Murano Glass, Continuity and Transformation (1400–1800)[1]

Francesca Trivellato

Visitors arriving at the Venice airport in the last few years have been greeted by a sizeable poster, among other advertisements, promoting a new trademark for artistic blown-glass made in Murano (Figure 10). The poster depicts a middle-aged, dark-haired and well-built man wearing an apron; his shirt is unbuttoned and his sleeves up are rolled up. On a table in front of him lie his metal tools and a refined golden glass bowl. In the background, the fire is burning in a glass furnace. The slogan on the picture says: "No Global"; in smaller fonts, one also reads, "Murano glass is only made in Murano."[2] The message is simple and effective: the millenarian artisanal craft of glass blowing is still alive in Murano and a new trademark guarantees quality in a mass-consumption market flooded with counterfeit objects. The subtext is all too evident: masculinity embodies the artisanal, local, secretive know-how that has remained uncorrupted over the centuries.

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[1]I am grateful to Cesare Moretti for his help with questions about glass technology. This article builds on Trivellato, *Fondamenta dei vetrai*. In the Venetian system of money of accounts, 1 ducat = 6 lire and 4 soldi, or 24 grossi; 1 lira = 20 soldi. In this article I will use the following abbreviations: ACPV = Archivio della Curia Patriarcale di Venezia; ASV = Archivio di Stato di Venezia; BMC = Biblioteca del Civico Museo Correr di Venezia; BNM = Biblioteca Nazionale Marciana di Venezia.

[2]The picture is part of the advertising campaign for the trademark "Vetro Artistico Murano." It can be seen at www.muranoglass.com. Campaigns for trademarks such as this have been spurred by recent regulation imposed by the European Union (including new rules about environmental standards); they stirred resentment among medium- and small-scale artisan producers who were hit hard by the costs of implementing such regulation. Some remarks on the centrality of Murano glass in today's Venetian tourist industry are to be found in Davis and Marvin, *Venice, the Tourist Maze*, 173. For interesting parallels with the changing representations and self-representations of artisans in today's Greece, see Herzfeld, *The Body Politic*.

The purpose of this article is to show that glass making in Murano and Venice (because glass items were in fact made in Venice too) has always been a dynamic craft and not the exclusive province of men. From its flourishing in the fifteenth century to its profound reorganization in the latter part of the twentieth century, glass making underwent radical changes and incorporated many incremental innovations –which followed different paces at different moments and in different sectors. In this article I will focus on the significant transformations that reshaped the craft in various ways during the early modern period in response to both local demand and foreign competition.

The masculine characterization of glass making is itself a historical product. In early modern Europe, guilds restricted access to high-status occupations, and the position of master glassblower in particular, to men, and generally (though not always) to men of local birth and descent. As a consequence, in Venetian glass manufacturing as in most European skilled industries, socio-economic hierarchies were intertwined with gender hierarchies. As recent scholarship has amply demonstrated, discrimination against women as guilds prescribed it did not mean that women, including independent unmarried women, were excluded from the skilled and semi-skilled labour force.[3] Venetian glass manufacturing was a segmented and highly diversified economic sector. Kept away from the high-status, high-pay jobs in the Murano furnaces, women were employed in greater numbers in the secondary operations of bead manufacturing in the town of Venice.[4] Their role accounts for a substantial part of the story of Venetian glass' success at home and abroad.

Glass manufacturing figures prominently among the examples of the rise and fall of the city's industries during the early modern period, and of the decline of Venice as a production centre in the seventeenth

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[3]Ogilvie, *A Bitter Living* and 'How Does Social Capital Affect Women?'.

[4]There is no biological reason why women were excluded from glassblowing, considering that they have the lung capacity to perform this task. However, any master glassblower needs the assistance of one or more aids. These aids were young male apprentices in the guild. To allow women to become master glassblowers would have required that they be assisted by a male subordinate—a threat to gender hierarchy with no precedent in the city's crafts. Women thus specialized in jobs such as silk spinning or bead stringing that were low in status and could be carried out in all-female environments. The long-term patterns of such labour discrimination are all too evident. On gender norms in the artisanal world of contemporary Greece, see Herzfeld, *The Body Politic*, 90–98.

century more specifically. Guild organization and state intervention have been blamed alternatively for this decline.[5] In line with arguments developed by the recent historical literature and other contributions in this volume, this article revises the conventional account by examining the structural changes that took place in Venetian glass manufacturing from 1400 to 1800, and draws attention to the seventeenth and eighteenth centuries, when foreign competition was most intense. It contends that guilds shaped the direction of these structural changes in many ways, but were not simply rent-seeking institutions. In the hands of capable entrepreneurs, they became malleable tools of winning short- and medium-term economic strategies. The constraints that they placed on technological and organizational developments, moreover, should be examined in light of the limitations imposed by local geographical conditions. The profile of Giorgio Barbaria that opens this article illustrates the ways in which entrepreneurs could exploit the organization of urban production (including guild and state supervision) and, at the same time, testifies to the cumulative effects of long-term processes of change in the industry.

