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Relationship Between Materials, Design and Comfort Used in Office Furniture for Improved Ergonomic Performance

Burcin Saltik
Arkin University of Creative Arts and Design, Kyrenia, N. Cyprus, TRNC
burcin.saltik@arucad.edu.tr
https://orcid.org/0000-0002-2585-1114

Abstract
While furniture is an important item in every aspect of our lives, office furniture has become one of the prominent product groups with the change in working culture over the years. Comfort and ergonomic design became one of the targets of furniture designers and producers. Connection systems (although used in different ways), which are among the most important issues in office furniture, add a different value to the office furniture they are used in and stand out as an important factor in the marketing of the product. The fact that connection systems have such importance in office furniture has been an issue taken into consideration in the context of gaining a competitive advantage for manufacturing companies. With this study; The effect of connection systems on office furniture design and the functionality/ergonomics of the final product using connection systems within the scope of usability and comfort performance. These mentioned points were investigated through a survey conducted on a total of 73 companies in terms of scale, large, medium, small, and micro. Research results have revealed that the connection systems used in office furniture are of great importance in every aspect, and the ergonomic design criteria in this part of furniture are concerned only with large and micro-scale companies. The micro-scale companies are undermining this factor in their product. It is thought that this study will contribute to the institutionalization of manufacturing companies, increasing their comfort, and ergonomics, increasing the number of enhanced connection systems used, and improving product quality and sustainability.
Key words: Office Furniture, Comfort, Furniture Accessories, Ergonomic Design.

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1. Introduction

Furniture is designed and produced to meet people's general needs and ensure safety and comfort; It is a typical example of global products that fulfill basic functions such as eating, seating, storage, display, and so on and adapt to the requirements of international trade with high design input (Durmus, 2005). Today, the furniture industry, which has managed to get ahead among all other industrial branches with a growth rate of 20% (Rame, et al., 2023), continues its development on an international scale. The furniture industry, which has significantly accelerated Turkey's share in the world trade volume, seeks its future in a competition policy based on design and branding, not on cheap prices (Yeniceri, 2007).

Turkish office furniture industry; It started to industrialize in the early 1960s and started to develop in the 1980s (Kocaoglu and Keskin, 2009). The development of trade, the establishment of new private companies, the rise of the banking sector, and the construction of luxury business centers have helped the

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sector to grow (Sagdıc, 2008). The most serious development in the sector occurred in 1998-1999, and the office furniture sector grew by 300-400% in these years (Economic Internation, 2024). Considering that the market size of the Turkish furniture industry exceeds 6 billion dollars, the office furniture market has approximately 30% of this figure with a business volume of 1.5 billion dollars (Beaudouin-Lafon, 2000). Nowadays, the office furniture industry is growing with the return to working in the office after COVID-19 and the development of open office logic, and the number of office furniture manufacturers is increasing day by day. The ergonomic design and comfortable furniture became one of the priorities for the users because of the long time stay and usage of work or new lifestyle which lets the people inside more than outside (Belay, 2022). For this reason, the office furniture sector, which constitutes approximately 25% of the furniture industry, has increased the importance of the connection systems used in its production with this increase (Eker, 2002). Due to the increase in the production of office furniture, the connection systems used are also changing and increasing in number every year (Serin, et al., 2014). There is a rapid innovation process, and companies that produce connection systems complete their new product designs ahead of the market and present them to furniture manufacturers. (Vavik and Keitsch, 2010). Every innovation used in this context is reflected in the customer in terms of design and quality, leading to customer satisfaction, an increase in furniture preference, and market growth (Demirhan, 2019). Office furniture product groups are areas where fasteners and/or connection systems are used extensively, and it is generally more accurate to talk about a connection system rather than fasteners in office furniture. (Valipoor and Ujang, 2011). In addition, previous studies (Damlayici, 2020) on the use of furniture and accessories have similar findings.

In this study, the currently used accessory systems are mentioned and the usage preferences of the manufacturers are investigated. The study raises the following questions; 1) What is the role of connection systems in the ergonomic design of furniture? 2) Which companies are considering ergonomic design in connection systems of the furniture? 3) To what extent the furniture companies believe in using sustainability in their products? The purpose of this study is to reveal the connection systems and/or fasteners used by companies producing office furniture according to their sizes and to determine what kind of preference they make according to what conditions. This study aims to reach the maximum comfort of office furniture design for the users; the objective of the study is to investigate the effect of the connection systems used by manufacturers on the ergonomic design of office furniture. The study is limited to Turkish companies and focuses on office furniture connection systems.

