrolment in seminars and exhibitions
original response c	N/A	the more products the better	N/A	through visiting exhibitions	N/A	N/A			
Q9: How familiar is your organization with technologies like CNC automation and parametric design in furniture production?	Manufacturing company 1	Manufacturing company 2	Manufacturing company 3	Manufacturing company 4	Manufacturing company 5	Technology provider 1	Technology provider 2	retail 1	Designer 1
scale	80%	30%	50%	0%	100%	Irrelevant	irrelevant	20%	10%
original response a	complete CNC workflow for fabric patron	uses 3D cad for product visualization	Greek market client has special need not suiting for mass production	Better for efficiency, yet with a lot of drawbacks. Stealing job positions from humans	We have invested in machinery and software that allows us to be adaptable	N/A	provides their customers with parametric tools	Does not understand the basic concept of parametric design	works with subcontractors for special orders
original response b	Most of woodworking in CNC	uses 3D printing for prototyping	N/A	They try to push technology. This is a mistake as we will lose our knowledge of the trade. All knowledge aqumulates in only few people.	N/A	N/A	All of their machines are compatible with all CAD software	N/A	N/A
-									

Q10: How often do clients ask for specific specifications?	Manufacturing company 1	Manufacturing company 2	Manufacturing company 3	Manufacturing company 4	Manufacturing company 5	Technology provider 1	Technology provider 2	retail 1	Designer 1
scale	100%	10%	60%	70%	100%	60%	70%	60%	40%
original response a	Clients need everything	Client chooses from existing catalogue	Used to be more	Clients choose him to manufacture existing designs, but always ask for different specifications	Every job is different	Customized jobs, every job is different	has helped his customers with configuring different options of the same furniture line	N/A	color of lighting, standard products in shelf
original response b	Threat of outcome not being useful, Client not qualified to judge ergonomics	N/A	N/A	Clients choose him for better quality	our clients always need customized specification	Bathroom furniture are pretty standardized	Different dimensions in kitchen and wardrobe design	N/A	Limited demand to dimension change, due to lack of products offering this
original response c	N/A	N/A	N/A	N/A	N/A	N/A	Most factories design the furniture completely new	N/A	They do not change the product as garandee will not apply
Q11: What are the 3 most frequently requested customization options in your business?	Manufacturing company 1	Manufacturing company 2	Manufacturing company 3	Manufacturing company 4	Manufacturing company 5	Technology provider 1	Technology provider 2	retail 1	Designer 1
original response a	paint RAL	Overall dimensions	wood type	always ask for different specifications	Specific construction method	Most factories either work with standard construction, and do custom in rare occasions, or completely set up for custom unique pieces	change in overall dimensions of standardized product	N/A	Intensity of light
original response b	color and texture of fabric	wood type	color and texture of fabric	Dimensions for tables and offices	Overall dimensions of products	N/A	extra customization, drawers, shelving, lighting	N/A	Variety of light
original response b	change in overall dimensions of standardized product	N/A	change in overall dimensions of standardized product	N/A	Materials	N/A	material (type and color)	N/A	N/A
Q12: Is there a benefit for integrating efficient customization	Manufacturing company 1	Manufacturing company 2	Manufacturing company 3	Manufacturing company 4	Manufacturing company 5	Technology provider 1	Technology provider 2	retail 1	Designer 1

options for your products?									
scale	20%	20%	N/A	40%	N/A	20%	100%	N/A	N/A
original response a	Time consuming	low price of standard	N/A	Not financially profitable to change dimensions	N/A	Most factories are set up for complete customization of furniture, Few can have standard construction	Too much technical information for customer to know	N/A	N/A
original response b	Very risky	High price of customization	N/A	N/A	N/A	Production of custom can be up to 80% loss	Customer should not be able to change the construction, yet it would be nice to give him options	N/A	N/A
Q13: If the customization of products is possible and easy, would your company gain a competitive edge over the competition?	Manufacturing company 1	Manufacturing company 2	Manufacturing company 3	Manufacturing company 4	Manufacturing company 5	Technology provider 1	Technology provider 2	retail 1	Designer 1
scale	0%	100%	0%	90%	30%	0%	20%	100%	N/A
original response a	Follows European standards	personalization to the customer	if it was easy everyone would have it, No advantage for me	To do this you have to have the manufacturing capabilities, not just selling furniture	Mass production aims to lower costs, making custom orders increase cost by 30-35%	Production can only be either one or the other.	Change in dimensions is too specific, does not know if it is enough for competitive advantage	N/A	N/A
original response b	Has to set up fabrication to accommodate different sizes	Does not lose the client	N/A	would provide client with advantage, would not provide advantage on manufacturing	N/A	N/A	It is possible that even though he thinks this will not work, maybe it is a breakthrough that he does not currently understand.	N/A	N/A
original response b	Has not seen this applied somewhere else	N/A	N/A	Client would be happy, even though market with clients needing this niche is small	N/A	N/A	to niche of an audience	N/A	N/A
Q14: How familiar are you with the term Mass Customization?	Manufacturing company 1	Manufacturing company 2	Manufacturing company 3	Manufacturing company 4	Manufacturing company 5	Technology provider 1	Technology provider 2	retail 1	Designer 1
scale	10%	30%	50%	0%	N/A	60%	70%	N/A	N/A

original response a	Does not want to change his designs.	Does not want to change furniture in scale	have been trying to change from custom to order	focuses on traditional manufacturing with solid wood. Mass production can not achieve this	N/A	Most factories work with a 10% markup in price for customizing existing products	It happens in sheet material kitchen	Their customers always have unique and personalized demand	N/A
original response b	yet makes his furniture Just In Time	makes it manually	N/A	Works every time on different design. Starts from scratch, does not prefabricate	N/A	No automated procedure for Mass customization in dimensions	N/A	N/A	N/A
Q15: What challenges do you foresee in offering customization options to your clients, either from a production, market, or technical standpoint?	Manufacturing company 1	Manufacturing company 2	Manufacturing company 3	Manufacturing company 4	Manufacturing company 5	Technology provider 1	Technology provider 2	retail 1	Designer 1
original response a	only useful for small scale production	Not suitable for mass production	Lack of human recourses	Client can not understand measurements and size	Challenging during peak production times	standardized production means low cost, if you need customized then cost goes up	Client can not visualize the change, incapable of understanding change in dimensions	NO CHALLENGES, their factory has the ability to offer personalized products	Client need vary vastly
original response b	Very high cost of change, Design again from scratch	High cost of customization	Inability to bare the cost of custom changes	You have to redesign from scratch	One should not modify their production line, as it is costly	You can not stock raw material cut in rough dimensions, Because then you have to process the same part multiple times	Client should be guided in material selection	N/A	Difference between choosing and designing furniture, designing is better as client gets exactly what they need
original response c	Impossible to cater to construction change of designs, too much complexity. High probability of mistake	Can not cater to specific request	N/A	can not stock products	You can not produce and store standardized items during downtime	Can only work on Made to Order basis. There never existed the concept of having stock of semi ready product, that will be then worked again and customized. High cost of storing and reprocessing.	High level of complexity and labor	N/A	N/A

