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ABSTRACT

This study presents a methodology for analyzing the historical textile industry, focusing on how supply chain dynamics and the material properties of textile fibers directly govern technological diffusion. The model is applied to the silk trade network from the 8th to the 15th centuries—a critical period for textile-driven economic development. The evolution of a specific artisanal technology, musical instrument manufacturing, is utilized as a unique tracer to map these material-driven constraints. A core analysis contrasts the physical properties of traded silk fiber with those of locally sourced animal gut fiber, demonstrating how the limited availability of silk in Europe—a primary product of the textile trade—forced a material substitution that, in turn, drove significant technological adaptations in instrument design. Findings confirm that major hubs within the textile trade network, such as Baghdad and Venice, functioned as epicenters for technology-driven innovation. This research contributes a quantifiable, material-centric framework to textile history, demonstrating that the physical logistics and inherent properties of textile goods were significant structural forces in shaping artisanal technology.

KEYWORDS

silk, textile fibers, supply chain management, material properties, network analysis

INTRODUCTION

The Silk Road is often conceptualized as a vast network of arteries that once pulsed with the flow of luxury goods, connecting the great civilizations of East and West [1]. For centuries, caravans laden with silk, spices, and precious metals traversed unforgiving deserts and formidable mountain ranges, weaving a tapestry of commerce that profoundly shaped global economic history. The production and trade of textiles, particularly silk, were technologically intensive and economically transformative activities that drove the growth of cities and the accumulation of vast fortunes [2,3]. However, this network was far more than a simple conduit for

merchandise; it was also a vibrant ecosystem for the exchange of ideas, technologies, religious beliefs, and artistic styles [4,5]. While the material trade in goods such as textiles has been extensively documented and analyzed, the transmission of intangible heritage, such as music, has often been studied in a cultural vacuum, detached from the very physical and economic systems that enabled its movement [6,7]. This scholarly gap highlights a significant problem: the lack of a robust, materially grounded framework for understanding how complex cultural systems are transmitted across vast geographical and historical spans.

This study aims to bridge that gap by investigating the historical trajectory of the Arabic musical system known as Maqam—a sophisticated framework of melodic modes—and its gradual transformation into the European ecclesiastical Mode system, which became the foundation of Western classical music. The central question is not merely whether this transmission occurred, but how the underlying logistical and material realities of the pre-modern world shaped its path and nature. While historical musicologists have long acknowledged a connection, the mechanisms of this transmission have remained largely speculative, often attributed to abstract notions of “cultural influence” without sufficient consideration for the tangible enablers of such change.

This paper puts forward the thesis that the migration and evolution of music from the Arabic Maqam to the European Mode were not isolated cultural phenomena but were fundamentally shaped and influenced by the network structure, material flows, and social ecology of the silk and textile trade. We argue that the textile trade did not merely act as a passive vehicle for the migration of musicians and their instruments. More profoundly, the material resources, technological knowledge, and economic wealth distributed by this trade created the essential physical and social conditions for musical evolution and the reconstruction of cultural identities in the burgeoning urban centers along these routes. The very materials of the trade—from the silk used for strings to the woods for instrument bodies—and the economic power it generated were active agents in this historical process.

Our central argument is that the evolution of musical systems was heavily constrained by the material availability, logistics costs, and physical properties of resources within the textile supply chain. To substantiate this thesis, the article will first review the relevant literature and establish a theoretical framework combining Network Theory and Material Culture Analysis. It will then detail a dual-method approach involving the construction of a historical trade network map and a material-acoustic analysis of key musical instruments. The subsequent sections will present the results of this analysis, discussing the identified co-migration patterns between textiles and music, the material impact of trade goods on instrument evolution, and the role of new social strata in fostering hybrid musical cultures. Finally, the conclusion will synthesize the findings and discuss

their implications for both textile studies and musicology.