2. Materials

2.1 Ergonomic design for furniture

Ergonomic furniture design emphasizes making furniture that enhances the functionality and the comfort of the users, in addition to efficiency, and health by reducing deformation and promoting posture during long-term usage (Pheasant, and Haslegrave, 2018). An effective ergonomic design considers the physical dimensions and typical movements of human beings. It is considered the optimum height of the seats, backrest support, and adjustability to prevent musculoskeletal factors (DeLooze, et al., 2003). According to research and studies, successful ergonomic design in furniture can promote productivity in working places and decrease the risks of a sedentary work environment (Robertson et al., 2009). See Figure 1.

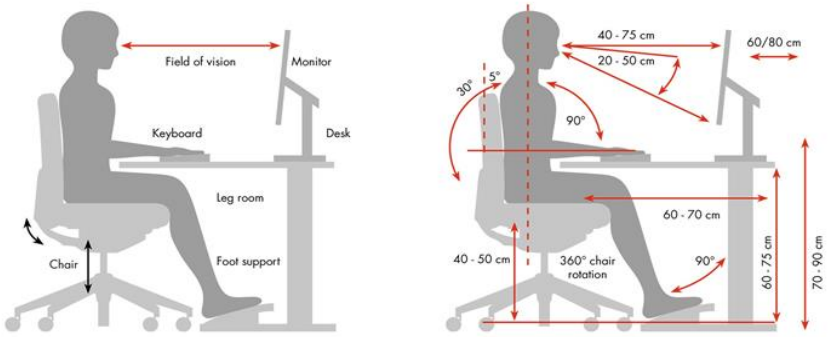


Figure 1. Furniture ergonomic design (OMSIAD, 2018).

2.2 Furniture connection systems

When the connection systems used in office furniture are examined all over the world, they can be grouped under 3 main headings according to the type of product and material (Saltik, 2013). These groups are also the main points for comfort and ergonomic factors in office furniture systems.

a) Drawer connection system

b) Door connection system
c) Table (panel) connection system
These systems are adapted to products shaped according to the relationship between consumer and manufacturer. Since the table (panel) connection systems are almost the same in all furniture types, the main difference in this study is the use of drawer and door connection systems.

2.2.1 Drawer connection systems
Drawer connection systems used in office furniture are evaluated under the following headings depending on the pedestal design.

2.2.1.1 Metal drawer case system
Generally, there are two systems. The two systems are the same in terms of content but differ only in terms of size, visual ergonomics, and usage functionality.

In the first system; the drawers are single-sided and only available in black color.
In the second system; The drawers are also available in double-sided and aluminum color options.
The manufacturer produces only the body and panels as wooden parts. All remaining accessories are provided as a system (Figure 2). In terms of size, this system is based on metal drawers. Apart from special manufacturing all over the world, dimensioning is done according to DIN norms.

Figure 2. Metal drawer case system (Hettich, 2022).

2.2.1.2 Wood veneered drawer case
Compared to wooden drawer cases, pedestals are generally used in office furniture. In other words, the entire set used consists of wooden veneer (Figure 3).

Figure 3. Wood veneered drawer case system (Hettich, 2022).

2.2.1.3 Laminated drawer case

Fiberboard lam (MDF lam) or chipboard lam pedestals are mainly used in standard sets in office furniture, depending on the drawer case. The entire set consists of solid material. The rails used in this type of pedestal are plastic (white) wheeled rails in decreasing amounts and telescopic rails in increasing amounts. Inside the telescopic rail; Standard model, self-pulling model, braked, and pressurized models are available. These features are integrated into the rail (Figure 4).

Figure 4. Laminated drawer case (Hettich, 2022).

2.2.1.4 Plastic drawer case

The drawer used in the plastic drawer system is made of plastic. Carrying capacity and lifespan are less than the metal version. The drawer can be designed to be used with plastic wheels, telescopic or hidden rails. It is a system used in cheaper models.

2.2.1.5 Sidewall drawer case

There are two types: old and new. The drawer frame is created using the side rail. While plastic wheeled rails were used in the old sidewall rail system, a hidden rail inside the sidewall is used in the new system. It is available in partial or full opening, with and without brake versions (Figure 5).

Figure 5. Laminated drawer case (Hettich, 2022).

2.3 Door connection systems

Cover connection systems used in office furniture are defined as hinged or sliding systems.