1. Giorgio di Antonio Barbaria, an Eighteenth-Century Glass Entrepreneur[6]

Giorgio Barbaria was a third-generation resident immigrant in Venice. His family was originally from a village in the Alps, Ampezzo (today Cortina d'Ampezzo).[7] At the beginning of the eighteenth century,

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[5] Cipolla, 'The Decline of Italy,' first pointed to guilds' responsibility for keeping labour costs high and opposing technological innovation. Rapp, instead, held the Venetian government responsible for the same phenomena; Rapp, *Industry and Economic Decline*.

[6] I call Barbaria an "entrepreneur" because, although it is uncertain to what extent he created new products and production methods, he was nonetheless an innovator in the quest for outlet markets for his products and he aptly manipulated guild regulations. His entrepreneurial role should be understood in the context of a corporate economy rather than as the embodiment of Schumpeter's ideal-type entrepreneur.

[7] Until the end of the war of the League of Cambrai (1509), Ampezzo was part of the Venetian state. It then passed under Habsburg rule, but maintained a privileged position in the Austrian territories. In 1810 it was temporarily annexed to Napoleon's Italian Kingdom, and then, after the First World War, it was annexed to Italy. See Mariotti, *Cortina nei secoli*.

Giorgio's grandfather joined some of his townsmen working in Venetian glass bead manufacturing.[8] In 1754, a booming year for Venetian glass beads,[9] Giorgio's father, Antonio, was elected head official of the *perleri* or *suppialume* guild.[10] This guild controlled the production and sale of lamp-beads (*perle a lume*), which were made by melting glass rods of various colours and designs on an oil lamp. A different guild, the *pateronostreri* or *margariteri*, was in charge of the making and local retail of small seed-beads, known in Venice as *conterie*; these were made by cutting thin and hollowed glass rods into small fragments, which were then rounded off manually.

Glass beads were traded extensively in colonial markets and factored into the mercantilist policies of several European states. In 1767, the Imperial consul in Venice informed Vienna that, to his surprise, Venetian glass bead manufacturing employed thousands of people and was worth several million ducats.[11] As evidenced by the visit of future emperor Joseph II to some Venetian glass furnaces and workshops in the summer of 1769, the Habsburg crown was interested in the trade.[12] In 1767, in violation of the Venetian laws that forbade the export of specialized labour and raw materials pertaining to the glass industry, Giorgio Barbaria worked for the Austrian government in an attempt to establish a factory of seed-beads in Ampezzo as part of Maria Theresa's *Mercantil-Schema*.[13] Since the late 1640s, documents attest to the illicit export of semi-finished products necessary to make both seed and lamp-beads from Venice to Ampezzo.[14] Ampezzo, however, never became an important centre of glass bead production.

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[8] Most information on the Barbaria family is drawn from the records of the parish where they resided in Venice. The occupation of Giorgio's grandfather in 1705 is documented in ACPV, *Parrocchia di Santa Maria Formosa. Registri battesimi*, registro 9, fol. 247.

[9] ASV, *Cinque Savi alla Mercanzia, II Serie*, busta 359; ASV, *Inquisitori di stato*, busta 820.

[10] ASV, *Inquisitori di stato*, busta 822.

[11] ASV, *Inquisitori di stato*, busta 903.

[12] ASV, *Inquisitori di stato*, busta 821.

[13] ASV, *Inquisitori di stato*, buste 819, 820, 822. See also Preto, *I servizi segreti*, 415–416. This was not the first attempt to establish such a factory in Ampezzo, but none had proved successful in the previous fifteen years.

[14] ASV, *Arti*, busta 437 (*Mariegola dei perleri e suppialume*, fols. 49v–56r). In 1766, Venetian guild masters complained that Germans from Ampezzo ("tedeschi sive ampezzani") had long been illicitly exporting glass rods to their village; ASV, *Censori*, busta 28.