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

This study is situated at the intersection of several academic disciplines, drawing upon insights from textile history, material culture studies, and historical musicology to construct a comprehensive theoretical framework. The centrality of textiles, particularly silk, in pre-modern global trade is well established [8]. Scholars have demonstrated that silk was far more than a commodity; it functioned as currency, a diplomatic tool, and a potent symbol of status and power across Eurasia [9,10]. The intricate supply chains required for textile production and trade—from sericulture in China to weaving workshops in Persia and finishing centers in the Levant—created a robust and resilient network that structured human interaction on a continental scale [11]. Material culture theorists have emphasized that objects are not passive artifacts, but are deeply embedded in social relations and are active in the construction of cultural identities [12,13]. Textiles, in this view, are “social skins”, mediating relationships and communicating complex social information. While this literature provides a foundational understanding of the textile trade as a powerful socio-economic engine, its direct role in facilitating the transmission of other cultural forms, such as music, remains an underexplored dimension.

Historical musicology provides the essential vocabulary for understanding the cultural forms under examination. The Arabic *Maqam* is a system of melodic modes used in traditional Arabic music [14,15]. A *Maqam* is not merely a scale; it defines the melodic contours, tonal centers, and typical phrasing of a piece, often incorporating microtonal intervals not found in the Western equal-tempered system [16]. It is a system deeply rooted in improvisation and oral tradition.

To properly execute the subtleties of a *Maqam*, an instrument must be highly responsive to the player’s touch, allowing for the slides, vibratos, and precise pitch inflections that are core to its expressive power. In contrast, the European medieval ecclesiastical *Modes*, which formed the basis of Gregorian chant and later polyphony, were more rigidly defined diatonic scales. While they also conveyed distinct moods, their structure was more fixed, lacking the microtonal and improvisational fluidity of the *Maqam*. The European *Mode* primarily served liturgical chant, where its structured melodic lines were designed to carry sacred text and provide a foundation for later polyphonic development—a purpose that demanded clarity, stability, and pitch accuracy above all else. Scholars have pointed to the Iberian Peninsula (Al-Andalus) and Sicily as key points of contact where Arabic musical theory and practice may have influenced European traditions [17]. However, these studies

often focus on textual evidence and stylistic similarities, leaving the material and logistical pathways of influence less clearly defined.

To bridge this gap, this study introduces a dual theoretical framework. First, we employ Network Theory, as applied to historical analysis, to model the Silk Road not as a monolithic line on a map, but as a complex system of “nodes” (trading cities, ports) and “edges” (trade routes). By assigning “weights” to these edges based on estimated volumes of textile trade, we can create a dynamic model that visualizes the flow of goods and, by extension, the probable pathways for the flow of people and ideas. This model allows us to move beyond anecdotal evidence of cultural contact and quantitatively analyze the correlation between the intensity of material exchange and the incidence of cultural hybridization.

Second, we integrate this with a rigorous Material Culture Analysis, focusing on the musical instrument as a central analytical object. We treat instruments not as static cultural symbols but as assemblages of specific materials whose acquisition, properties, and workability are paramount. The evolution from the pear-shaped Arabic *Oud* to the European Lute serves as our primary case study. We hypothesize that the materials used in their construction—particularly the choice between silk strings, common in the East, and gut strings, which became standard in the West—were not arbitrary aesthetic choices. Rather, they were dictated by the logistics and economics of the trade network. The physical properties of these materials directly impacted the instrument’s timbre, tuning stability, and playing technique, thereby creating a material basis for the divergence of musical systems. This framework allows us to connect the macro-level dynamics of the trade network to the micro-level realities of artisanal practice and acoustic possibility.

MODELING AND ANALYTICAL FRAMEWORK

This research employs a dual-method, interdisciplinary approach that combines qualitative historical analysis with quantitative systems modeling to systematically investigate the causal links between the material network of textile trade and the intangible transmission of musical culture. Figure 1 provides a flowchart of this research design, outlining the parallel analysis of historical network mapping and material-centric pathway analysis.