2.3.1 Hinged door connection systems

There are six different varieties.

a) Sliding type cup hinge
b) Clip-on and external brake- type cup hinge
c) Clip-on and integrated brake- type cup hinge

d) Hinges specially produced for offices
e) Leaf hinge
f) Spindle hinge

Since leaf and spindle hinges are not used much in office furniture other than special production, cup hinges are mostly used in office furniture (Figure 6).

Figure 6. Sliding type cup hinge (Hettich, 2022).

When it comes to cup hinges, the products of all supplier companies are identical. The only difference is in the axes and the visual size of the hinges.
Hinges produced specifically for the office are not multi-pivot, that is, multi-axis, but single-axis. Due to its lack of wall thickness, it provides maximum use inside the cabinet and a special opening opportunity of 230° and 270° (Figure 7).

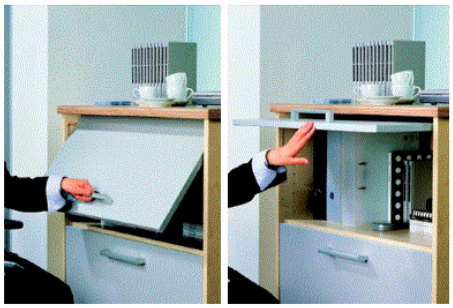
Figure 7. Hinges specially produced for offices (Hettich, 2022).

2.3.2 Sliding door connection systems
There are three different types
a) Sliding system with a bottom mechanism
b) Sliding system with a top mechanism
c) Door sliding slide system (Lift-Up)

The main purpose here is to get rid of the distance in the door opening. In top-operated systems, no rails are visible and visibility is at the forefront. (Figure 8-a).
In systems that work from below, it is a system used only to give the wardrobe a sliding system feature. Bottom-operated systems have a higher carrying capacity and are used in models with larger doors in cabinet sizes (Figure 8-b).
The Lift Up cover system is a sliding system used exclusively for office furniture (Figure 8-c). In this system, the cover lifts and slides under the top table. There is no brake involved. It is a simple but useful sliding system. In sliding door connection systems, the operating logic of the products of the supplier companies in this field is the same. Differences arise in carrying capacities and installation methods.

a) Sliding system bottom mechanism

b). Sliding system top mechanism



c). Door sliding slide system

Figure 8. Sliding systems (Hettich, 2022).

2.4 Table (panel) connection systems

Table (panel) connection systems, which were developed to connect the tables in furniture construction to each other to form the envisaged construction, are carried out using different methods. These methods have also led to the emergence of different office furniture models. Nowadays, instead of using solid wood, new metal-based fasteners have started to be used, along with the use of wooden tables such as chipboard lam and MDF lam.

These fasteners;

a) Dowel milled (Mini fix)
b) Self-doweled milled (Mini fix)
c) Double-sided fastener
d) Pull fastener
e) Tail pull fastener
f) TZ Trapezoidal fasteners
g) Screw pull connection
h) Filled table (light panel) fasteners

2.4.1 Dowel milled (Mini fix)

It is a connection element consisting of a metal head, metal and/or plastic body, and plastic and/or metal dowel (Figure 9). Metal Head varies according to the thickness of the chipboard or MDF slide with thicknesses of 12 mm, 16 mm, 18 mm, and 30 mm. There are two types: zinc casting or galvanized.

Figure 9. Dowel milled (Hettich, 2022).

2.4.2 Self-doweled milled (Mini fix)

It is a connecting element consisting of a metal head and/or plastic body. The dowel is at the bottom of the body. Also, there is no need to use dowels. (Figure 10). The body has two types of thickness and length.

Figure 10. Self-doweled milled (Hettich, 2022).

2.4.3 Double-sided fastener

It is especially used in table combinations. Models are available in different lengths and angles. It consists of 2 metal heads and a chromed steel body (Figure 11). There are also articulated versions for 90° and 180° mountings.

Figure 11. Double-sided fastener (Hettich, 2022).

2.4.4 Pull fastener

It is used for the assembly of shelves or body elements. The difference compared to other models is that the body of the puller connection on the bottom base can also be tightened from above. What is needed for this is a through hole in the base. (Figure 12).

Figure 12. Pull fastener (Hettich ,2022).

2.4.5 Tail pull fastener

It has the same features and models as the puller fastener. The only difference is that it has a tail. An additional hole is needed for the mounting of the tail section at the mounting location (Figure 13).