After the aborted Habsburg project, Barbaria shifted his efforts toward Venice and devoted his energy to expand the markets for his glass beads. In a period when Venetian patricians and merchants became more and more sedentary, Barbaria sailed off to Spain at least four times, to Portugal three times, to France and perhaps England. He also had a vessel built for his commodity trade between Venice and Lisbon. In 1775–76, he embarked for Cadiz and Lisbon, where he traded in colonial goods and oversaw the arrival of his *conterie*. The Portuguese capital was a major outlet for these types of Venetian beads, which were used in the Atlantic slave trade – low-quality beads were actually called *contaria da Lisbona* in Venice because of the destination to which they were shipped. In spite of his previous association with the Habsburgs, Barbaria succeeded in obtaining the support of Venetian magistrates, who facilitated his travels in return for information and industrial espionage. In reality, these travels served his personal interests more than they benefited the Venetian glass sector as a whole.[15]

Economic success facilitated Barbaria's ascent in the world of guilds. In 1780, as his father had done a quarter century before, he became the head official of the *perleri* or *suppialume*. In the 1780s, he continued to travel along the routes most profitable for his trade in glass beads. In 1790, he claimed to have exported seed beads worth 200,000 ducats in the previous two years[16] – a remarkable percentage of Venice's exports of this product (Table 1). Born in Venice of a family who immigrated there two generations before, Giorgio was still considered an *ampezzano* (a man from Ampezzo) by the Venetians and himself regarded Ampezzo as his motherland.[17] His full recognition by Venetian society and corporate institutions was, clearly, incomplete.

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[15] Barbaria also counted on personal networks. In 1775, his brother-in-law was the Venetian consul in Lisbon, and later moved to Barcelona, where Giorgio arrived in 1787. On Barbaria's travels see ASV, *Cinque Savi alla Mercanzia. I Serie*, busta 693; ASV, *Cinque Savi alla Mercanzia. II Serie*, busta 385; ASV, *Inquisitori di stato*, buste 156, 821, 823. On his ship, see ASV, *Notarile atti*, busta 4602, fols. 4128r–4129r; busta 4246, fol. 2878r; busta 10286, fol. 5068v; busta 10304, fol. 8668v.

[16] ASV, *Censori*, busta 21.

[17] See Barbaria's letters and other documents collected by the Venetian magistrates inquiring about him; ASV, *Inquisitori di stato*, busta 819. In the *post-mortem* inventory of Gianmaria Barbaria, a relative with a glass bead shop in Venice, mentions a "signor Zorzi Barbaria d'Ampezzo" (our Giorgio or an homonymous relative from Ampezzo?); ASV, *Giudici di Petizion. Inventari*, busta 472.43.

In March 1790, following an established practice, the Venetian government announced the issuing of a monopoly patent to anyone able to produce dark glass bottles that resembled those made in England. In January 1791, Giorgio Barbaria acquired the monopoly.[18] It is unclear how exactly he went about producing such dark glasses, given that they required higher temperatures than those that Murano furnaces allegedly reached. In England, a new type of glass bottle –darker, stronger and thicker than those commonly available– began to be made in the middle of the seventeenth century after coal replaced timber in glass furnaces.[19] Coal was introduced into Murano only in the twentieth century, but higher furnace heat could be obtained by introducing a grill separating fuel and crucibles in a timber furnace. The introduction of such a grill in Venetian glass furnaces is usually dated to the 1850s.[20] At the same time, we know that in 1774 a chemistry professor, Marco Carburi, had recommended that some innovations be made in the structure of Murano's furnaces.[21] Although the glassblowers' guild permitted this experiment to be conducted only in one furnace, it is possible that Barbaria had access to sufficient technological information to adapt the structure of his furnaces to make dark glass bottles.

The economic gains deriving from the monopoly of dark glass bottles, however, do not seem to have been the driving force of Barbaria's initiative. With this monopoly also came a dispensation from the Murano guild's prohibition on non-natives of Murano owning and running a glass furnace. Already in June 1791, after claiming that he had made over 26,000 dark glass bottles, he petitioned the central magistrates to enter the Murano guild as a merchant-producer. His request was initially turned down. Barbaria assured the state authorities of his good intentions and noted that he had excellent raw materials, but repeatedly denounced the many obstacles to production that he faced, including the absenteeism and ineptitude of master glassblowers and the sabotage of Murano guild members. In January 1792 he again requested the

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[18] ASV, *Inquisitori di stato*, buste 818 and 820. Barbaria's bottle furnace is also mentioned in Cecchetti, *Monografia della vetraria*, 36–37; Gasparetto, *Il vetro di Murano*, 129; Panciera, 'L'economia,' 547; Zecchin, 'I fondenti dei vetrai muranesi.'