original response d	Network complexity (Very difficult to find network to work in such automated way)	N/A	N/A	Has to set up fabrication to accommodate different sizes	N/A	High level of material remnant (ρετάλι)	Most factories offer completely custom furniture, so it is not far from the thesis idea, yet every piece is exactly what the client wants	N/A	N/A
original response e	Product can not be beautiful and useful in all dimensions	N/A	N/A	When you change dimensions and make bigger, you will have more loss on materials	N/A	N/A	N/A	N/A	N/A
original response f	waste of materials	N/A	N/A	When you mass produce, you can not modify. This is the reason people come to me for their furniture	N/A	N/A	N/A	N/A	N/A
-									
Q16: How do you foresee the furniture industry to evolve in 5 to 10 years?	Manufacturing company 1	Manufacturing company 2	Manufacturing company 3	Manufacturing company 4	Manufacturing company 5	Technology provider 1	Technology provider 2	retail 1	Designer 1
original response a	not very positive	80% will be e-commerce	Production will become standardized, due to lack of human resources	Trend towards mass manufacturing	Industry will become more automated	Industry 4.0 in Greece, Industry 5.0 in EU.	Shift towards mass production, mainly export and hospitality	Complete automation	Follow the lead of bigger companies, accept their products
original response b	Products will come from cheaper labor countries	Threat from big players	Customizable products will be expensive and few will be able to afford	N/A	Bespoke projects will decline	Greek industry automation will delay compared to Italian or German industry	Most very small businesses will close, Most small will combine to become Medium. This happens due to the high level of automation a factory will need and the high cost of imprinting this	Development of environmentally friendly methodologies and products	N/A
original response c	N/A	Clients need cheap solutions	N/A	N/A	Production will move toward standardized and cost-effective processes	Difficulty in securing funding to upgrade production with intelligent machines due to lack of manpower	All indications like taxing, funding and automations seems to be favoring bigger companies	N/A	N/A

original response d	N/A	Products will come from cheaper labor countries	N/A	N/A	N/A	Difficulty in finding personnel in ruler areas.	Human hand labor is hard to find, and also will not be needed. The old uneducated craftsman will die and be changed with an educated designer	N/A	N/A
original response e	N/A	N/A	N/A	N/A	N/A	High importance of barcode in every part of cabinet, data, identity and quality control for every piece following it in every step of life cycle	Rapid need for growth in size by companies is extremely necessary	N/A	N/A
original response f	N/A	N/A	N/A	N/A	N/A	Furniture industry will need to be educated with school, foreign languages and software	N/A	N/A	N/A
Q17: What 3 future developments or innovations that could enhance manufacturing and sales efficiency do you anticipate?	Manufacturing company 1	Manufacturing company 2	Manufacturing company 3	Manufacturing company 4	Manufacturing company 5	Technology provider 1	Technology provider 2	retail 1	Designer 1
original response a	N/A	e-commerce	Technology & AI robotic manufacturing	Technology and new tools will help the workflow	Increased use of parametric and automation technologies	Intelligent machines are the future, minimal human afford, high cost of 300k euros	Shift in mass production, with lack of customizability	Cost reduction	N/A
original response b	N/A	Large scale fabrication-distribution	3D printing with new materials	online connection with suppliers, automatic material supply via Electronic Data Interchange	Barcodes on products will become standardized	Example of innovation is the software SPAZIO 3d industry 4	more cooperation between companies	Environmentally friendly methodologies	N/A
original response c	N/A	Innovative solutions with little competition	more cooperation between companies	New conventional tools always emerge	N/A	With new technology, factory floor will be maned with 3rd class workers (cheap manpower), while intelligent educated people are needed in the office, where they oversee the complete process.	N/A	N/A	N/A

8.6 Interview transcriptions

8.6.1 Papadatos S.A.

Describe your role.

Vasilis Tsirkos, Production manager, is the link between production and management. Takes data and information from management, like plans, changes, or a request for something new and is responsible to communicate it for production. Sometimes this communication means that he and his team will produce blueprints, find materials and in general how the wishes of management can be practically enforced for production.

The business has around 40 employees.

What is the value proposition of the company?

They offer high quality furniture both in construction and design. For designing they cooperate with Italian designers for most pieces, while they can also design some pieces in-house. Manufacturing is happening exclusively in-house.

3 main difficulties in the last 3 years.

He deals with many difficulties on a day-to-day basis and is difficult to pick 3. Of course, covid and the quarantines proved a difficult situation within the sector. His role relates to difficulties and problems as he must deal with suppliers and with manufacturing, where all sorts of problems arise. His role is to solve problems.

Examples of mistakes can be found in blueprints and design, CNC cutting mistakes, material quality inexpediencies. They find themselves often under the pressure of time, since they export products and have strict deadlines in closing the containers and shipping.

3 difficulties to come.

The field is so big. Difficulties in communicating with people, designing products and manufacturing them. All these processes are lengthy and involve many people and components that problems arise daily. When problems are that many in quantity, they tend to be overwhelming.

His opinion is that this scenario is present to every factory that deals with production. It is the nature of the work. He believes that you cannot do anything to prevent these problems from occurring. An example of these problematic and stressful experiences is the period before an exhibition, where they have to present new designs, because apart from the standard manufacturing of existing products, they have to deal with the prototyping phase. This experience can be extremely creative yet tiring. Some products undergo an extensive prototyping phase that can have up to 15 alterations of physical prototypes.

3 success factors

Organization is extremely important. There has to be a correct target set by the management, then a correct analysis of these goals has to be made, and then work towards following it.

3 failure factors

If you fail to do the above, you are probably not in the right place. You should also account for the imponderables, factors that are difficult to calculate or predicted.

How do you measure success?

Every enterprise with profit character measures success with profit, profit in money and in successful sales. Sometimes a product may have less profit margins, yet if it is successful means that customers like it and are willing to buy it, which gives us great pleasure. In Papadatos they do not sacrifice all aspects of a furniture so that they have the greatest amounts of profit, they first design and manufacture products according to their standards so they are happy with the quality of their work.

He believes that their products should have a fair price according to their quality of design, manufacturing and the competitors' products.

How important is R&D

It is important in all of the manufacturing sector. Anyone that makes products has to be aware of new materials and market trends. It is bipolar. On one hand you must be aware of design and color trends, and on the other hand you have materials, what wood are you using, what fabric, what foam? Think about it as a continuous search for data and images that will eventually be mixed to produce a new product.

New product development usually starts with the design given by a contracted designer, usually from Italy. While we receive the drawings we begin to work on its manufacture. We have every chief of the according manufacturing department say how it will be made. For example, the woodworking department decides on the best way to manufacture the frame, while upholstery decides on the best way to fabricate the cushions. All the technical details are up to each department, so that the final product is what the designer designed. The designer usually suggests a way of construction, yet the special manufacturing details are added later.

How much CNC and parametric design you use?

In recent years, all our upholstery is cut using CNC machines. We keep all digital data of the cuts. Also, recently we have incorporated CNC routers for our woodworking department. This happened due to the trend of manufacturing curved forms. The woodworking CNC was delayed as it was not deemed necessary in the past years, while in upholstery it was imperative to cut complicated patrons using CNCs. When the need for woodworking arose, we swiftly incorporated them in our processes.

