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The Evolution of the Italian Footwear Industry and The Role Additive Manufacturing Plays in Its Future

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Contents

Introduction

For thousands of years Italy has been cultivating and refining its leather footwear craftsmanship, leading them to become an undisputed world leader among manufacturers of fine leather footwear. Today, Italy is considered not only a global leader in leather products but is also renowned for its development and application of innovative materials, manufacturing processes and machinery design in the footwear industry. This paper investigates how Italy is embracing additive manufacturing processes in the footwear industry and harnessing these technologies to meet the needs of today's consumers and secure resilient supply chain systems.

The Evolution of The Shoe

The concept of the shoe has evolved greatly over thousands of years. Materials, manufacturing methods and even the purpose of footwear have all advanced considerably over time. Footwear was initially designed with the sole intention of protecting feet from the surrounding environment, and to an extent, this objective remains the same today. However, nowadays there are additional important factors to take into consideration.

It is widely thought that footwear was first established around 40,000 years ago, in the form of *simple wrap around boots held together by rawhide laces* to protect feet from freezing conditions (see Appendix A). Sandals made from leather or vegetation were subsequently introduced by the Egyptians, the Etruscans and later, the Romans, to protect their feet in warmer conditions (see Appendix B). During this period of time the shoemaker became considered a valued craftsman. These craftsmen began to tan a variety of leather using processes such as vegetable tanning and tawing (see Appendix C). Soon, different styles of shoe began to appear, and they became a great sign of power and status.

As time went on people became more interested in improving the performance and style of footwear. Craftsmen started to develop new methods of manufacturing to improve

footwear quality. In the Middle Ages, *the turnshoe method* became commonplace for shoe manufacturing. It involved making the shoe *inside out and then turning it so that the seams were on the inside of the shoe together* (Real Leather, 2021) (see Appendix D). This resulted in shoes that were more durable, better fitting and considered more stylish. It *dominated Europe until around 1500*, when it was largely replaced by the *welted rand method*, *where the upper, insoles and outsole are stitched together* (Real Leather, 2021) (see Appendix E).. The welting process remains one of the oldest, most labour-intensive methods of footwear manufacturing still used today.

The 1700's revolved around class and royalty with shoes becoming a representation of social status. The higher classes started introducing precious metals and stones, silks, and satins, and they began to place high value on customisation, seeking out personal designs and unique embroideries (see Appendix F).

It was not until the mid-18th century that shoemaking became more industrialised, although, most of the work was still being done by hand. The introduction of the industrial sewing machine in 1846 was when *the true mechanisation of shoemaking began to advance* (Sole Science, 2020). This enabled shoes to be made quickly and inexpensively, resulting in the erection of factories across the globe and the birth of the industrial revolution.

Perhaps the greatest turning point in footwear manufacturing was the development of adhesives to produce the first *stitch-less shoes in 1910* (Sole Science, 2020). This invention eliminated the need for skilled craftsmen and began to accelerate the industry towards mass production. As most countries followed this manufacturing trend to produce footwear faster and cheaper, the Italians on the other hand, refused to follow the crowd. Instead, they continued to cultivate and refine their leather footwear craftsmanship which would inevitably lead them to earning themselves the title as a world leader in fine footwear.

The 20th century, post WWII, saw the rise of Italy's illustrious fashion scene. Italian shoe designers began *to adapt to changing demand by devising entirely new shapes and styles that most of the world had never seen before*, and they did it without sacrificing an ounce of quality (Paul Evans, 2014). The aesthetic aspect of footwear was becoming more and more valued by consumers as shoes evolved into elegant accessories used to elevate outfits and make bold fashion statements.

Over the years, footwear design and manufacturing has *evolved from a traditional craft into a multibillion-dollar market* (Sole Science, 2020). As we enter the new digital age, industries are looking for ways to integrate customization capabilities into their manufacturing processes to satisfy the modern consumers need for personalised footwear products. With fashion trends and consumer needs changing more frequently now than ever before, the footwear industry is at the forefront of innovation. New technologies focused on delivering sustainable, unique footwear materials and improving production processes are advancing year on year.

Today, Italy is the number one producer of footwear in the European Union. While *the country's reputation for production of bespoke footwear of the highest quality leans heavily on their heritage*, it is also a result of their willingness to embrace the latest technological developments and use them innovate and refine their production processes as the market changes (Carl Friedrik, 2021).