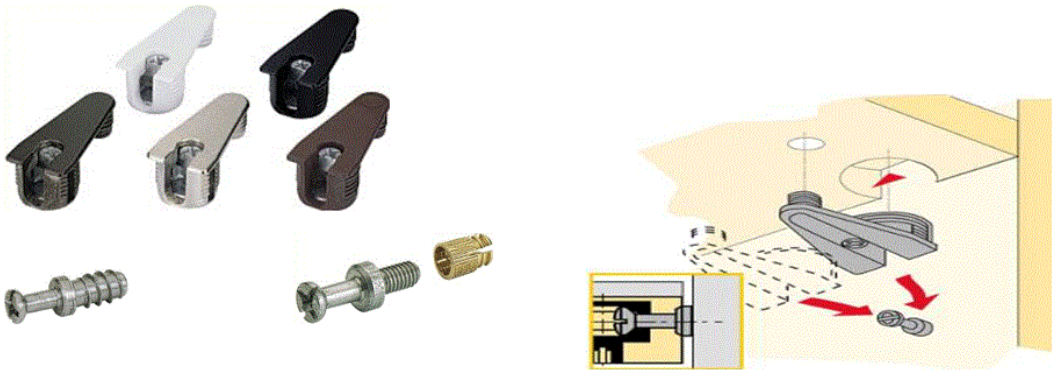


Figure 13. Tail pulls fastener (Hettich, 2022).

2.4.6 Trapezoidal fasteners

It is used in the assembly of shelves and bodies. It is mainly preferred in solid furniture. It consists of 2 parts: cover and inner part. (Figure 14).

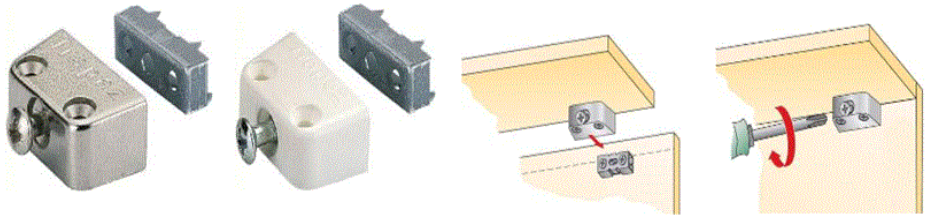


Figure 14. Trapezoidal fasteners (Hettich, 2022).

2.4.7 Screw pull connection

It is a connection type that is mostly used in micro-scale manufacturers of office furniture. The table to be connected is pulled to the other table side with the screw.

2.4.8 Filled table (light panel) fasteners

It is possible to find office furniture made with lightweight panels to avoid heavy desks. Lightweight panels can be preferred especially in the production of table tops. (Figure 15-a). It is not available in rustic models, but is used in standard and office furniture. In order to be durable in such lightweight panels, the fastener must be mounted on the upper and lower table. (Figure 15-b). When we look at the supplier companies that provide service in table connection systems in general, it is seen that the products are similar to each other and the differences are only visual.

a). Light panel b). Light panel fastener

Figure 15. Light panel and Panel fastener (Hettich, 2022).

3. Methods

In this study; Data was collected via survey and the survey was made online. After all survey data was collected and then analyzed by SPSS statistic programs and Excel tables. Survey questions were written and selected related to materials-design-ergonomic triangle bases (Blaxter, Hughes, Tight, 1996).

The survey was carried out within the scope of a total of 73 large, medium, small, and micro-scale manufacturer companies operating in this sector throughout Turkey. These companies were identified by examining the databases of OMSIAD (Office Furniture Industry and Businessmen Association) and the relevant chambers of industry and commerce. By scanning the internet, records of companies that were not included in the databases in question were also accessed. In the classification made according to the employment information of the enterprises, the definition of TUIK (Turkish Statistical Institute) was taken into account. In this context, by the classification 1-9, 10-49, 50-249, 249+; Those employing 1-9 workers are defined as micro-scale, those employing 10-49 workers are defined as small-scale, those employing 50-249 workers are defined as medium-scale, and those employing 250+ workers are defined as large-scale. See Figure 16.