Mass customization

Not very much. They choose not to change their designs. Big factories with production lines are seldom willing to incorporate these methodologies in their production. Mass customization is a characteristic for smaller companies. Bigger factories have huge costs associated with changing their fabrication method. Of course, they can easily change the material to be used, yet it is very costly to perform changes in the dimensions of the cuts. The changed products go out of production line. All associated departments have to reengage, it is like designing it from scratch.

All our products are manufactured according to demand. We do not stock our products due to the variations on choices we offer our client. We offer 25 colors of paint in mat and gloss, meaning 50 alterations, so we cannot stock this many options. Also, in fabric we have hundreds of choices, so every product is manufactured just in time according to our customers wishes

What are the challenged of mass customization

Even though we offer a lot a variety of colors and textures, all of our option does not change the construction of every product. To paint a credenza a different color, or even a custom one, is completely different than asking us to remove a drawer and shortening the piece 20cm. This has consequences in all parts of the assemble. For example, for a credenza with steel base and marble top, changing the dimensions forces us to redesign all the subassemblies, i.e. the actual woodworking, the steel base and the marble top, introducing further possibilities for mistakes. The internal structure of our products is predefined. We are more open to engage in changes of the dimensions for special projects of hotel furnishes, where the quantities of the orders can support the redevelopment of the products.

In a change of dimensions scenario, you have to recalculate the price, produce again the blueprints. It has happened to us before to change the external dimensions of a product, redusing it for 50cm. We communicated with every department to change the overall dimensions by 50cm, they did, and when we tried to assemble it we found an incompatibility with the woodworking frame and the metal base, the fixing points for the screws were not aligning. This is because of the complexity of changing the designs. Of course this problem was solved, yet in the expense of time and material waste.

They choose to offer clients options that do not affect their manufacturing cycles.

How often do clients ask for special options?

I used to work in the sales department in one of our departments. Client's love ordering custom products in the furniture industry, if they had the options, they would only ask for custom. If you do not limit them, they can ask for whatever they want, which is often a mistake as due to the lack of knowledge they may need ergonomically incorrect furniture. For example, they may need a high sofa, because this is the way they had theirs in their family home, if you agree to change your design and manufacture this high sofa, both the design would be off, but also the sofa would not be useful ass most feet would not touch the ground.

Our main production is aimed at foreign markets, we export most of our products, so our hole methodology in fabrication and sales is in accordance with the standards in Italian industry. This customized options that are suggested in this thesis cannot be found anywhere in foreign factories, this happens not because they do not want to help their clients, but because it is not correct.

The client is not able to judge and change dimensions of a product. To reach the final product many alterations have been made by the manufacturing team so when someone wants to intervene in this process by changing the dimensions and analogies of a product it is most likely that the result would be a mistake. For this reason, most manufacturers do not wish for their designs to be changed to protect their clients.

What are the 3 most frequent change options asked by the customer?

Fabrics are our main option. Fabric and color are the main request for a customer.

Dimensions, clients may ask for different dimensions in height or length. This is the second most occurring customization option asked by the clients.

If it were easy to change the dimensions of furniture, and could be offered in special dimensions, would a company gain a competitive advantage?

For the problems described above, we choose not to delve into custom dimensions. There are companies that only undertake custom projects. They lack our production lines.

Theoretically the goal of the thesis can work, yet you must set up the production line accordingly based on custom products. Also, the Greek reality is going to prove a problem. A company, no matter the size, must cooperate with other companies. For example, we do not process marble, we order our parts from other companies. We have found a company where we have given them our specifications and performed our quality control checks with them, and they produce for us our parts. This also happens with the metal working.

To produce a product there need to be many machines, and many companies, and many people. In Greek reality most companies can not perform this level of coordination due to the lack of either infrastructure of willingness. For example, one of our old marble producers did not have a CNC machine and we were forced to cut a wooden patron and send it to them. You can see it is not convenient to send a 2meter wooden patron every time, in 2024 it reaches the limit of insanity to do this. We had a great deal of trouble in finding partners that can process our materials in a modern way following our standards.

The level of detail in our orders for parts is big. We specify the exact position for every screw mounting point, and we expect it to be correct. This level of precision cannot be achieved with manual means, and you need digital methods of manufacturing. This digital manufacturing is lacking in most of Greek industry, so this level of coordination cannot be achieved easily.

Also, I have visited Italian factories that work in a completely digitized way, and they also choose to work in a standard way, because all of their measurements and cutting parameters are calculated for maximum yield. If you change the dimensions the yield will be less meaning inefficient. You should take all parts of manufacturing in your endeavor.

Obviously, you can perform a production line that incorporated this design options you are suggesting, yet if you do this, your products will likely not be either beautiful nor ergonomic. A client should not ask for a table of a different height other than 75cm as a change in this dimension would lead to a table that is not ergonomic. This is the reason we have standardized the dimensions for the furniture.

How will the industry evolve?

Not very positive. Most of quantity of production is not produced in house. Parts are imported from cheaper countries, like China. It is difficult to predict anything, yet the notion is not positive, we consume more than we produce.

What are future innovations?

No comment

8.6.2 Woodinimac

Describe your role.

We install, program, train, support the machines, the whole package. My name is Manzieri Natalino, owner of woodinimac, I have 25 years of experience as a technician and as a salesperson from some dealerships we have. We also have consumables such as cutting tools. I have followed the technology from the beginning, with DOS software up to the present that we have Windows 10, so I have an opinion on the whole modernization process. The evolution of technology has helped CNC machine users immensely. There are cabinet programs in which our customers can design a wardrobe, a kitchen or a dining room and the design can be done directly and in machine language. The machine language, without having to make any conversion on the machine. All the design is done in the office and the information is passed online to the machine. This is why modern factories do not want skilled staff down at the machines, but a good designer-programmer in the office who will do all the work and be 100% responsible for the result the machine produces. The machine operator will simply load the machine with wood and run programs already prepared by the office. All programs are designed in the office while the production is simply executing them.

As a rule, every company that produces a CNC has its own CAD-CAM software, so in the present day there is a company called ARCHIMAD, which is a company that protects the consumer and the seller in terms of giving the CE, the safeguards to protect the operator of the machine. Based on the protection of the operator, the legislators forced the machine manufacturing companies to develop a page on the machine which will be the simulation page. This page realistically depicts the machine operations that will be done on the part by the machine, so that the machine operator is 100% safe. It is something that has saved many workplace accidents.

When you purchase a cutting tool from us, we provide a .dxf file which contains the exact profile of the tool so you can have the actual tool in the simulation and simulate before running the program with absolute accuracy. This has been provided by technology and security measures.

What are the three main difficulties.

Furniture making as an industry faces one main problem, the workforce. When I talk about a workforce, I am talking about a workforce in terms of finding people educated who are designers who can design a piece of furniture to go on the machine. That is where the problem is, the problem is not finding workers to load the machines, there is no university educated workforce that can do that design. The few designers that do exist have increased the competition and the prices they are asking for are high.

You also see the few designers that exist sitting in a company for a few years and changing companies within 2 years because they are being snapped up by competitors. You see designers who have changed 4 and 5 companies and after 10 years have a salary of more than two thousand euros per month, and that is the real economic value of this job.

There just are not those people, and there is not the accountability from young people to put their heads down to study properly, get technical training in an industry and say I like this

industry, this is what I want to do. Most of the people who have pursued this career are the children of those who own factories, there are no young kids coming in who are not involved in the industry.