The Rise of Additive Manufacturing

Additive manufacturing (AM) is becoming increasingly popular with the footwear industry, *due to the pillars of sustainability and digital transformation that the sector needs and the growing demand for personalized products both in design and functionality*. AM is the *process of creating a three-dimensional object one layer at a time*, from a CAD or digital 3D model (Linke, 2017). The use of AM enables products to be produced more quickly, with

less waste and has the ability to produce complex customised designs that would otherwise be impossible to create. The most common form of AM used in the footwear industry is 3D printing and it is usually exploited to produce advanced insole, midsole and outsole footwear designs

Today, Italy is considered to be at the forefront AM innovation, *ranked 11th worldwide for the use of AM technologies with an AM market estimated to be worth between $500 million and $1 billion* (ITA, 2022). Just last year, Italian middle-distance runner Miro Buroni partnered with the Italian sportswear and footwear manufacturing company Diadora, to *create a pair of shoes using 3D printing with composite materials* (see Appendix G). The structural parts of the shoe (insole, midsole, spikes and ribs) were printed in carbon fibre using selective laser sintering (SLS). This resulted in a shoe that is more flexible, resistant to deformation and easily customisable. Although, footwear soles remain the most commonly 3D printed components today, recent innovations have also seen footwear uppers adorned with or even created entirely from 3D printed fibres.

Leading Italian manufacturer *Eddy Ricami* has recently strengthened his manufacturing offering by *bringing advanced additive manufacturing technology to the high-end industry* (Saunders, 2021). The company now has the ability to print intricate patterns and textures directly onto textiles, realising the high-fashion customers personalised product demands (see appendix H). The application of 3D printing elements directly onto traditional Italian leather is the perfect marriage of tradition and the new digital age.

Another key innovation in 3D printing was seen last year when a team of *scientists from Tufts University developed a leather-like 3D printing material made of silk* (Sertoglu, 2021) (see Appendix I). The material is sustainably sourced, entirely recyclable and biodegradable, as well as offering mechanical properties comparable to those of real leather. This is especially interesting from the perspective of the Italian leather footwear industry as it

is beginning to branch out to find more sustainable leather alternatives and integrate AM into their manufacturing processes.

As synthetic leather alternatives continue to become more favourable and experimental laboratories across the world start to explore the potential of using AM to invent more sustainable leather like materials, it likely that it is only a matter of time before the Italian leather industry is able to fully harness the capabilities of 3D printing to create innovative and completely sustainable faux leather footwear products.

Recently, innovations in 3D knitting technologies for footwear uppers have been pushing the boundaries of what is considered AM. Although traditional leather is still the most commonly used material in footwear upper production today, the popularity of non-leather textile alternatives is on the rise. In 2019 *the non-leather segment accounted for the highest share in footwear market growth and is projected to grow at a CAGR of 5.0% from 2020 to 2027* (Correa, 2022). This increase in popularity is a result of a surge in casual athleisure trends as people are becoming more health and fitness conscious. Consumers needs are revolving more around comfort and sporting performance than ever before. This is naturally beginning to shift footwear trends away from materials like leather and towards more suitable knitted upper constructions. Knitted textiles have been successfully integrated into footwear products due to the materials superior comfort, odour resistance and breathable characteristics. Recent innovations in knitting machinery technologies have also resulted in personalization capabilities which has increased the use of knits for shoe uppers.

As well as being a global leader in leather production, Italy has been carving out a niche for itself in the manufacturing of textile machinery, yarns and fabrics. It is now considered one of the world's main suppliers of textile machinery. The Italian manufacturing company Santoni specialises in the innovation and production of seamless knitting machine technology. Most recently the company launched their Santoni X MACHINE, which was

developed to create seamless, knitted footwear *using revolutionary 3D intarsia technology that maps the foot for perfect fit and form*, whilst also offering unlimited patterns and colour combinations (Safety Magazine, 2019) (see Appendix J). The machines technology allows the upper to be seamless, eliminating the need to cut and sew, hence cutting down on waste, as well as significantly speeding up finishing times and reducing labour. The innovative machine also has the unique ability to integrate personalised knitted cushioning and the introduce heel quarter stiffeners at the rear if required. Like all Italian manufacturing companies, Santoni prides itself on delivering top tier innovative technologies, focused on producing performance orientated products, that are held to prestigious Italian quality standards.