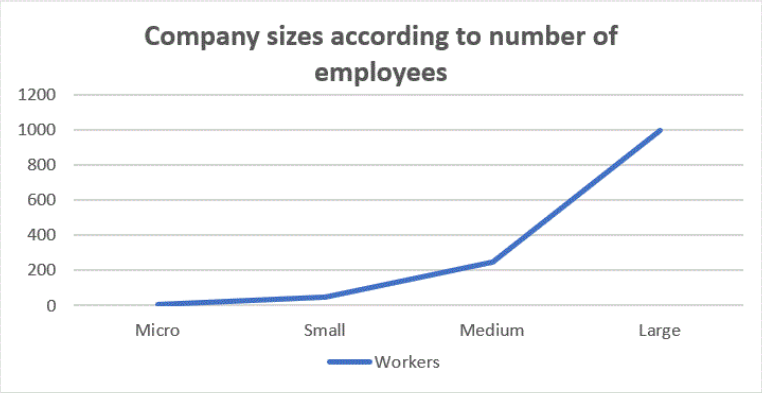


Figure 16. *Business size of companies* – (TUIK, 2022).

A data collection tool (survey) was developed in order to be used in the interviews to be held in the businesses whose address information was obtained and to compile the relevant information. In preparing the data collection tool, the studies used by TUIK were used, and in determining the questions and details of the survey, the opinions of sector employees and previous scientific studies in this field were used. The survey applied; It consists of two parts: questions about the company answering the survey and questions about production and sales, and a total of 34 questions. In the questions aimed at identifying the problems in the survey, the 'other' option was included in addition to the guiding answers, allowing the expression of different opinions. Data collection was carried out face to face by visiting the factories as a result of telephone conversations. In businesses that were not suitable, the survey was conducted by mail or fax to ensure a high participation rate.

4. Results

It has been determined that large-scale enterprises mostly procure their connection systems from abroad, while small and medium-sized enterprises procure their connection systems from domestic warehouses. This is interpreted as the fact that exporting enterprises make such a choice in order to avoid problems in the supply of raw materials and, accordingly, in exports.

As a drawer connection system; Large-scale enterprises; It was observed that they preferred the laminated and wooden drawer frame system the most (39%), and they preferred the wooden and metal drawer system equally (25%). For small scale businesses; It was observed that he mostly preferred the laminated drawer case (Figure 17 & 18).

It has been observed that the metal and plastic drawer frame system is not preferred in small-scale businesses. It has been determined that these systems are mainly preferred by large-scale enterprises and the reason for this is that most of the enterprises have their own metal and plastic workshops and do their own production.

In addition, it has been observed that drawer connection systems are used according to human dimensions like 35-40-45 and 50 cm width (Bruseberg, McDonagh-Philp, 2002).

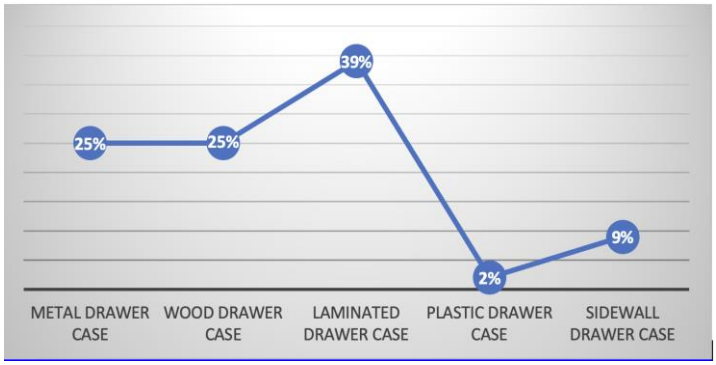


Figure 17. Proportional distribution of connection systems used by businesses according to drawer type.