[19] Godfrey, *The Development*, 228–229.

[20] Zecchin, *Vetro e vetrai*, 1:339.

[21] Gasparetto, *Il vetro di Murano*, 128; Zecchin, *Vetro e vetrai*, 1:338–339. On the resistance to coal and English furnaces in France, see Scoville, *Capitalism and French Glassmaking*, 158–163.

interruption of dark bottles production. This time, he was allowed to do as he wished. Barbaria had no intention of abandoning his investment in glass manufacturing tout court. After some hesitation, the state magistrates granted him a new passport to travel to Spain and England, where he was to dispatch his seed-beads and gather information on the glass production of competing European countries.[22] Back in Venice, in September 1792, Barbaria resumed production of dark-glass bottles with the sole purpose of being permitted to enlist among the citizens of Murano and enrol in the glassblowers' guild, a privilege that he finally was granted in 1793.[23] Indicative of his real aims is the fact that Barbaria also asked permission to experiment with a book of recipes to make colored glass rods that he had purchased from the widow of one of the largest Murano producers of enamels. It was by making and selling glass beads, not dark bottles, that Barbaria made his fortune. And it was by appealing to central government authorities that Barbaria circumvented and finally broke through the most restrictive of the Venetian guilds, that of the Murano glassblowers.

Thus, not long before Venetian guilds were dismantled in 1806–08, a successful merchant producer who traveled across the Western Mediterranean and Europe still aimed at entering the prestigious guild of Murano glassblowers. To his eyes, membership in this guild probably provided less economic advantages in terms of access to skilled labour, raw materials and information than it conferred a special rank on the son of immigrant artisans. It was by acquiring the monopoly of dark-glass bottles that Barbaria made his way into the guild hierarchy. But dark glass bottles, which required raw materials and technology scarcely available in Venice, could not compete with the much better English equivalent. Barbaria knew this, and therefore invested more in glass beads and seed-beads in particular. That is, he invested in a traditional product that did not require any technological innovation but yielded high profits. As we will now see, the structural evolution of Venetian glass manufacturing made beads a profitable business and goes a long way toward explaining Barbaria's economic strategies.

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[22] ASV, *Inquisitori di stato*, busta 823.

[23] Zanetti, *Il libro d'oro*, 108.

2. Guilds, Technology, and Innovation

In the fifteenth century, as Near Eastern glass production declined, Venice established itself as the world leader in glassmaking.[24] Murano's primacy was due to the incomparable quality of its crystal glassware, which in turn derived from the use of pure raw materials and the training of skilled workers. The primary component of glass paste is silica (the vitrifying agent). Pure silica, however, melts only at over 1700° C, a temperature that preindustrial furnaces were unable to reach. Various ingredients (fluxing agents) were thus added to siliceous sands in order to lower their melting temperature. Before modern chemistry synthesized artificial elements, all chemical reactions were neither based on the use of pure ingredients, nor fully intelligible to their practitioners. Chemical innovations were thus the outcome of trial and error, progressive approximations, and the involuntary inclusion of raw materials that contained residual components sometimes irrelevant and sometimes useful to the chemical process.

In the early fifteenth century, a crystal glass of unprecedented transparency was developed in Murano by using a combination of a pure vetrifier (river pebbles) and a flux obtained from leaching vegetable ashes.[25] The glassblowers' guild did not permit the use of any other fluxing materials until the early eighteenth century. These ashes of seashore plants were very expensive. The best were imported from Syria and Egypt; others, of acceptable quality, were brought from Sicily, Spain and Malta. Later, glass furnaces used ashes from plants growing in the lagoon of Venice with suitable results.[26] After these ashes were leached

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[24] On glass technology in early modern Europe, see Charleston and Angus-Butterworth, 'Glass'; Toninato, 'La sezione tecnologica'; McCray, *Glassmaking in Renaissance Venice*; Moretti, Salerno and Ferroni, *Ricette vetrarie muranesi*, 25–29.

[25] The Murano glassblower Angelo Barovier has long been credited as the inventor of this kind of crystal glass around the year 1450; Zecchin *Vetro e vetrai*, 1:199–211, 220–224. Documentary evidence, however, indicates that he was the one who perfected this technique, but the invention actually occurred at the beginning of the fifteenth century; Jacoby, 'Raw Materials.' On the importance of Levantine ashes for European manufacturing, see Ashtor and Cevidalli, 'Levantine Alkali Ashes.'