Also, the industry has no help from the state in terms of subsidies, it has been static for the last 5 years. In the old days there were more subsidies to build infrastructure and square footage in buildings to accommodate the new machines. Subsidies are mostly given to large companies while smaller ones are sidelined. Example, if you enter a development law with 45% funding for creating facilities. In a 1M investment 50% is in building and 50% is in machinery, while the company must hire two employs educated with at least a TEI level degree. The problem is that these two employs are extremely difficult to find. Funding is dependent on human resources, which are in great lack. This problem returns to the human resources problem we talked about above.

How often do customers ask for a different dimension?

All productions are customized. Every job is different, no two jobs are the same. Very few customers do the same work, for example the bathroom furniture is standardized in a substantial percentage, but there is the percentage that wants the bathroom furniture 52,55 or 57 cm instead of 50 cm. But this modification changes the production cost because it comes out of the standardization. The productions are standardized to make a furniture cheap; they should be standardized so that the shredder can cut 5 sheets together and not one by one for each piece of furniture. This is to bring down the costs. One understands that in Greece we do not have ready-made furniture like IKEA, where the customer will go to get a ready-made piece of furniture with standard dimensions. The manufacturing companies in Greece, they go to do customized manufacturing. Each order is a new order with its own specific dimension chosen by the customer. Θα μπορούσε μια εταιρία να κόβει όλα τα κομοδίνα της πχ στα 55εκ και μετέπειτα να επεξεργάζεται για τις διαστάσεις για τον εκάστοτε πελάτη;

No, you can't do that, because you have to have a stockpile of stuff that will go to B processing. The machining that goes into a piece of melamine furniture is cutting up the individual pieces of furniture, drilling the holes for screws, bellows and hinges and finally welding the frames. If it is a finished product on the shelf, this treatment cannot be repeated.

(NICK NOTE: The process he is describing is talking about a piece of furniture that is prefabricated and ready to go that is waiting to be sold on the shelf. The methodology I am describing is about separating the work. The chopping of the pieces continues to happen first, however then I put a pause on the work. I suggest grouping the dimensions in rounding up, i.e., furniture with dimensions from 50+ to 55 will come out of the 55 pieces. The coarse cut 55 pieces will wait on the shelf until the order comes in, and then they will be accurately cut by the next machines that drill the holes for the screws. I am not talking about a total change in manufacturing methodologies, I'm talking about adding a pause in between processes. The overall physical processes that take place on the piece remain the same in both cases with the addition of an individual cutting in my case, but this will be done on the same machine that drills the holes.

This results firstly in total customer satisfaction, as the customer will buy furniture in the exact dimensions he wants, and then that in my warehouse there will not be ready-made furniture

waiting for sale, which already have a high cost due to the processing they have undergone, but roughly cut pieces that will be used to satisfy the customer.

The changes to the existing methodology are therefore that I do not store finished furniture but the pieces that make it up, at an initial stage of processing. Also, the machining of the pieces remain essentially the same, with the change in the date of their realization, instead of pre-sale they are moved to post-sale. This is likely to have organizational problems, but with the use of modern technology these are likely to be easily solved. END NOTE)

There are lots of software in furniture manufacturing, every single one of them is capable of different things. SolidWorks like software can have integrated CAM software that can be easily automatically converted into machine language.

How do you foresee the industry to develop

I do not know if I can say it will evolve. The evolution right now is about industry 4 and industry 5 that Europe has. It is a subsidy program that is about how you automate your production, how you offload your machines, so with suction cups and automation, in Greece it's going to take a long time for that to come. There are efforts for automation of this type, but they are not at the European stages of Italy and Germany.

I have set up a machine in Ioannina, which is for a warehouse with 4500 panels which has a shredding machine, and it takes the panel and automatically loads it into the shredder to cut the dimensions for each customer. The company is a large lumberyard. At the same time this machine works all night to prepare the orders to be ready in the morning. It is an Intelligent machine, which thinks for itself and needs zero supervision. These are technologies that are now starting to enter the Greek market. Consider that the cost of such a machine is around 250 thousand euros. This cost without subsidy is prohibitive for most industries. Subsidies for this kind of investment are very demanding, they ask for many objectives, which, although difficult and almost unattainable, are correct development objectives, but which are again stuck in the problems of human resources.

Labor is hard to find even in big cities like Athens and Thessaloniki, think what happens in the provinces. So, it's much harder in the provinces, but there are courageous companies, like the one in Ioannina, who are investing in this kind of technology. Technology is advancing a lot, the question is how ready the furniture industry is, which, remember, is an empirical industry, which for so many years has been an illiterate industry. The dads that are there still have not finished school, they are all experts, all from their 10 years in the trade. Now the kids are coming in and starting to evolve the industry, going to school, getting into software, learning the English language.

What innovations are you seeing?

A major innovation is the barcode, which is an ID tag on each part that identifies and follows the part and identifies it for each drilling and assembly operation.

It is a methodology starting with the barcode tag, which using ERP software can control the life of each piece and confirm the correct processes that have been done on it.

8.6.3 Isac Advanced Robotics

My name is Christos Isaakidis, general manager at Isac. I participate in all areas of the business. From finance, accounting, marketing, to the production and development part of the business. Our company manufactures CNC robotic machines which are aimed at furniture makers, graphic designers, and machine shops. The company employs seventeen people.

Value proposition

We help our customers to increase their productivity and make their tasks much easier.

What are the 3 difficulties?

Definitely it is the staff, with all that entails, in terms of finding and training them. The expansion of the customer base and the development of our products.

Our own staffing needs are different from those of furniture makers. Cabinet makers need machine handlers and assemblers, and in general they need wood craftsmen. We need technicians who can build a machine. Although our needs are different, in general the labor market in Greece is something that has been hurting a lot in recent years.

Three difficulties to come.

Staff will continue to be an issue. I think it always will be, or at least on the horizon where we are now. Then there is the growth part, how fast we can grow, which has to do with liquidity, with the product itself, with outreach activities. We certainly have difficulty with foreign competition.

Three success factors

On the machinery side, we have the advantage that the machines are our own, so we are not talking about a standard product that is a give and take and is standard, we can customize it to the measures and needs of each customer, which is very important. A second one is the delivery time, where most machines are usually ready for delivery or ready within a month, whereas in the competition due to importation it is in the quarter. Another strong point is our specialization and our technical support because most companies deal with different machines, they may have 10 or more different types, we deal specifically with CNC nesting machines and from there we have various other custom-made machines. In terms of KPIs we would say that the machines are our own, so we can modify them as per the needs, secondly that they are readily available by 90% and the third and most important is the technical support part, where we are fully qualified.

3 factors of failure

For any business, so for us, if we skip the R&D part of our products and if we don't follow what the competition is doing, especially abroad (where, truth be told, they are ahead of us), we have to see how to adapt these technologies and these styles to our own machines and our own daily life. This is especially important to do so that we don't stand still, that's why we have a specific department working on this.

Then a particularly important one is marketing and brand awareness, from participation in exhibitions and advertisements, where if we stopped that, practically the operation of the business would stop. We also have the exogenous factors which have to do with the economy in general.

How important is R&D to your business?