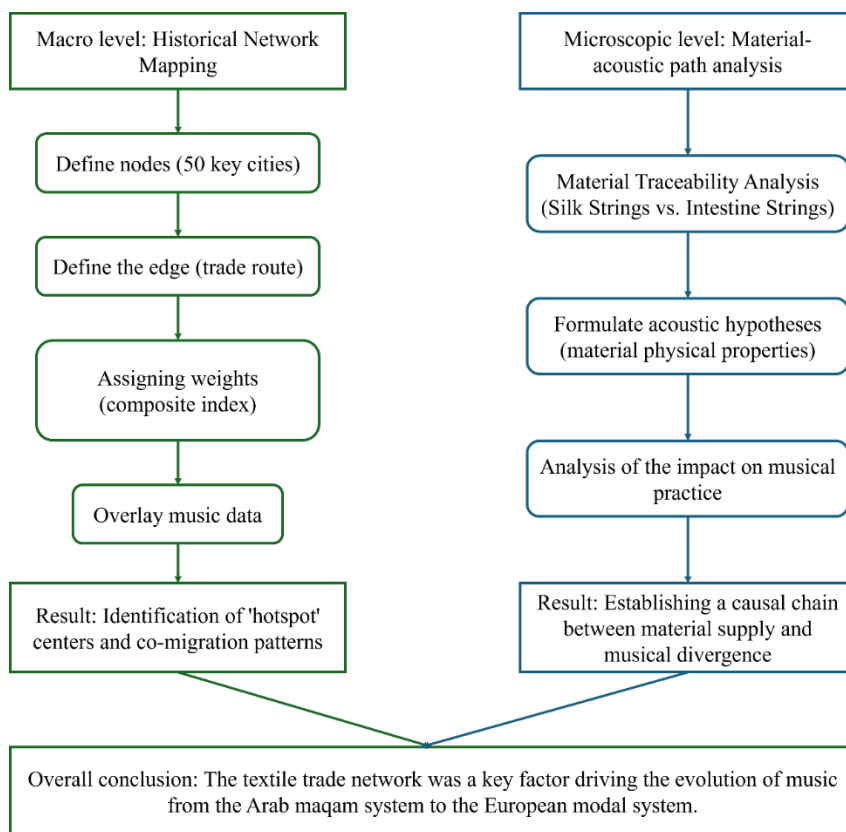


Figure 1. Flowchart—Schematic Diagram of Dual Research Methods

Modeling the Textile Trade Network

The first component of our methodology is the construction of a weighted, dynamic network model of the Silk Road textile trade between the 8th and 15th centuries. This period encompasses the height of the Abbasid Caliphate, the cultural flourishing of Al-Andalus, and the rise of Italian maritime republics such as Venice—all critical junctures in the story of Maqam-Mode interaction. The network model was constructed through the following steps:

- **Nodes:** The nodes of the network were defined as 50 key cities known to be significant centers of production, consumption, or transit for textiles. These include major metropolises such as Baghdad, Damascus, and Constantinople; Central Asian oasis hubs like Samarkand and Bukhara; and European ports such as Venice and Genoa. The selection was based on a synthesis of primary historical sources (e.g., travelogues and merchant records) and secondary scholarly works on economic history.
- **Edges:** The edges represent the primary trade routes (both overland and maritime) connecting these nodes.

Weighting: To quantify the intensity of textile trade, a composite weighting index was developed, as precise

quantitative data for this period is scarce. This index is based on a proxy system incorporating factors such as: (1) the frequency of a route's mention in historical trade documents; (2) the known presence of *caravanserais* or *funduqs* (merchant inns) specializing in textiles; (3) archaeological evidence of textile workshops or large-scale dye vats; and (4) qualitative assessments from historical scholarship regarding a route's importance for the silk trade. Given the data limitations, this composite index is intended as a heuristic model to estimate the relative intensity of trade, resulting in a qualitative ranking of routes to facilitate pattern identification rather than a precise statistical measurement.

Once the baseline textile trade network was established, we overlaid a second layer of data: historical records of musicological significance. These data points included the documented movements of prominent musicians, the locations of influential music theory schools, the first appearance of specific instruments (such as the lute in European iconography), and the locations where key Arabic musical treatises were translated. By mapping these events onto the textile network, we could systematically analyze the correlation between high-traffic textile routes and the incidence of significant musical exchange, identifying critical nodes where both activities were highly concentrated.