[26] Vegetable ashes varied in price according to quality and market availability. In the seventeenth century, the best ones normally cost about 50 ducats per pound of 477 kg (ASV *Giudici di Petizion. Rendimenti di conto*, busta 978 and Coronelli, *Isolario*, 1:39). In the 1770s, ashes from Spain and Sicily could cost less than 40 ducats, but their price could also go up to 75 ducats, while locally available ashes (*roscano*) cost only 14 ducats (ASV, *Censori*, buste 38 and 39). On the search for cheaper substitutes

and the insoluble salts (calcium and magnesium carbonates, silico-alluminates) filtered, a solution that consisted of almost pure sodium carbonate was obtained and this solution was used as flux.[27] In the middle of the sixteenth century, the German physician Georg Bauer (pseud. Giorgio Agricola, 1494–1555) described sodium ashes as the main "secret" behind the extraordinary quality of the glass made in Murano.[28]

The vitrifying agent used in Murano was obtained from quartz pebbles of the nearby rivers, preferably the Ticino or the Adige. Once ground, these pebble turned into a powder that was very rich in silica (with contents up to 98%).[29] The vitrifying and fluxing agents were mixed together and placed in a reverbatory furnace where, at a temperature of ca. 800°–900° C, chemical reactions began to take place and the so-called *frit* was formed. The frit was then poured in crucibles, which were placed in the main furnace; there the actual melting process took one to a few days at a temperature that experts presume was around 1100–1200° C.[30] In this second stage, manganese oxide was added as a decolourizer for crystal glass, and a number of metal oxides (such as lead) and various salts were added to make glasses and enamels of specific colours. At this point, molten glass was ready to be blown or shaped into rods and plates.

These methods of Venetian glassmaking remained virtually unchanged for about two hundred and fifty years. They were first made public in a printed manual entitled *L'arte vetraria* (*The Art of Glass*), published by the Florentine abbot Antonio Neri (1576–ca.1614) in 1612. Neri observed and possibly even worked with Venetian masters in Murano, Tuscany, and the Low Countries. His *L'arte vetraria* purported to reveal the "secrets" of Venetian glassmaking, but the complexity of the production processes and the incomplete descriptions in

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for vegetable ashes in late-eighteenth-century Venice, see Bassani, 'Gli scienziati veneti.'

[27] It remains unclear how the oxides necessary to stabilize glass (calcium magnesium oxides and alumina) were introduced in the paste because the leaching process should eliminate them and no recipes indicate the presence of alkaline earth carbonate.

[28] Agricola, *De re metallica*, 583.

[29] Verità, 'L'invenzione.'

[30] For a description of Venetian glass furnaces, see McCray, 'An Integrative Review and Examination of Glass Furnace Technology.' Only one author argues that wood-fired glass furnaces could reach temperatures of 1350° C; Cable, 'The Operation,' 319.

Neri's manual limited the impact the book had in fostering foreign competition by disseminating specific know-how.[31] The text nonetheless enjoyed great success, was translated into numerous languages, and arguably inspired some of the experiments carried out by the major inventors of new types of glass in England and Germany.[32]

During the seventeenth century, and more intensively during its last twenty-five years, revolutionary inventions and innovations introduced in England, Bohemia, and France challenged the supremacy of Venetian glass technology. These developments are generally considered to have halted Venetian competitiveness in the production of blown-glass objects, especially crystal glass. After 1615, coal (instead of wood) became the only fuel allowed in English glass furnaces.[33] Subsequent changes in the structure of English glass furnaces led to further increase in temperature and made it possible, among other things, to produce the kind of dark bottles that Barbaria struggled to imitate. In 1676, George Ravenscroft patented in England a lead-based crystal glass known as *flint glass*. That same year, Johann Kunckel obtained a crystal glass using potash in place of soda in Bohemia.[34] English *flint glass* and Bohemian potash-crystal could now compete with Venetian sodium-based crystals in terms of quality, and Bohemian glass (if not English *flint*) had the advantage of being made with considerably cheaper raw materials. In addition, Venice suffered competition from France, where in 1665–66 Finance Minister Colbert set up the *Manufacture Royale des Glaces de Miroirs* to produce mirrors on a larger scale than in Venice, and hired some glass workers from Murano. The turning point in this French enterprise occurred in 1688, when a new technique of mirror making was patented.[35] In Venice, "crown" mirrors were made out of blown cylinders of melted glass, which masters stretched manually into rectan-

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[31] Various authors have stressed the limited impact of the printing press in the diffusion of technological knowledge in comparison to the importance of the circulation of skilled labour. See Cipolla, *Before the Industrial Revolution*, 154–159; Epstein, 'Property Rights.'