It is very important, I wouldn't say it's totally necessary, because I see that sometimes, you can get to a point where the product stays the same and unchanged during the applications, just in the end there will be a saturation in the market. What we are looking at is that there are continuous improvements both in the practical part, having more functions in our machines, and in the part where we are going to adapt modern technologies to give feedback on the overall life cycle of the product.

So we have an R&D department, and it's very important, I just wouldn't say it's the most necessary part for us. The research and development department and the new product development department employs two people.

How do you measure success

The most measurable indicators in any business are the financial ones. They could not be more different, namely turnover and profitability. We have about 15 statistics which we check systematically. They have to do with the internal processes of the company. But the main factor for a company is the financial part.

How familiar you are with parametric planning.

Our role is to show our clients how to plan parametrically and provide them with programs to plan with this methodology so that they get the result they want in the measures they want. We have our own software, which is aimed at woodworkers, and then we work with all the software providers from Europe to China.

The demand and feasibility of mass adaptation.

I see that there is this need, I know that even if someone makes a nice buffet and wants to make ten more. Those ten more will not be the same, the customers are not IKEA customers who are going to pick something off the shelf, they need items that are made for them, so you understand that you need customization. That is where the parametric part is needed. Otherwise, there are some people who are willing to redesign it from scratch.

Generally, there is a need. I personally cannot define it, but there is.

On a scale of 1 to 5 with 5 being the big one, I would put it at 3.5 importance. In the kitchen and wardrobe part for example, customization is standard, it is a given. There is no way someone can build a kitchen and happen to rebuild the same one, the chances are zero. When we go to tables things are more standard, the table can be 10cm shorter and not spoil the world.

Most frequently requested modification options

The color of the materials almost always differs; however they do not affect customization. For example, in a melamine kitchen, the color of the melamine has no real difference in the surroundings of the construction.

The raw material can also vary, it can be MDF painted with lacquer, plywood with veneer, natural wood, Corian or HPL.

The most basic and number 1 is the dimensional piece. Width length height to start with and then the number of individual components, how many shelves, how many drawers and what type it is. Still in this category we also have the thickness of the materials. Whether the frame will be made of 16mm thick melamine or 25mm thick melamine.

Would there be a benefit to incorporating customization options?

Of course, Usually these changes are made by the factory to the customer's order. The customer is exceedingly difficult to do such work. The manufacturing information is so large as far as the internal clearances of the mechanisms, materials and general construction is concerned, and it takes a technician to do this work.

If all this adaptation were easy would there be a competitive advantage?

It is too niche; I do not think it would make it easier for anyone or give a competitive advantage to do this kind of action. This is for two reasons. Usually, the customer does not have the perception to understand exactly what it is that they need. The second is that they cannot visualize it very well. Many people have no perception of the size and usability of the furniture, and in conjunction with the same materials they are not familiar with I think it will be quite a difficult action.

I put it another way, If the entire process is easy, I do not know how much of an advantage it would give a company and how much customers would be interested. But it would be a breakthrough that I do not understand at this point.

What challenges do you foresee?

The end consumer does not know the final dimension they are looking for and does not understand the issues of ergonomics, nor do they understand the differences in manufacturing materials.

From a production standpoint, if each product is custom, it has a higher cost which of course is not prohibitive. Usually, the customer wants to buy something custom made. From a production standpoint it is done in the marketplace right now.

How easy is it to make the transition from the parametric CAD model to CAM

It is practically very easy, you don't do anything differently. In many programs CAD and CAM are married perfectly. If you make a change in CAD, it is automatically made in CAM.

How will the furniture industry evolve in the coming years?

I think it will be oriented towards Mass Production; most companies will switch to the hotel and construction part.

Because of the automation that will be needed, for a company to have all the necessary tools they will need to have the corresponding factory. This equipment cannot be played on a small scale. Small companies will close while larger companies will merge to become even larger with automation. Rapid need for growth in size by companies is extremely necessary.

All indications like taxing, funding and automation seem to be favoring bigger companies. Human hand labor is hard to find and will not be needed. The old uneducated craftsman will die and be changed with an educated designer.

Q17: What 3 future developments or innovations that could enhance manufacturing and sales efficiency do you anticipate?

Shift in mass production, with lack of customizability. more cooperation between companies

8.6.4 Kourmoulis ABEE

I am explaining my overall idea. Mr. Kurmoulis replies:

Until the customer reaches the point of choosing the final dimensions of the furniture, he will have to choose between the style of the design, its coloring and then the way of its construction. Once all of the above has happened, then and only then will he come up with the final dimensions. So when you go to do customization, it should be done in its overall construction.

*(Note: Mr. Kourmoulis, refers to the overall construction as the factory part of his operation is the construction of a kitchen and a wardrobe for the furniture makers. What Kourmoulis SA is trying to accomplish is to pull the production of melamine furniture from each independent and small cabinet maker. Their aim is to use the advanced technological means at their disposal to produce furniture on behalf of the furniture makers in the area. Thus, it is envisioned that the small furniture maker will be involved in consulting with the end customer, measuring the fitting area and finally fitting and delivering the project. Therefore, the production of the furniture produced by Kourmoulis ABEE must operate in the logic of MASS PRODUCTION, but also in the logic of MASS CUSTOMIZATION, as each cabinetmaker chooses to manufacture his furniture in a different way and with different connectivity. I mention indicatively some assembly places such as the simple 3.5*50 mm screw, the combination of this screw with capillaries, the use of minifix system and the use of cabineo system. Mr. Kourmoulis based on his business plan and his mode of operation, not only can he offer custom-made constructions, but he can also choose the specific way of construction. End note)*

On the basis of the course of the debate, I refer to the staffing problem facing the furniture industry.

There is no programmer-operator. The programmer (designer) is not hard to find, there can be telecommuting. I can send a developer from another place my specifications and he can do the design for me. The cutters that the machine will work on who will put them on?

this is supposed to be an easy (standard) procedure

It is an easy process for young people, for me now it is a difficult process. I have learned some things on the machine. Today, for example, the operator is missing and I have been trying to set up the machine since morning. We started cutting a job today and the tool was not cutting

as it should, so I had to change the cutter. I put in the data of the tool as given by the supplier and it was not correct, it was 1.3mm longer. So it took extra modification process on my part, as I had to modify the tool data and do the testing all over again.

The employee we have in this position has this process figured out, it's a standard procedure for him. He has found his own methodologies for how the machine works and has optimized the processes to be productive. I have stayed on the "mommy" program, I go in to make these modifications the way my machine master showed us.

(note: Mr. Kourmoulis is the owner of the business and is responsible for all its operations. It is not his responsibility to know how to handle CNC nesting in every detail of it. The employee who is responsible for the operation of the machine on the day of the interview was absent from the building for reasons not disclosed. My understanding is that there is no clear instruction, either from management or the machine manufacturer, on the correct methodology for changing cutting tools. So in this particular case, whether due to illness or for whatever reason, the company's production has stopped, and to continue requires actions outside of normal machine maintenance. This is a very useful data for this thesis, as it demonstrates the need for a specific protocol for the daily maintenance of the machines. As will be admitted later in the interview, although the company has very modern technology it is locked in by its own staff, as due to the highly skilled position of the machine programmer-operator it is difficult to replace his knowledge in a short period of time. End note)

Introduction

My name is Kourmoulis Dimitris, Kourmoulis ABEE is the name of the company, we deal with kitchen and wardrobe construction and special constructions. Now we are going to change the course of the business and offer our services in a package. In wholesale. The business employs about 8 people. We are trying to achieve not having any fitting of the structures, just having the construction.