The rise in popularity of AM processes in the footwear industry is expected to see even more growth in the coming years, as both sustainability and customisation will continue as key drivers of footwear design and production.

The 21st Century Consumer

Today's modern consumers have more choices, greater knowledge, and higher demands than ever before. They have access to information about any product or service in an instant. The *empowered consumer has zero tolerance* (Kaplan, 2020) and will no longer wait around for a business to create the products they want and bring them to market efficiently. Through the lens of connectivity and collaboration, powered by mobile devices that keep them connected wherever they may be, consumers will actively search for alternative products that are cheaper, faster, and greener.

Industries across the world are *facing heightened challenges in the form of the new empowered consumer* (Kaplan, 2020), as the lines between businesses and consumers continue to blur. Businesses must accept they are no longer in control and need to take steps

themselves to meet customers where they are. They need to understand exactly what the consumer wants, when they want it and how they want it, in order to hold their attention.

Gen Z is becoming an increasingly important consumer group. Whilst Gen Z once seemed like a far-off challenge for businesses, they now *represent 40% of global consumers* (Smith, 2022), and this figure will only continue to increase with time. It is essential that industries learn to adapt to meet the requirements of this modern generation now if they intend to hold value and stay ahead of the competition.

In the footwear market especially, trends are becoming progressively driven by this empowered consumer group and the needs of this market are shifting rapidly. A key trend expected to continue to shape the industry is *purposeful purchasing* (Johns, 2020). This digital generation grew up surrounded by the internet and smart phones. As a result of this access to data and knowledge, they are becoming more conscious of the implications of their purchases. Gen Z are actively seeking out brands that work towards positively impacting the world socially or ecologically. From recycling, using more eco-friendly materials, refining manufacturing processes, or giving back to the community, products with an authentic sustainable story are poised to take over the industry. Although the Italian leather footwear industry has been long associated with indulgence and real leather luxury, in recent years it has taken significant steps towards introducing and promoting premium synthetic leather alternatives and has worked to develop production processes that are more ethically conscious.

The modern consumer continues to value quality in footwear products above all else. This is good news for the Italian leather footwear industry, as it is already renowned globally for the premium quality of their leather footwear products.

Perhaps the most critical consumer trend influencing the footwear industry today is personalisation. Modern consumers are willing to pay premium prices to have a product

designed specifically for them or to have the opportunity to customise a product themselves. Italy's adoption of new technologies and innovation in AM is already supporting this consumer demand by fabricating unique, high quality footwear products.

The New Retail Landscape

The digital era is starting to gain momentum and e-commerce has securely established itself as the primary marketplace for footwear products. This digital trend was accelerated by COVID-19 as *e-commerce sales increased by over $244 billion in 2020*, the first year of the pandemic (Brewster, 2022), as consumers engaged in contactless shopping and curbside pickup.

While online shopping has gained popularity, *brick-and-mortar stores are also embracing digital elements* as they work harder than ever to compete with the consumers increase appetite for e-commerce (Smith Brain Trust, 2021). These stores are attracting customers is by creating immersive experiences that will encourage people to get back in-store as the world reopens.

Customisation trends have been gaining traction over the past few years in the footwear industry. As consumers start to place greater value on personalisation, more and more e-commerce stores are starting to offer online shoppers the option to alter the colour, material, and finish of footwear products. There are even retailers offering in-store personalisation stations.

It is predicted that this trend will continue to infiltrate the e-commerce market for years to come. Italy's AM facilities and extensive experience in the production of bespoke leather goods, puts the Italian footwear industry at the forefront of mass personalisation, and thus primed to take advantage of this new retail market.

The Effect of The Pandemic on Global Supply Chains

The COVID-19 outbreak represents one of the largest disruptions encountered in the last few decades and has resulted in the breaking of many global supply chains. The pandemic led to the *closure of shops, accelerated shifts towards a more digital world and triggered changes in online shopping*. A trend was demonstrated in the reduction in demand for non-essential products, such as footwear. To cope with this drop in demand, many international manufacturing companies began to re-purpose their production lines in an attempt to keep their factories open, by producing PPE in the form of face masks, gloves and nonsurgical gowns.