[32] On the impact of Neri's publication and translations, see the introduction by Rosa Barovier Mentasti to Neri, *Arte vetraria*.

[33] Price, *The Patents of Monopoly*, 72; Godfrey, *The Development*, 150–155.

[34] Charleston and Angus-Butterworth, 'Glass,' 221–224. Ravenscroft was most probably a keen entrepreneur rather than the actual inventor of this new product; MacLeod, 'Accident or Design?'. On the possible contribution of Murano émigrés to this invention, see Moretti, 'The Development of Lead Crystal in England.'

[35] Barrelet, *La verrerie en France*, 81–82.

gular shapes. In Paris, cast-place mirrors were now made by pouring melted glass paste on a large surface and then polishing the surface. Thanks to this new process of mirror making, it was now possible to make much larger and regularly shaped plates. Moreover, production time was cut in half and lower-skilled workers were replaced by skilled artisans, thus reducing labour costs substantially.[36]

The timeframe and the ways in which Venetian producers responded to these foreign innovations still await systematic investigation. Recent research, however, allows us to examine which novelties were introduced in Venice after the late seventeenth century as well as how they were adapted to local conditions. We can also speculate about the reasons why some innovations were rejected. Institutional and market forces, as well as the availability and costs of raw materials, weighed heavily on the selection process. Overall, we witness both continuity and transformation. For technological and economic reasons (potash-crystal is harder to obtain at the lower temperature reached by Murano furnaces, and sodium-based fluxing agents were more easily accessible to Venetian markets), sodium crystal glass remained prevalent in Venice. At the same time, craft guilds did not, as is often suggested, obstruct all technological innovations, especially not in times of economic difficulty.

The first myth that we must debunk is the idea that guild statutes strictly regulated technological aspects of the production process. In most early modern Italian towns, the opposite was true.[37] In the case of the Murano guild we observe a progressive relaxation of the control exerted over production processes in the long run. The first guild statutes, written in 1271 and amended up to 1315, contained only three standards. Openings on the furnace sides were limited to three (four after 1305). Beech and alder were the only types of wood that one could burn in glass furnaces. Finally, the use of ferns to extract vegetable ashes was forbidden (they would make a northern European type of potash-glass).[38] The new statutes issued in 1441 maintained only the first and second standards.[39] By 1766, all restrictions concerning technological aspects disappeared from guild statutes except for the prohibition on

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[36] Scoville, *Capitalism and French Glassmaking*, 40; Pris, *Une grande entreprise*, 1:312.

[37] Moioli, 'I risultati,' p. 30. For a comparison with southern Germany, see Ogilvie, *State Corporatism*, 345–348.

[38] Monticolo, *I capitolari*, 2.1:61–98.

[39] BMC, *Mss. IV*, no. 26, fols. 10r, 12r, 16r.

using "forbidden ashes," that is, those from brick furnaces, and for the request that merchant-producers sell raw materials and timber to those who needed them at reasonable prices.[40] Clearly, the statutes left room for individual experimentation. Unfortunately, this experimentation has left relatively few traces in the written records. As we shall see, privately owned recipe books in which glass masters annotated the quantity and types of raw materials that they mixed together in their day to day work are among the most useful documents for the study of technological innovation in Venetian pre-industrial glass furnaces. Additional information derives from petitions by glass producers to state magistrates requesting exclusive privileges.

In 1474, Venice was the first state in Europe to pass a law that protected the intellectual and material rights of inventors. As is often noted, however, patents can be deceptive documents for the history of technology, especially when it comes to the chemical industry, because they tend to concern instruments and devices rather than production processes.[41] In the case of Venetian glass manufacturing, private recipe books inform us about technological change that is largely undocumented by patents of inventions.[42] They also often (though not always) allow us to identify the author(s) of an innovation. This is an important correction to the tendency to speak of the "secret" that surrounded the Venetian glass industry as a collective endowment of the Murano guild, that is, a public good protected by the state. Recipe books point to the competition between families and individuals, and to the role that specific, private "secrets" played in this competition.[43] By implication,

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[40] Zecchin, *Il capitolare*, 47, 139–140. As an exception, Giorgio Barbaria was authorized to utilize ashes of brick furnaces instead of the more expensive kelp as fluxing agent for his dark-bottle furnace in 1791; ASV, *Inquisitori di stato*, busta 818.