Our difference is that we follow the client's specifications. For each new business client, we create a file with their specifications, which we use for each subsequent order. Example some client wants their kitchens to be 90cm high, another 87cm high. So we have created folders for each one which contain all the construction mentality of each one. So each of our work can be personalised for each individual client, at no extra cost.

Can you work with an architectural firm?

Ethically it's not right, since my client is the carpenter-maker, it's not right for me to go straight to the office, the source of the slavery, because I'm taking his job. Even if the office comes to me, I will send it to a partner, whom I trust for its result and our good cooperation. When my ideal client is the carpenter, it is unreasonable for me to chase business from his architect client. The work comes in both cases here, with the difference of the intermediate carpenter, who is responsible for the client's fix, measurement, specifications. I in turn will produce the construction plan, do the furniture, pack it so that the carpenter can receive it and do the final installation. So the carpenter is the processor. In my view, in construction work from now on, someone else will make, someone else will measure, someone else will agree the plan and someone else will cut.

What I'm hearing from the discussions I'm having in the diplomatic context is that it's changing the manufacturing system and going to a more mass production. From what I understand you guys are doing mass production, however customized for each customer.

Whether he orders me a house or a hotel with 70 rooms, it's exactly the same for me. The production is depending on what each client asks for. We have a potential A, which we have not exhausted so far. Right now we will cut 70 rooms of a hotel of one client, at the same time carpenter clients with extra work are coming in. These in turn go into the production line and move on.

What production capacity do you have?

Our machines can cut up to 35 sheets of melamine with full processing per day. By full processing we mean all the drilling for hinges, salers, shelves, cabineo, in general all the processes that a kitchen box needs. Assembly is done on site at the place of installation. Or construction design is done to a high degree. We know down to the last screw, leaving here goes immediately to the project, no further processing is needed.

(note: as an indication from my experience how the average 12ft kitchen needs 5 sheets of melamine. So this factory has a production capacity of about 7 standard kitchens or about 85 running meters of kitchen. The above figure is for the net pieces without the banding around the perimeter, edge banding, a process which can be done in parallel with the CNC nesting cutting of the individual pieces. Roughly to complete the process it will take 3 people and 8 hours of net work from each person. We conclude that the productivity of the factory is 30 current kitchen meters per employee. Again, from my experience, in a typical kitchen construction in the traditional way, it takes a skilled worker-finisher about 1.5 days of work to complete the construction in the factory, so the productivity of a traditional cabinetmaker is 9 running meters per day.

Another factor in the comparison of the traditional cabinetmaker with the CNC nesting technique is the fact that the cost of robotic machines is quite high, but even a simple cabinetmaker's shop has increased costs of machinery.

Still, the last factor in performance is the fact that CNC nesting manufacturing produces the finished pieces of furniture, which will eventually be assembled at the building site, meaning that their volume during transportation is the smallest possible, whereas in traditional manufacturing, cabinets are shipped ready to be assembled, a process that facilitates the speed of assembly, however it hinders the cost, ease and efficiency of transportation to the final destination. End note)

What do you have to say about the competition in Crete and Greece in general?

There is no concept of competition in Greece. There are few people who will put the real costs down, from energy, labour, consumables, wear and tear of machinery, calculation of depreciation of machinery. This machine costs 200 thousand euros and will produce correctly for 10 years, so you have to calculate a daily amount that the machine has to make. This has to go into the costing.

One last thing is that the Greek has to calculate the tax in his cost invoice. Everyone is operating with black money under the table. You can't operate like that anymore, it's very

difficult. All the money is visible through the bank, so the competition has to calculate the tax. They still have to calculate the moral cost of the employee, the employee has to get his gifts, the necessary salaries that is. Also no employee works based on what the government says, they all work at 40% over, which is a big cost of doing business.

What are the 3 difficulties in the last 3 years?

Staff, staff, staff, staff. Nothing else, everything else can be overcome. The degree of difficulty of the jobs has gone up. The clients have been over-searched. Most important of all is that there is no staff, and since there is no staff everything has gotten out of hand. This also applies to the professionals, where there are no longer enough of us, because we have gone from a time when we were out of business looking after each other, and we have come to a time when we don't know where to start. We have come to the other extreme, which means that everybody is asking for more, for so many years we were a spring that was closing and that spring has now been released, and that spring has been ejected, carrying everything with it, from energy, fuel, whatever. Even an employee who comes in has to be paid extra. All of this is going up in a not healthy way, very steeply, and I can tell you that in many cases there is obscenity, which if you put it down is not obscenity. If you put it down and figure everything in, as is done in other countries, to pay the tax, all the expenses, to have a profit left over, and to have five drachmas in the company piggy bank, so that when it comes time to change the equipment you have money and you don't have to borrow again and pay debts for another 15 years.

What 3 difficulties are coming?

If something does not change, I feel that we will go to the other extreme, at some point people will come from third countries, everyone will be dubbed a craftsman and will come to positions of responsibility. That will bring prices down and not in a healthy way. Competition for jobs will go up.

What are the success factors?

Success comes after a lot of hard work, a lot of bumps, and a lot of backstabbing. No matter what step you reach, the bump will be there, the stabbing will be there, it's just a matter of how you perceive it and get over it. The faster you get over it the more successful you become.

Factors of failure

A good one can stay on the sidelines because he understands the value of his work, knows how to cost properly, and tries to get paid for his work. Because there are many businessmen across the street who, for their own reasons, lower their prices to get the slavery and jeer thinking they will get their expenses paid. Expenses are standard, if you don't work above your expenses you will get in. Few people realize this. When an entrepreneur doesn't put down all his costs, whether he has one person on staff or 300, look at the production potential you have and say I'm selling there. That is to find the range in which you can operate. I think over 80% of professionals have not done that kind of thinking. So mispricing is a major factor in failure. Proper organization in finance is a very important factor.

Method of costing.

There may come a time before you when you realize that work is not coming. That's where the zero point is. From there you start with zero profit and I'll get to making a 30% profit rate

during periods of increased workload. So in the dead periods I start at, for example, 1000 to maintain my shop and keep the staff from leaving, so that in the full season I charge 1300. In this full season, the company has to make a profit, depreciate the machinery, the crooked expenses so that from these 1300 in the 4-5 months of work, there is a 10% profit left in the company.

How familiar your company is with CNC and parametric design,

We have had robotic machines for the last 10 years. 3 years ago we went for modernization of our machines. The parametric part is needed everywhere. To create an object, stretch it with a simple movement and change its dimensions and all the machining it needs, it's a big advantage instead of designing it piece-by-piece, side-by-side-base-frame-frame. When you have a box and you instruct it to go from 72cm to 90cm and from 30cm to 50cm wide and it becomes automatic, you save a lot of time.

You currently have a B2B model, could this methodology be done in a B2C logic?

I could have done a sole proprietorship with this methodology. Everywhere you need this parametric logic. It's good in that we don't have people and we don't have time to devote to all things. If I have a tool that saves me time on a job, to be able to do it myself is a huge advantage.

Why isn't there a similar mentality in retail?

They haven't experienced it yet.