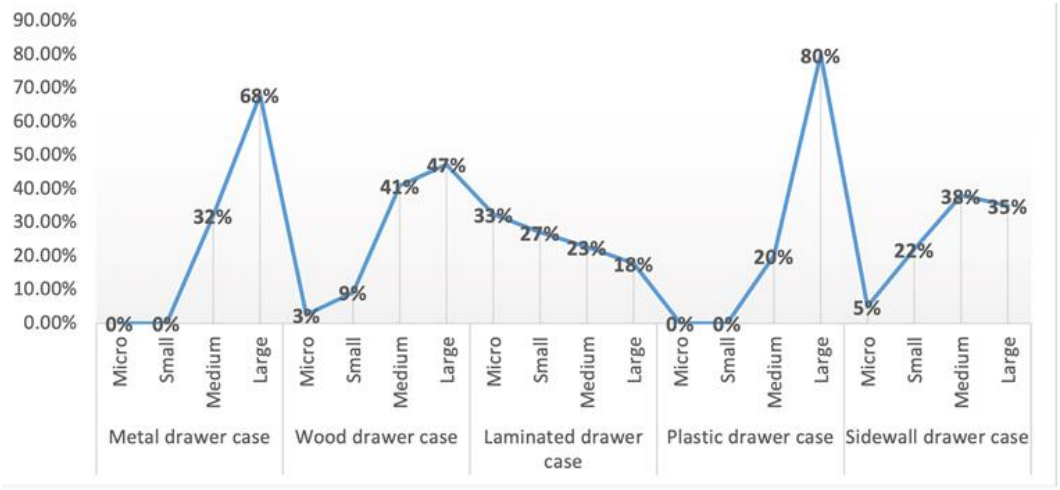


Figure 18. Proportional distribution of connection systems used in drawer types by businesses according to their size.

As a door connection system; In choosing the hinge type, it was determined that the majority of businesses preferred the sliding type hinge (56%), followed by the clip-on type (23%) and the clip-integrated brake type hinge (21%) (Figure 19).
It has been observed that the sliding type hinge type is generally used by all businesses, and is preferred more by micro and small-scale companies (63%). It has been determined that the clip-type hinge is preferred by medium and large-sized companies (70%) in terms of quality production and export options. It has been determined that 60% of the companies use soft-brake hinges, and the preference for the hinge model with integrated brake is 30% and the preference for the hinge model with external brake is 25%. The usage rate of both models of hinges by businesses is 45%. See Figure 20.
Although the dowel hinge type is not used in small-scale companies due to its cost, it is slightly preferred in large and medium-sized companies due to its ease of use in production and durability. However, its use in general is low (16%).

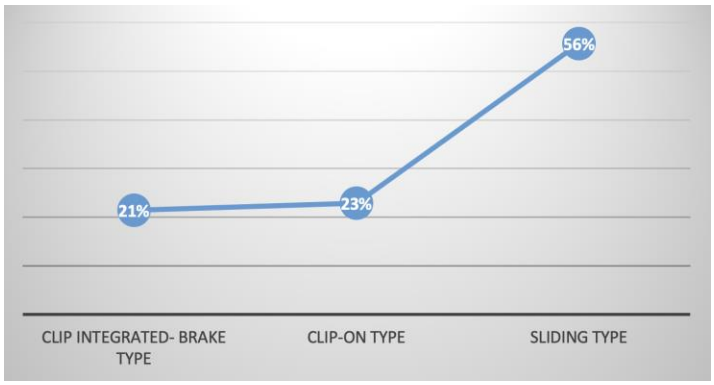


Figure 19. Proportional distribution of hinge models used.

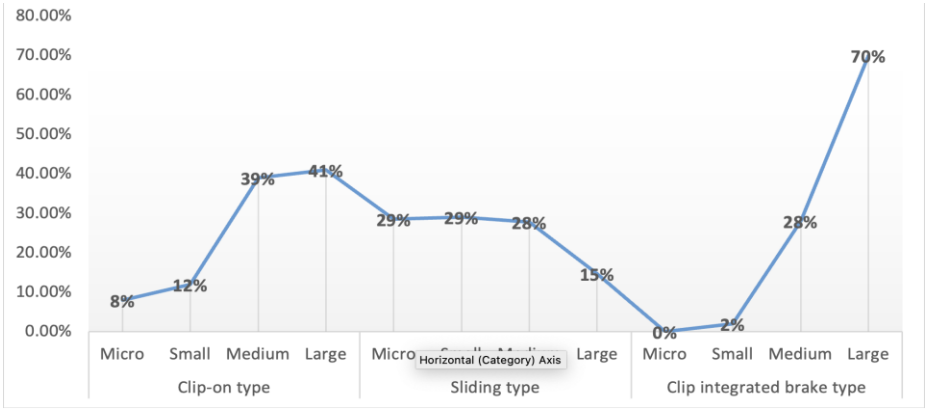


Figure 20. Proportional distribution of hinge types used by businesses according to their size.

The most preferred rail type used in the slide drawer system is; Plastic wheeled rail (48%), followed by the telescopic rail (32%). It has been observed that telescopic and hidden rails are mostly preferred in office suites and higher-quality works. In the wooden drawer system used in office sets and luxury products, hidden rails (39%) and telescopic rails (36%) are used, and it has been determined that plastic wheeled rails are used in normal sets (25%). See figure 22.