[41] See the volume *Les brevets* and the monographic issue on "Patents and Inventions" of the journal *Technology and Culture* 4 (1991). See also MacLeod, *Inventing the Industrial Revolution*.

[42] A more comprehensive analysis of the role of patents in the technological change of Venetian glass making will be possible once the entire series of patents of invention granted by the Venetian Senate is published by Carlo Poni and Roberto Berveglieri.

[43] Pamela Long initially ('Invention, Authorship') overemphasized, in my view, the role of state protection of the "secret" of Murano glass manufacturing at the origin of the Western concept of intellectual property. In a more recent publication (*Openness, Secrecy, Authorship*, 89–91), she offers a more balanced assessment of the importance of "communal property" and competition among various glassmakers. Following the earlier work of Pamela Long and conventional wisdom, William Eamon

we need to see the Murano guild not as a monolithic and monopolistic institution, but as one in which oligopolistic interests were compounded by competitive interaction among the entrepreneurial elite. This concept contrasts with the largely accepted thesis according to which competition in a guild system concerns only prices, while production processes and product quality were strictly regulated. "Venetian glass" was not, as argued by R.T. Rapp and commonly repeated, a consistent and uniform product.[44]

In Murano, at least from the 1690s onwards, some producers began to use new materials as both vitrifying and fluxing agents in order to reduce production costs while maintaining the high quality that made Venetian products attractive. In 1696–97, a glass recipe records the usage of a sand called *saldame* in partial replacement of quartz pebbles.[45] In the first decades of the eighteenth century, the Murano guild was granted permission to exploit caves in Istria and Dalmatia, Venetian overseas territories where this sand was found.[46] *Saldame* was not as rich in silica or as pure as pebbles, which continued to be employed mostly in the making of crystal glass, but was much cheaper and also saved on labour costs since it eliminated long and expensive grinding operations (see below). New fluxing agents were also introduced in Murano earlier than the standard literature recounts. Levantine ash was by far the most expensive raw material used in Venetian glassmaking. English and Bohemian competitors succeeded in doing away with it or reducing its importance in crystal-glass formulas that included potash and lead. In Venice, the production of a potash-based crystal is traditionally dated to 1737 and attributed to the genius of a local master and entrepreneur, Giuseppe Briati (1686–1772).[47] In fact, this innovation must have taken place at least two decades earlier.[48] Moreover, a recipe book shows that in the late seventeenth century at least one Murano entrepreneur, Ettore

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also exaggerates the secrecy of artisanal "secrets"; Eamon, *Science and the Secrets of Nature*, 81–82.

[44] Rapp, 'The Unmaking of the Mediterranean Trade Hegemony,' 514–515.

[45] Zecchin, *Il ricettario Darduin*, 201.

[46] ASV, *Inquisitori di stato*, busta 819. *Saldame* of acceptable quality was also found in the Dalmatian island of Vis, while that extracted near Polcenigo in Friuli was of considerably lower quality.

[47] Gallo, *Giuseppe Briati*.

[48] Documentary evidence in Boesen, *I vetri veneziani* and Gasparetto, "Les relations entre Venise et la Bohême.'

Bigaglia (1628–1694), was using potassium nitrate (saltpetre) to make an English-type of crystal.[49] By the second half of the eighteenth century, saltpetre became a common staple among the major Murano producers, who petitioned the state to acquire it in substantial quantities at a reduced price.[50]

In the 1680s, Ettore Bigaglia and his two brothers controlled the largest glass company in Murano, which produced primarily crystals and mirrors.[51] In all likelihood the correlation between technological innovation and firm size is not a coincidence.[52] Murano was an island of some 5,000 inhabitants spread over about a square mile, but all glass furnaces were concentrated along the same street, called *Fondamenta dei Vetrai*, which bordered the main canal in the direction of Venice. This cluster of businesses was typical of European and Italian urban manufacturing. It fostered the exchange of information, raw materials, and human capital, but should not be confused with a consensual image of collective endeavours. Competition among firms of the same guild stimulated technological change, as seen in the differences in equipment available and the innovations adopted by various entrepreneurs. This competition, in turn, took place in the context of a regulated economy. Although it would be an exaggeration to talk of economies of scale in the context of pre-industrial Murano, a convergence between company size, state-granted economic privileges, and technological innovation is apparent. In the eighteenth century, the largest and most entrepreneurial producers of crystal glass (Giuseppe Briati, and the Mazzolà and Mestre families) avoided the risk of publicizing their secrets by submitting a request for formal patents. Yet they constantly appealed to state authorities to acquire privileges in return for their innovations.[53]