The Composition and Calculation of the Composite Weighted Index

To address the scarcity of precise quantitative trade data from this period, we developed a composite weighting index (I) to serve as a proxy for the relative intensity of textile trade along each route. The index is constructed using a weighted additive model, which combines scores from four distinct proxy factors (S_1, S_2, S_3, S_4). The formula is as follows:

$$I_{route} = (W_{doc} \cdot S_{doc}) + (W_{infra} \cdot S_{infra}) + (W_{arch} \cdot S_{arch}) + (W_{schol} \cdot S_{schol}) \quad (1)$$

Where w is the weight assigned to each factor and S is the standardized score for that factor. Each proxy factor was scored on a scale of 0 to 3 based on the strength of available evidence for a given trade route.

Historical Document Score (S_{doc}): Reflects the frequency and significance of a route's mention in primary source documents.

- 0: No significant mention.
- 1: Infrequent or secondary mentions.
- 2: Frequent mentions as a known trade route.

- 3: Consistently cited as a primary artery for high-value goods such as textiles.

Infrastructure Score (S_{infra}): Quantifies the physical evidence of trade infrastructure.

- 0: No evidence of specialized infrastructure.
- 1: Evidence of basic roadside inns.
- 2: Documented presence of multiple or large-scale caravanserais or funduqs.
- 3: Strong evidence that this infrastructure specialized in the textile trade.

Archaeological Score (S_{arch}): Based on direct physical evidence of textile production or trade.

- 0: No significant textile-related finds.
- 1: Sporadic finds of traded textile fragments.
- 2: Evidence of textile workshops or concentrated tool finds.
- 3: Evidence of large-scale production facilities, such as extensive dye vats.

Scholarly Assessment Score (S_{schol}): Synthesizes the consensus view from modern secondary scholarship.

- 0: Not considered significant by modern historians.
- 1: Regarded as a minor or regional route.
- 2: Widely considered an important route for general trade.
- 3: A strong consensus exists that this was a critical route specifically for the silk/textile trade.

The weights for each factor were allocated based on our assessment of their relative reliability as indicators of textile trade intensity. The weights sum to 1.0.

Historical Documents (W_{doc}) = 0.3 (30%): Assigned a high weight as textual evidence provides the most direct narrative account.

Scholarly Assessment (W_{schol}) = 0.3 (30%): Also weighted heavily as it represents a synthesis of all available evidence.

Infrastructure (W_{infra}) = 0.25 (25%): A strong indicator, but its specific use can be less certain than texts.

Archaeological Evidence (W_{arch}) = 0.15 (15%): Receives the lowest weight due to potential preservation bias.

For instance, a major overland route to Baghdad might score: $S_{doc} = 3$, $S_{infra} = 3$, $S_{arch} = 2$, $S_{schol} = 3$.

Its index score would be:

$I_{Baghdad} = (0.3 \cdot 3) + (0.25 \cdot 3) + (0.15 \cdot 2) + (0.3 \cdot 3) = 2.85$. This high score (out of 3.0) justifies a thick line width in the network visualization.

Material-Acoustic Pathway Analysis

The second component of our methodology is a focused analysis of the material evolution of the short-necked, fretless lute, specifically the transition from the Arabic Oud to the early European Lute. This analysis proceeds in two steps, focusing on material selection and technological adaptation.