It has been observed that the bottom mechanism system is mostly the first preferred system (38%). The preference rate for the top mechanism system is 25% (Figure 21). It has been determined that small-scale businesses do not prefer the top mechanism sliding wardrobe connection system, and factors such as cost sales and marketing are effective in this regard. It has been determined that the overhead system is mostly preferred by medium and large-sized enterprises.

In addition, it has been observed that wardrobe connection systems are used according to human dimensions like 180-190 and 200 cm height (Bettendorf, 1998).

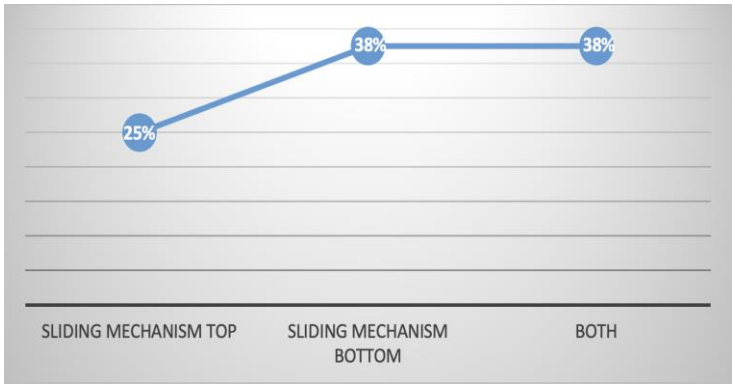


Figure 21. Sliding wardrobe connection system types usage situation proportional distribution.

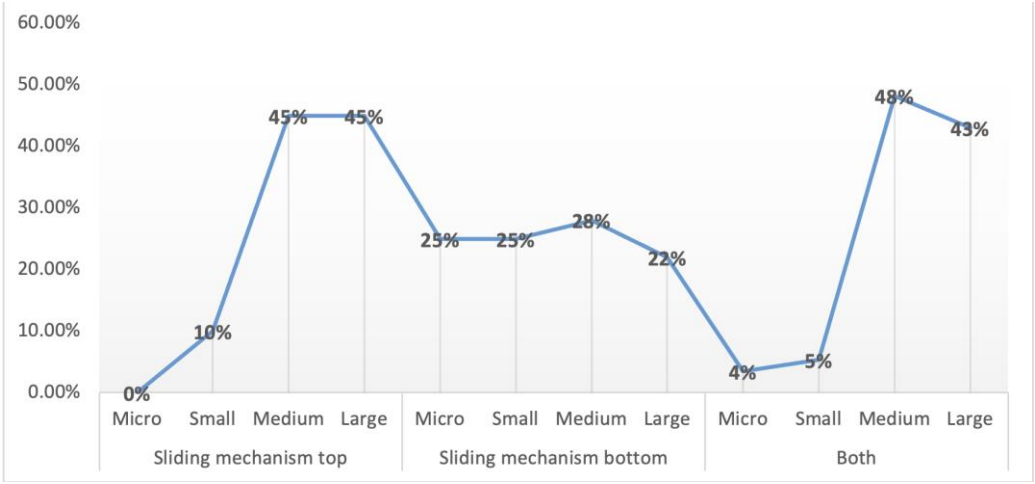


Figure 22. Proportional distribution of sliding wardrobe connection system types used by businesses according to their size.

As a table (panel) connection system; it has been observed that businesses mostly prefer doweled mini fix milled (58%), followed by self-doweled mini fix milled (22%) and tailed pull fasteners (18%) (Figure 23). It has been determined that the dowel puller element is preferred by all businesses (58%), while the self-dowel puller element and tail connection system are generally preferred by large-scale enterprises. (20%). See Figure 24.

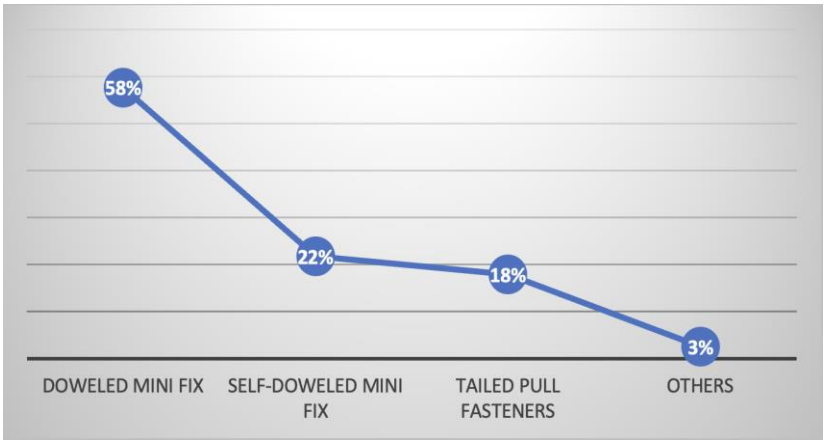


Figure 23. Proportional distribution of puller system types used by businesses.