Would there be a competitive advantage if someone entered today's market with such a parametric methodology?

Mass has come out for one reason and one reason only, to be cheaper. It's one thing to make a 2 meter buffet, it's another to tell me I have a warehouse with 30 2 meter buffets. If the customer wants it at 195cm, that buffet that I'm going to rebuild from scratch for one piece has at least 30-35% higher cost.

This is the case when the buffets are shelf ready products. What happens in cases where each buffet is made to order?

(note: I am referring to the interview with Papadatos, where it was mentioned to me that it is not possible to stock from ready-made products as the colour and material choices vary in 50 different combinations. End note.)

These companies are bespoke. That is this company is set up differently, it works on a bespoke basis. It is positioned differently in the market, anyone who wants something special, or something specific for themselves, has searched the market and hasn't found it in off-the-shelf furniture, will end up with this one knowing they will pay 30-35% more. A 2m buffet and an identical 195cm buffet do not have the same cost.

If theoretically combining your own manufacturing methodology with the example manufacturer's product standardization, would the cost of the buffet be similar in both dimensions?

When a line is automated, let's say a kitchen. With the software I work with, with the machines I have, I have no problem producing a kitchen in whatever dimensions you want. Whatever you

tell me, the time I need is to design it and then it is cut without any problems. It is no longer cut by a worker, metre by metre, piece by piece. It's put into the machine in code, and the machine executes the necessary commands, you don't sit down to break down each job, break it down into pieces and then those pieces are cut and processed individually and then assembled for delivery. Now the drawing has all the parameters it needs, all the operations and machining each piece needs, and automatically with one button it goes to the machine with all the changes you requested.

This is what puzzles me, since it's so easy and easy to use this process of customization, why doesn't it happen on a wider range? Why are there companies that work with the piece-by-piece logic you mention? Why is it that I can take out a buffet, not work parametrically, get the manufacturing dimensions essentially by hand, work them out by hand (even if I use CNC for the machining remains manual programming), and end up with a static design without the ability to change anything.

That's the old school. The new generation will come into this part. The Europeans are already into this logic, it's been that way for years.

(note: this view contradicts Papadatos' view, where he claims that no one in Europe is working with this methodology. End note)

Why can't the logic of the kitchen you use be married with the logic of the furniture, table or buffet. That is, the kitchen in the way that is made by you with a solid table.

No relation. And the machines are different. To make a kitchen you work with a ready-made and standardized product, panels, which is essentially cutting and gluing. To work on solid furniture you can't work on it with a machine, nor is it a standardized process. At its simplest, if you want a round piece you have to work the ribbon into it and then do it by hand because of its particular geometry. These will disappear from the market now because there is no expertise for it. There will be the machine which will be operated by someone who knows about computers but not the art of cabinet making, who knows how to design standardized and execute robotically.

(note: Although standard panel lumber, with raw solid lumber have several differences, it is a fact that it is possible to work solid lumber on modern machines. Of course, it takes extra expertise which involves not only the initial design and operation of the robotic machines but also the wood technology. An example of the manufacture of solid wood products using CNC machines is the chair making industry. In the next discussion-interview I will talk to a chair manufacturer in Bulgaria, who can clarify some things. End note)

The operator on the production line doesn't need to know about slavery, as long as he can read the information from the labels on each piece that have come out of our software. When the software analyses the slave, it also prints a label for each piece. This label contains all the information of the piece. The operator does not know what this piece is, where it goes, or what will be done with this piece. All the organization of the work has been done in the office. In production all they see are melamine cut-outs. The operator's responsibility is that each piece is correctly cut and correctly glued, based on the information on the label

General information about the staff

The only thing that is certain is that Greece is now in a transitional stage, in which technology is starting to enter very dynamically into all jobs. Greece is becoming more robotic. We entrepreneurs at the moment have taken a step and started to take machines without people to work on them. We took machines because there are no hands. In the old days, this shop had 35 people working in it, I could have taken the CNC by then, but I was saying why take the CNC and have my shop hanging on one, the operator, who can at any moment stop working and as a result the whole shop will be put on the brakes. The job I was going to do with the CNC I did with 20 people, but because there was an abundance of hands there was no reason for the investment. There's no reason to put 200k into an investment and hang on to one. The serious thing is that you're hanging on to one. He may be a kid or he may be a big guy, when he realizes you're hanging on to him he's going to take advantage of you.

There is no way to protect the company from this phenomenon unless a law is passed. The employment contract right now only protects the employee, and not the employer at all. My production depends on a single man, whose work is currently in demand, he can leave at any time and go to work elsewhere.

Could you hand over the design to a third party company, which would design for you while you would manufacture for a third party?

This company will have the same problem as I do. As a company, you can find the CNC carpenter customers. But on the inside, this company is still dependent on human hands. The working designer will go to this company because he feels secure, he wants to get the 1000 euros steadily for life. The same designer can also come to the respective carpenter's workshop, understand that he has potential and work there for better money. As far as personnel is concerned, at the moment nationwide it is a problem.

(note: the company is essentially a partnership. Several mills regardless of geographic location can work together. The design firm will have several designers who will produce the designs, while Mr. Kourmoulis may only have one, so immediately the power of the designer in this firm is much less, so the argument is essentially moot. This company I am proposing will work with several factories that work with Mr. Kourmoulis' logic. The physical presence of the designer on site is deemed unnecessary, as the whole design process, as well as the connection to the machines, is done via the internet. End note)

(note: Another problem that Mr. Kourmoulis identifies in this company, apart from the recorded interview, is that the designer in his shop needs to be the operator of the machine. The following statement by Mr. Kourmoulis was made outside of the recorded conversation, after the interview, when he suggested that I move to Rethymno so that we could work together, however I stated that moving is out of the question at this time, and I left open the possibility of mixed work, working remotely, while visiting the factory in cases where further coordination is needed. The above suggestion was rejected, as Mr. Koumoulis needs his designer to operate the Nesting CNC machine as well.

His factory currently needs the designer's person to be the operator's person as well. That is, to be the person who, in addition to designing the project and scheduling it, will also do the routine maintenance and changing of the cutting tools as well as operate the CNC machine.

This we know from the interview with Mr. Magieri that this is not a correct tactic. The person of the designer and the person of the machine operator are two different people, who even have different backgrounds.

What is understandable based on the interviews and my personal experience is that the concepts and jobs in these industrial environments that have integrated these modern technologies and methodologies are still very unclear. My experience in factories that have integrated this way of working, such as that of Afoi Tzoumani, also confirms the power that the individual designer has over the factory, as he or she is often the only person, in collaboration with the machine operator, who can understand and operate the production line. This phenomenon is particularly noticeable in very small companies with up to 10 employees who have invested in these methodologies.

The designer-programmer and the machine operator are the only two people who have the appropriate expertise, and are isolated from their peers in other companies as there is a fear of brain drain between companies, developing a common methodology for machine operation is difficult (I am essentially talking about creating and supervising iso specifications). Personal initiative seems to be the only factor in improving work efficiency, while the assistance given to the designer is incomplete and limited to simple demonstration of the software.