- **Step 1: Material Sourcing and Analysis:** This step involved a comprehensive review of historical, iconographic, and organological sources to determine the primary materials used in lute construction in different regions and periods. We paid special attention to the materials used for strings and the resonant body. Our research confirmed a strong geographical and historical division: the use of twisted silk for strings was prevalent in Persia, the Arab world, and Central Asia—a direct byproduct of the region’s dominance in silk production and the textile trade. In contrast, European luthiers increasingly adopted strings made from sheep or cattle gut (*catline*), a locally sourced animal-based fiber. Similarly, specific tonewoods were mapped according to their native availability and trade routes.
- **Step 2: Material-Acoustic Hypothesis:** Based on the material analysis, we formulated a key hypothesis: the distinct physical properties of silk versus gut strings provided a material impetus for the divergence of musical aesthetics and instrument technology. The core of our hypothesis rests on the well-documented differences between these materials in materials science and acoustic physics. Silk fiber, composed primarily of fibroin, is known for its relatively high elasticity and lower density compared to processed animal gut (*catline*), which consists of collagen fibers and is significantly denser and stiffer. According to fundamental principles of string acoustics (the Mersenne-Taylor laws), a string’s timbre (音色) is heavily influenced by its material density and stiffness. A less dense, more flexible string (silk) tends to produce a richer spectrum of upper partials (overtones) and a longer sustain. Conversely, a denser, higher-tension string (gut) for a given pitch produces a stronger fundamental tone with a quicker decay of overtones, resulting in a clearer, more focused sound. Our hypothesis, therefore, posits that the acoustic properties derived from silk’s physical structure are highly conducive to the subtle pitch bending and rich ornamentation idiomatic to the Maqam system, while the stability and clarity of gut strings are better suited to the discrete, well-defined pitches of the European modal system, particularly in the context of emerging polyphony. Silk has lower tensile strength and higher elasticity than gut. Acoustically, this results in a sound with a richer spectrum of upper partials and a longer sustain; their flexibility is highly conducive to the subtle pitch bending, slides, and microtonal inflections idiomatic to the Maqam

system. Conversely, gut is denser and has higher tension for a given pitch, producing a clearer, more focused fundamental tone with less complex overtones. Its stability and powerful projection are better suited to the discrete, well-defined pitches of the European modal system, particularly as music moved toward polyphony, where clarity of individual lines was essential. This hypothesis argues that as the Oud migrated westward, away from the centers of silk production, the scarcity and high cost of silk strings compelled European instrument makers to adapt to locally available gut. This material substitution was not neutral; it favored a different sound and playing technique, creating a physical, acoustic pathway that facilitated the gradual shift from the fluid melodic contours of Maqam to the more defined scalar structure of Mode.

RESULTS AND DISCUSSION

The application of our dual-methodology yielded significant results that illuminate the deep connections between the textile trade and musical evolution. This section incorporates the primary visualization from our network analysis to visually substantiate our claims regarding co-migration patterns and the profound impact of material availability on instrument technology. Our discussion reframes these findings to consistently emphasize the textile trade network and material supply chain as the primary causal agents for the observed changes.

The historical network analysis produced a compelling visualization of the convergence of material and cultural flows, establishing a strong correlation between textile trade corridors and the pathways of cultural transmission. Figure 2 presents the resulting network map, which serves as the primary data visualization for this part of the analysis. The weighted map of the textile trade clearly showed that the most robust and high-traffic corridors were not exclusively conduits for silk bolts and cotton bales. When the data points of musical activity were overlaid, a clear pattern of convergence was observed, demonstrating that musicians, instrument makers, and scholars did not travel randomly; their movements followed the established, secure, and well-resourced pathways forged by the textile trade.