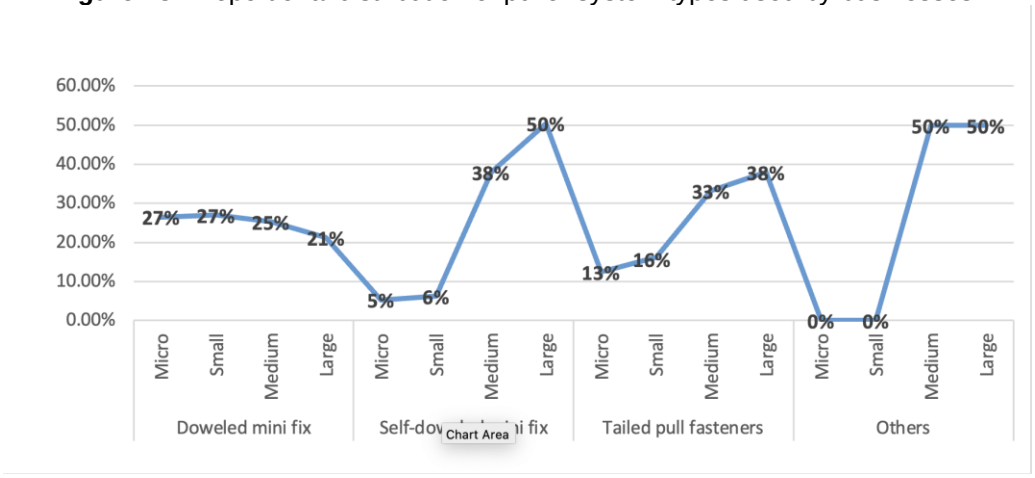


Figure 24. Proportional distribution of pull system types used by businesses according to their size.

5. Conclusion

The following recommendations can be made within the scope of the research results.
- When we look at the connection systems used in Turkey, it is seen that lower-quality products are used due to cost and design.
- The usage of lower products is affecting consumers' comfort.
- Regarding ergonomics and design cases; Micro and small companies are not considered and ergonomics related to the product is the same as medium and large companies.
- Medium and large companies have designed and chosen connection systems to enhance well-being and human health.
- All companies' choice not to use sustainable products problems can be solved by raising the awareness of consumers and providing them with information about the connection systems they use. This may force businesses to use higher-quality products.
- The outcome of this research is that applying a fundamental approach is also important because it has a big role and potential in decreasing environmental impact and improving health and social comfort.
- Companies that supply connection systems need to work more actively to raise consumer awareness. It is thought that advertising campaigns will be effective in this regard. It is beneficial for supplier companies to increase their dealer and product range in order to reach all companies.
- It has been observed that companies are using connection systems are used according to human dimensions in ergonomic conditions.
- It is also thought that manufacturers should work more closely with their R&D and design departments on current product information and quality, comfort, and ergonomic perception.

Although office furniture may seem less important than home furniture or kitchen furniture, it is actually at least as important. The reason for this is that business life covers 8-10 hours of a person's daily time, and the products used during this period must have certain features, especially in terms of efficiency and human health. These features can only be achieved with the connection systems used.

Increasing the functionality of the chair you sit on, the desk and pedestal you use, and the cabinet where you keep your files means that you can work more efficiently. In addition, considering that the most important issue is human health, it is also very important that the desk you use is adjustable and the ergonomics of the chair.

Studies on this issue should be continued and integration with Europe should be ensured. When we look at the design and connection systems in the world, especially in Europe, it is noticeable that there are differences between them and Turkey. If companies pay more attention to R&D studies in this regard and consumers increase their perception of quality and use higher quality products, the diversity and quality of connection systems will increase.

In the office furniture industry, which is an active and hot market, connection systems are an important issue in every sense, as explained in full detail above. This work should be continued and innovations should be added in the following years.

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Conflicts of interest

The Authors declare that there is no conflict of interest.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding authors/s.

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