The Italian leather industry was hit hard by the early stages of the pandemic. *Exports fell sharply by 27% due to the large drop in consumer demand* (Leather International, 2022). As a leading global innovator, Italy was quickly able to recognise opportunity and execute a national shift in production to distribute PPE products. Companies such as Armani, Gucci, and Fiat Chrysler, among others, were quick to switch production from fashion to functional medical products. Italy's extensive onshore access to designers, innovation, materials and manufacturing facilities is key to understanding the country's ability to adapt to changing consumer demands and global product disruptions. The industry's involvement with AM is another reason for its high resilience. AM's ability to support the customisation of products allows the industry to adapt designs more quickly and easily when disruptions or changes in consumer demand arise.

For decades, many companies have *primarily focused on supply chain optimisation to minimise cost, reduce inventory, and drive asset utilisation* (Grainger, 2021). This has resulted in large brands relying on long supply chains driven by political stability, lower costs and skilled workers. However, the pandemic resulted in industries having to rethink and transform their global supply networks. The shortening of supply chains across the world was

demonstrated as leading global footwear brands cut ties with offshore Asian manufacturing facilities and began to look closer to home for alternative manufacturing opportunities. Although manufacturing costs are higher closer to home, by reducing dependency on offshore manufacturers, companies can develop more resilient supply networks. Relocation of factories closer to home *alleviate delays and reduce other logistical challenges associat*ed with supply chain disruptions (Bader, 2022).

Conclusion

Over the years, footwear design and manufacturing in Italy has evolved from a traditional craft into a multibillion-dollar market. There is little doubt Italy's success in footwear production is a result of both its rich leather craftsmanship history and the country's willingness to embrace the latest technological developments and use them to refine and evolve their design processes as consumer demands change and supply chain disruptions arise.

Italy's footwear industry has implemented AM methods to enhance their product capabilities, offer consumers more personalised product opportunities and make manufacturing processes more sustainable. Italian manufacturers such as Eddy Ricami and Diadora provide an opportunity to bridge the gap between Italy's traditional leather craft and modern AM techniques. The rise in popularity of AM processes in the footwear industry is a trend expected to see even more growth in the coming years, as both sustainability and customisation will continue to be key drivers in the new digital consumer market.

The COVID-19 pandemic resulted in the footwear industry having to rethink and transform its global supply network. Industries across the world have been localising their supply chains in an attempt to reduce lead times and other logistical challenges. Italy's local and extensive access to designers, materials, and manufacturers, coupled with its connection to cutting edge AM technologies, allow it to adapt quickly and innovate in the face of ever-

changing product demands. This makes Italy an attractive, reliable collaborator for footwear companies across Europe and the United States looking to establish more resilient supply chains.

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Appendix

Appendix A

A cowhide shoe stuffed with grass for insulation. Found in Armenia.
World's Oldest Leather Shoe Found – Stunningly Preserved. (2010).
Retrieved from National Geographic: https://www.nationalgeographic.com/culture/article/100609-worlds-oldest-leather-shoe-armenia-science

Appendix B

Figure B1

Pair of woven reed overshoes, 1550-1070 BC. Found in Egypt.
The V&A Collection – A History of Shoes Timeline. (n.d).
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Figure B2

Two Roman Leather sandals (not a pair), 43-450 AD, found in London.
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Appendix C

Leather tannery illustrator the vegetable tanning process in Tuscany, Italy.
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Appendix D

Reconstruction of turnshoes from the Middle Ages.
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Appendix E

Replica of a welted shoe from the Middle Ages.
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Appendix F

Women's silk slipper with ornate metal embroidery, 1660-75. Found in England.
The V&A Collection – A History of Shoes Timeline. (n.d).
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Appendix G