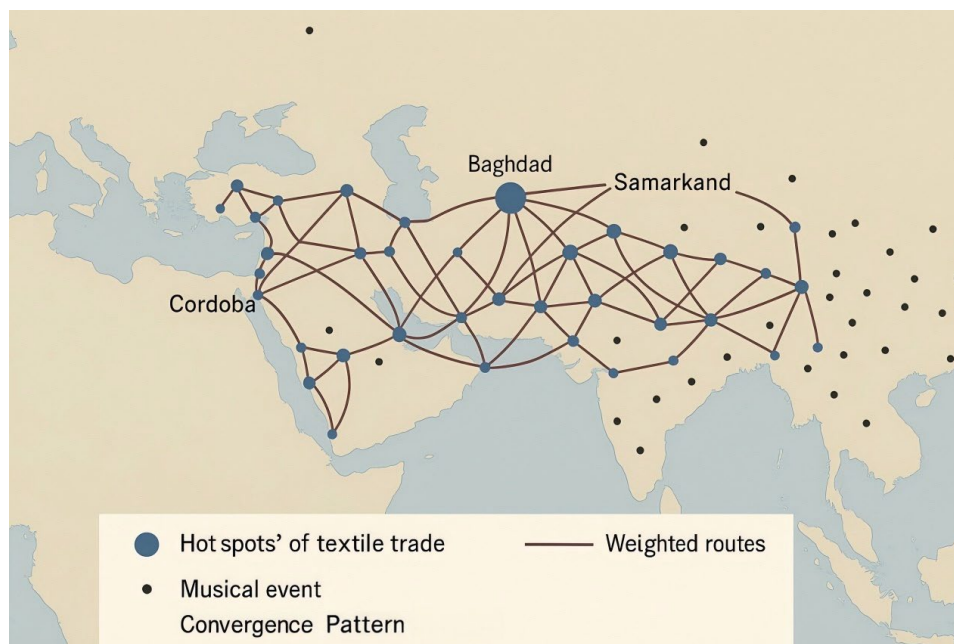


Figure 2. The historical network map of the textile trade network and the dissemination path of music culture from the 8th to the 15th century

The network's central hubs—cities that functioned as critical nodes in the textile supply chain—emerged unequivocally as epicenters of musical innovation and syncretism. For instance, Baghdad during the Abbasid era, the nexus of overland routes from the East and a major consumer of luxury textiles, was also the undisputed center for the development and codification of *Maqam* theory. Further west, the oasis cities of Samarkand and Bukhara, critical stopovers for silk caravans, were melting pots where Persian, Turkic, and Arabic musical traditions blended. Most strikingly, in Europe, the port city of Venice, which grew rich controlling the maritime trade of Eastern textiles, also became a primary gateway for the introduction of Eastern musical concepts and instruments, including the lute. Similarly, the cities of Al-Andalus, such as Cordoba, which were renowned for their silk weaving (*tiraz*) workshops, were the very locations where the *Oud* flourished and where the intellectual cross-pollination that influenced early European music theory was most intense.

These cities were not merely geographic crossroads but dynamic cultural reactors. The daily interactions between merchants, artisans, and scholars from disparate regions created an environment of constant intellectual exchange. A Persian merchant brought not only bolts of silk but also the melodies of his homeland; an Andalusian luthier repaired not only trade goods but also might absorb new instrument-making techniques from a traveling musician. The trade network, therefore, did more than transport material goods; it created

the necessary social density for cultural fusion and innovation to become inevitable. Figure 3 provides a conceptual map of these key hubs, illustrating their central role as points of convergence for trade and innovation.