This conclusion comes from a combination of Mr Kourmoulis' comments on the quality of learning the machines (CNC Nesting and Cabinet Vision) from his salesman, my personal experience with learning the same software (CNC Nesting, 6 axis CNC, CNC multidrill and Cabinet Vision) from the same salesman during my short period of employment at Eleftheriou SA. (a woodworking company that invested in state-of-the-art machinery in Thessaloniki that nevertheless faced strong resistance to change issues from its staff) and from my conversations with the operator of Bros. Tzoumanis, who confided that despite investing in machinery and software (5axis CNC and Spagio3D), his designer has failed to automate simple processes causing an extreme lack of efficiency. End note)

(note: Based on the above, it might be interesting to consider the business model of a company consisting of designers-programmers of these machines. The purpose of the company would be to take on the overall risk involved in an investment of this nature as far as finding and retaining the coveted designer from the carpenter shop in question. As this company would work with numerous cabinet makers and employ trained and skilled people in a collaborative framework, it would gain the knowledge and experience so that apart from taking the risk, it would be able to suggest methodologies to further increase the organization and efficiency of the country's factories and beyond).

What problems has my methodology for Custom parametric furniture

It would have problems in its production and in its space. When I'm a company that knows the breakdown of its workload by year, it will know that in its free time about 6 months it works 100%, 3 months it works 50%, and the other 3 it works marginally at 0. Those 3 months she needs to keep her staff busy and help future demand, so knowing that I have standard products I will ask my staff to cut 100 tables. So that way I know the staff will do a certain thing that will eventually be sold. But when you hit me with your methodology in the 6 months I have full time

work and ask me to break my production line to change the dimensions the cost of that is clearly superior to the simple unstocking done in the conventional case. The 3 month dead time I mentioned above is the standardization now. In the dead time you'll be putting out stuff you know you'll sell, that when it's time to sell you have ready and can get busy producing other projects or even your own so you can essentially double your production capacity.

How the furniture making industry will evolve.

Everything will become industrial, this bespoke, I want a glossy table with satin lacquer, or I want an oak table with 30% gloss will go out of the way. We're going to have fake products, industrialized. That is melamine, which will be very much evolved and will have real colors and textures, with more expensive costs of course. The work is going that way. Anyone who stays in the special piece will be in demand.

8.6.5 Hummel

Describe your role and how it relates to the furniture industry.

I am an engineering technologist, (mechanical engineer), and have been working since 01/05/1985 at hummel kitchen furniture. My role is complex. I serve customers by demonstrating the products of the company, I design, decorate and cost the furniture and electrical appliances compositions for the interiors, (kitchen, bedrooms, bathrooms,...), of the building. I analyse and send the orders to the production plants. I carry out the financial transactions of the company, (payment of staff, suppliers, etc.).

What is the value proposition of your company?

Quality and reliability,..

What are the 3 main difficulties of the external environment that your company has faced in the last 3 years? (3 short answers).

Rising costs, product shortages and unfair competition.

What do you think are the 3 main difficulties your business will face in the next 3 years? (3 short answers).

Falling construction activity, rising costs and unfair competition..

What are the 3 key success factors in your field?

Responsibility, product quality, reasonable cost to the consumer.

What are the 3 factors of failure in your sector?

o (3 short answers)

Poor product quality, poor positioning, poor management.

How do you measure success in your business?

We operate on business instinct.

How important is R&D (research and development) in your business?

5

How familiar is your business with technologies such as CNC automation and parametric design in furniture production?

5 for parametric design. In the sense that all parameters play a primary role in the design and operation of our premises.

How familiar are you with the term Mass Customization?

It doesn't apply to us as a business because our customers have specific, personalized requirements.

How often do customers request specific specifications?

3

What are the 3 most frequently requested customization options in your business?

I DO NOT UNDERSTAND THE QUESTION

Is there a benefit to incorporating effective customization options for your products?

IS THIS RELATED TO THE PREVIOUS QUESTION.

What challenges do you foresee in offering customization options to your customers, either from a production, purchasing, or technical perspective?

Our product manufacturing plants have flexible production and give us the possibility of personalization. This is very important because it is a real challenge and at the same time a demand of our consumers for special compositions and functions.

If product customization is possible and easy, will your company gain a competitive advantage over the competition?

5

How do you foresee the furniture industry evolving in 5 to 10 years?

Total automation and development of environmentally friendly techniques and products.

What 3 future developments or innovations do you foresee that could improve production and sales efficiency?

Development of underdeveloped areas of the world into a peaceful world without wars and shortages of basics such as food, education and health.

Reduction of production costs.

Using environmentally friendly techniques at affordable costs.

8.6.6 ANESIS

Describe your role and how it relates to furniture making.

I am responsible for the production in the company, with everything that this implies, i.e. from the purchase of the necessary mechanical equipment (depending on the strategy of the company), from the production formula for each product (which machines etc. are used for manufacturing), as well as dealing with costing. Also because of this capacity (production manager) I am also the person responsible for design issues, i.e. I am the spokesperson for the company's needs for products and so I am the one who briefs our designers.You mean that the brief is done after we have listened to our customers and our sales people, what their needs are and what are the attitudes that should influence us.

What is your company's value proposition?

Handcrafted, timeless furniture with unique design

What are the 3 main difficulties of the external environment that your business has faced in the last 3 years? (3 short answers)

Covid - Lack of human resources - Unstable economic environment

What do you think are the 3 main difficulties your business will face in the next 3 years?

Lack of human resources - Unstable economic environment in a global economy that is rapidly interacting through, from SMEs & social - Shrinking incomes for small and middle classes

What are the 3 key success factors in your field?

The stability of our values, our ambition, our professionalism.

What are 3 factors of failure in your field?

arrogance, lack of strategy and loyalty to the plan, external factors (competition, state)

How do you measure success in your business?

With numbers, with smiles inside and outside the company from our people, with growth rates

How do you know that your production and sales are where you want them to be?

Once a company is working properly and tracking the right numbers, it's very easy

How important is R&D in your business?

2 - Studies.One of the most important stages in a business, whether commercial or productive

How familiar is your company with technologies such as CNC automation and parametric design in furniture production?

3- Enough. Of course we are talking about the Greek market which is a small market with a particularly demanding market. community, so it does not help for mass production of quality products, as our company is set up.

How familiar are you with the term Mass Customization?

3- Strategically in recent years, our company has invested a lot of time and money in order to turn its production completely away from custom, trying through branding and design activities to build an identity of unique design.Of course, we still do customazation in wood colors and wallpaper.

How often do customers request specific specifications?

3 - Previously very often, now less often.I explained the reasons in my previous answers.

What are the 3 most frequently requested adaptation options in your business?

4 - Paint wood colours, fabrics on chairs, change of dimension of our standard product

Is there a benefit to incorporating effective customisation options for your products?

The question is not clear to me.

What challenges do you foresee in offering customisation options to your customers, either from a production, market or technical perspective?

Lack of human resources. Inability to pay the cost of custom needs.

If product customisation is possible and easy, will your company gain a competitive advantage over the competition?

If it's easy, then everyone will have it, so there's no competitive advantage because everyone will get it.

How do you foresee the furniture industry evolving in 5 to 10 years?

Due to lack of human resources (willingness to learn the arts) production will increasingly go to more mass -standardized productions.Customization will be at prohibitive prices that few can afford.

What 3 future developments or innovations do you foresee that could improve production and sales efficiency?

Technology & AI in robotic production, 3D printing with more physical materials, More synergies between companies