Pleko, the Spike Shoes 3D Printed Using Carbon Fibre.
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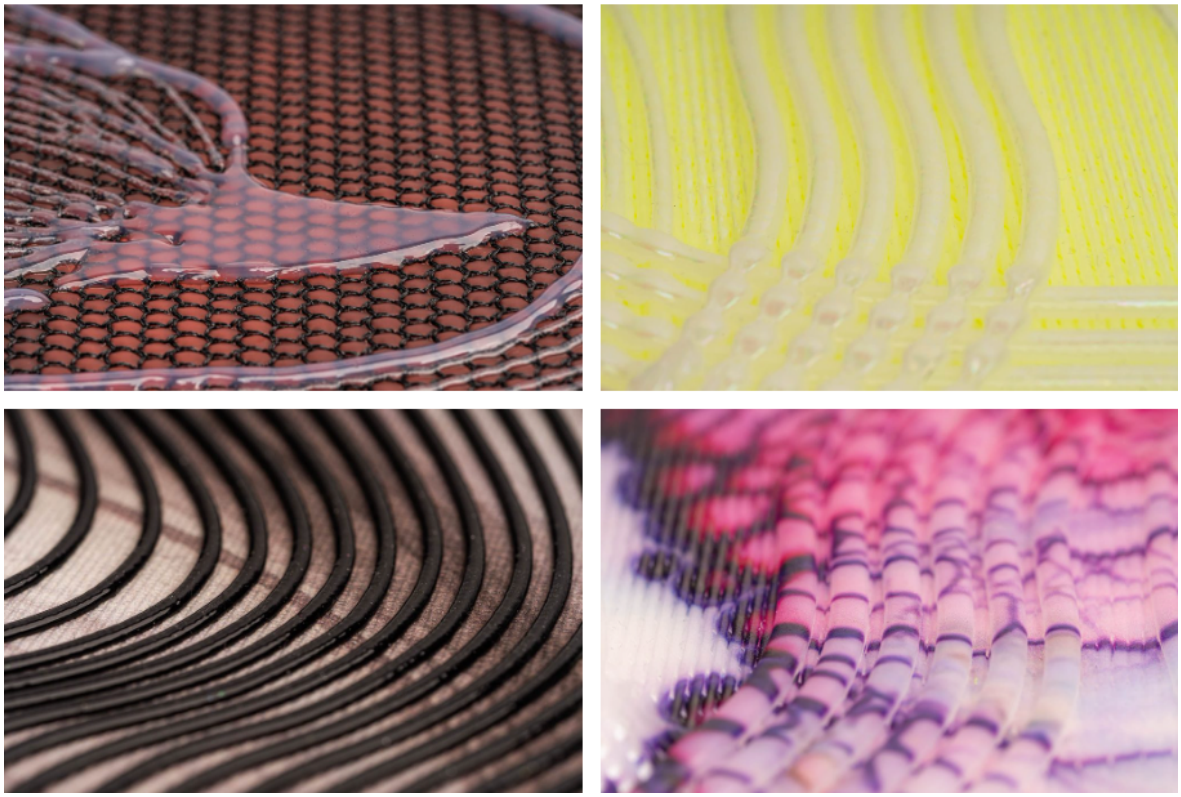
Appendix H



TPU textures 3D printed directly onto textiles.
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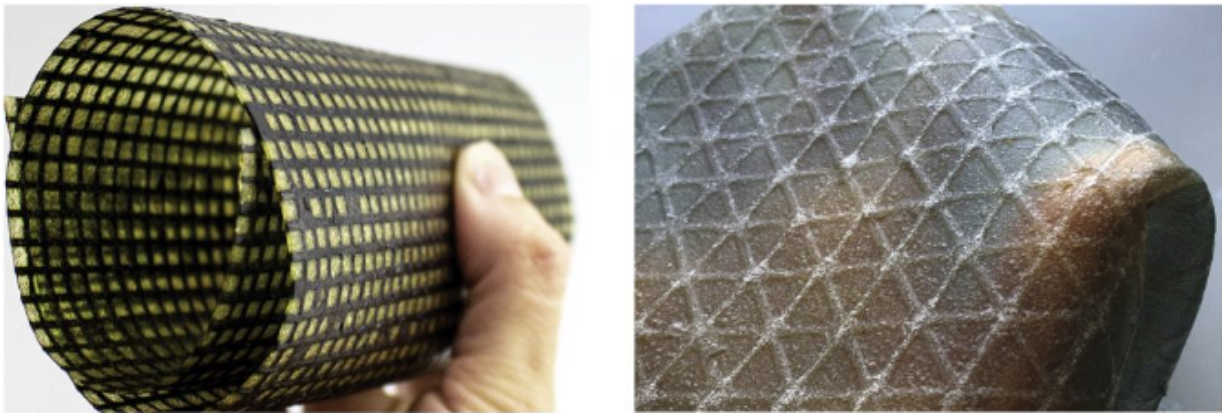
Appendix I



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Appendix J

Figure J1

The Santoni X MACHINE.
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Figure J2

Santoni X MACHINE seamless shoe upper.
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