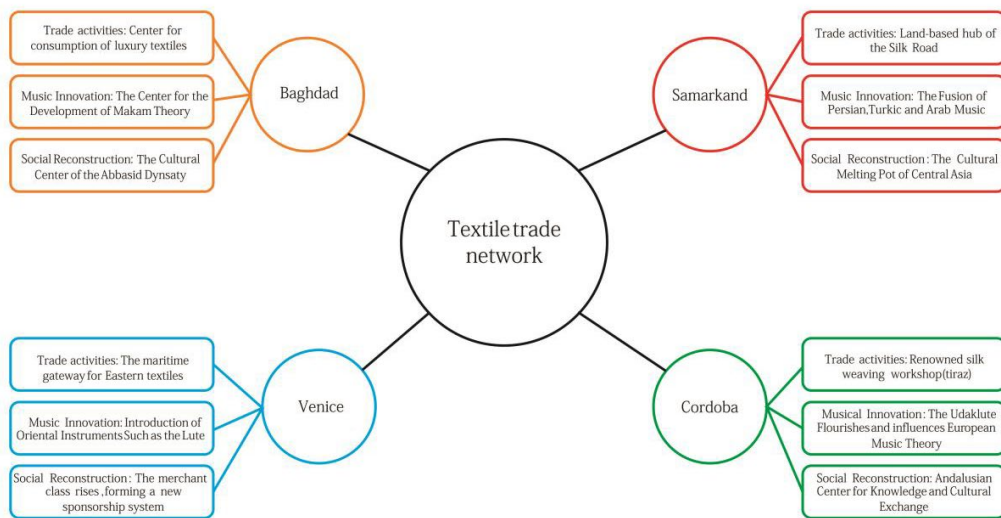


Figure 3. The convergence point of trade, music, and identity

The material-acoustic analysis of the *Oud*-to-Lute transition provides a causal mechanism for the musical shifts observed, highlighting the impact of supply chain constraints on material selection and instrument design. The evolution of this instrument was not merely a matter of changing tastes, but was heavily constrained and directed by the available material palette, which was arbitrated by the trade network. In the heartlands of the Silk Road, instrument makers had ready and affordable access to high-quality silk for strings—a direct byproduct of the textile economy. This material choice reinforced and amplified the aesthetic values of the *Maqam* system. The ability to execute subtle ornaments and microtones on pliable silk strings was central to the expressive power of the music. As the instrument moved into Europe, however, the supply chain for silk became longer, more precarious, and vastly more expensive. Silk was a finished luxury good, and its raw form was not widely available for a secondary craft such as string making. European artisans, therefore, initiated a supply-chain-driven process of material substitution, turning to an abundant local resource: animal intestines. This material substitution likely had profound acoustic and technological consequences. Playing *Maqam*-style microtonal music on high-tension gut strings is physically more difficult and acoustically less satisfying; the material itself would have been acoustically less conducive to such techniques. Instead, the clarity and stabil-

ity of gut strings lent themselves to the clear articulation of distinct pitches—a quality that became increasingly valued in the developing European tradition of sacred chant and nascent polyphony.

The sound produced by a gut string has a strong fundamental tone and a rapid decay of overtones, which allows individual melodic lines within a multi-voiced texture to remain distinct and audible. It is plausible that the rich, lingering harmonic spectrum of silk could have created a sonic blur, potentially undermining the auditory clarity that was becoming the paramount aesthetic goal in Europe's move toward complex counterpoint and harmony.

This material shift likely triggered a cascade of downstream technological innovations. To compensate for the higher tension of gut, lute makers had to reinforce the instrument's neck and body, leading to the addition of frets. This design change further codified the discrete pitches of the modal scales, moving the instrument's technology decisively away from the fretless *Oud* and its associated musical logic. This model suggests that the textile trade, by controlling the distribution and cost of silk, inadvertently set the material conditions that plausibly favored a different musical and technological trajectory in Europe.

Beyond the physical instruments, the textile trade created a unique social ecology that fostered musical hybridization, illustrating the broader socio-economic impact of the trade network. The immense wealth generated by textile commerce gave rise to a powerful and sophisticated merchant class in cities such as Venice and Cordoba. This new class of patrons had a worldview shaped by international commerce and a taste for the exotic, distinguishing them from the traditional aristocracy and the church, the two main patrons of music in medieval Europe. Their identity was cosmopolitan, and their cultural consumption reflected their position within the global trade network. For this burgeoning bourgeoisie, music was not only entertainment but also a marker of social status and cultural sophistication.

Unlike the Church, whose musical patronage was bound by liturgical function and theological doctrine, the merchant class was free to sponsor music that reflected their worldly, commercial identity. This new social function for music—as entertainment, a display of wealth, and an expression of a global outlook—opened a space for innovation where musicians could experiment with hybrid forms that were both evocative of the exotic East and intelligible to local tastes.

The patronage of these merchant families created a demand for new forms of music that blended elements from different traditions. The lute, with its direct lineage to the esteemed Arabic *Oud*, became a symbol of this worldly identity. The music played on it often incorporated the rhythmic complexities and melodic ornamentation of the East but was structured according to Western modal sensibilities. This hybrid music was a

perfect reflection of the patrons' own liminal identity—geographically European, but economically and culturally oriented toward the wider world of the trade network. In these trading hubs, music was actively used to perform and reconstruct a new social identity born directly from the economic matrix of the textile trade. The merchant's parlor, adorned with Persian carpets and Damascene silks, became a new type of concert hall where the sounds of a globalized world were synthesized, all underwritten by the profits of textile commerce. It is crucial to acknowledge that the material and economic framework highlighted in this study is not presented as the sole determinant of cultural evolution. The historical development of musical systems is an undeniably multifaceted process. Other significant forces—such as the liturgical requirements of religious practice, the specific aesthetic tastes of royal courts, and the direct intellectual exchange between scholars and musicians—undoubtedly played important roles in shaping musical traditions. This paper does not seek to discount these factors. Rather, it aims to establish the material supply chain as a foundational framework that created the conditions, constraints, and possibilities within which these other cultural developments unfolded. In this view, the availability of specific materials did not rigidly determine a single cultural outcome, but it significantly shaped the probabilistic path of technological and aesthetic change, making certain evolutionary trajectories more likely than others.

CONCLUSION

This study has re-grounded the history of cultural transmission in the material realities of trade and production, demonstrating that the profound cultural shift from the Arabic *Maqam* to the European *Mode* was not an abstract process of influence, but was intimately correlated with the physical structure of trade routes, the material properties of traded goods, and the social dynamics fostered by commercial exchange.

Our research has yielded three primary conclusions. First, the historical network analysis confirms that the pathways of musical migration along the Silk Road show strong qualitative correspondence with the primary corridors of the textile trade, with the commercial hubs of this network also serving as creative crucibles for musical syncretism. Second, the material evolution of the lute family, particularly the supply-chain-driven shift from silk to gut strings, provided a crucial physical and acoustic basis for the divergence of musical systems, representing a pragmatic adaptation to a new material environment dictated by the logic of the trade network. Third, the textile trade engendered a new merchant class whose cosmopolitan identity and patronage created a fertile social ground for the development of hybrid musical forms, which served as audible expressions of their unique place in a changing world.

The implications of these findings are significant. For the field of textile research and history, this study offers a new model for conceptualizing the cultural impact of the textile trade, moving beyond seeing textiles simply as traded objects to reframing the trade network itself as an active agent in the transmission and transformation of intangible culture. It provides a quantifiable methodology for assessing the role of textile trade in the dissemination of ideas, expanding the scope of textile cultural history. For historical musicology, this research provides a robust, materialist counterpoint to studies that rely primarily on stylistic comparison or textual analysis, by proposing a specific, evidence-based causal chain that links macro-level trade dynamics to micro-level acoustic realities. It challenges traditional narratives that attribute musical evolution solely to a vague notion of “influence” by insisting that material conditions are foundational. Specifically, our model demonstrates how supply-chain logistics can compel a material substitution (gut for silk), which—based on documented physical properties—plausibly alters acoustic potential and, in turn, favors a divergent aesthetic path. It argues that to fully understand why musical systems change, we must look not only at notes on a page but also at the wood, gut, and silk from which the music was made, grounding theories of cross-cultural musical influence in the tangible world of resources, technology, and the fundamental principles of physics. This study is not without its limitations. The network model relies on historical data that is often incomplete, requiring the use of proxies to estimate trade volume, which introduces a degree of uncertainty. Furthermore, while our material-acoustic analysis is now grounded in established scientific principles regarding the properties of silk and gut, its application to explain historical change remains a powerful but theoretical hypothesis. This crucial distinction reinforces, rather than diminishes, the need for the further empirical testing we propose.

These limitations point toward several promising avenues for future research. The central acoustic hypothesis could be tested through experimental archaeology: constructing replica instruments with both silk and gut strings to physically measure their acoustic properties and assess their suitability for different musical repertoires. Furthermore, a more granular analysis could trace the trade routes of specific tonewoods—such as maple, ebony, and spruce—used in lute and *Oud* construction, adding another layer to the material network model and examining how the availability of these woods influenced instrument design and sonority. A more granular network model could also be developed by incorporating additional datasets to refine the weighting of trade routes. Finally, this methodology could be expanded to analyze the transmission of other intangible cultural forms or applied to other major trade networks, such as the Indian Ocean maritime trade, to test the broader applicability of a materially grounded approach to cultural history.

Author Contributions

All work in this study was independently completed by Zhongbei MA.

Conflicts of Interest

The author declares no conflict of interest.

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