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[49]Moretti and Toninato, '"Cristallo" e "Vetro di piombo",' and Toninato and Moretti, 'Ricettari Muranesi.' A recipe for a translucent glass called *girasole* dating to 1693 also documents the use of saltpetre in Murano; McCray, Osborne, Kindery. 'Venetian Girasole Glass,' 21.

[50]See Panciera, 'Ancien Régime e chimica di base.' An essential component of gunpowder, saltpetre was a state-controlled manufacture. In Tuscany, English *flintglass* was produced at least starting from the 1710s; Ciappi, *Il vetro a Montaione*, 55–57.

[51]ASV, *Ospedali e luoghi pii*, buste 69.11, 70.2, 370.7.

[52]In general, at least for a limited time, technological innovation is more accessible to larger firms enticed to innovate by the potential for extra profit derived from their positions as oligopolies; Sylos Labini, *Oligopolio e processo tecnico*, esp. 63–65, 99–102.

[53]Relevant documents from the 1730s in ASV, *Consiglio dei Dieci. Parti comuni*, registro 187; filze 996, 984, 996, 1025, 1076.

It is undeniable that guilds and other formal institutions played a role in directing technological change, but in order to understand it we need not only to look inside the 'black box' of technology but also to consider guilds as black boxes. It is only by scrutinizing their internal socio-economic hierarchies and their relation to the outside political and economic order that we can assess their impact on specific technological innovations.[54] All recent historical studies of craft guilds in early modern Europe stress the diversity that existed between guilds of the same town or region and the high level of both horizontal and vertical conflicts that filled each corporate system. Guild organization in Venice, including in the glass sector, was no exception.[55] The Murano guild's policies towards technological innovation thus have to be read in light of inter-and intra-guild tensions. To grind siliceous pebbles, for example, was a laborious operation that required unskilled labour and firewood – the pebbles were heated up and then ground manually.[56] After the late sixteenth century, that is, nearly one hundred years before *saldame* was introduced in Murano, some mechanical mills activated by horses were used, and the guild never opposed this labour-saving innovation, not even when non-guild members from outside Venice owned these mills.[57] In 1661, for example, most Murano furnaces depended upon one grinding plant owned by a Roman citizen.[58] The mechanization of this preliminary stage of glassmaking did not encounter any resistance from one of the most influential guilds in Venice because its principal effect was to reduce the number of unskilled workers employed, who lacked representation in the institution, and to cut down on the use of timber, which was becoming increasingly scarce.

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[54] I borrowed the expression the 'black box' from Rosenberg, *Inside the Black Box* and *Exploring the Black Box*. Rosenberg's aim is not to analyze guilds, but "to break open and to examine the contents of the black box into which technological change has been consigned by economists." (Rosenberg, *Inside the Black Box*, vii).

[55] For comparisons with the guild organization of the Venetian silk industry from the sixteenth to the eighteenth century, see Molà, *The Silk Industry*, and Della Valentina, *Operai, mezzadi, mercanti*.

[56] A description of this operation in Agricola, *De re metallica*, 585.

[57] Patents of invention for grindstone machines designed specifically for the Murano glass furnaces were issued in 1596 (ASV, *Senato terra*, registro 66, fol. 11v), 1598 (ASV, *Provveditori di Comun*, busta 18, fol. 45v) and 1643 (ASV, *Senato terra*, registro 131, fol. 413r). I thank Carlo Poni for bringing the latter document to my attention.

[58] ASV, *Dieci savi sopra le decime in Rialto*, busta 422.

The French cast-plate method of mirror making, however, was not adopted in Murano until the mid-nineteenth century because it seriously impinged on the occupation and status of master glassblowers who had a voice in guild policies.

Technological change was also dictated by the structure of production costs and changes in labour relations in any given context. Unfortunately, we lack private accounts documenting the activities of specific Venetian glass furnaces in the period, but some budgets and inventories offer valuable information on production costs. Post-mortem inventories indicate the great difference in size between various Murano firms. Even in these sources, which were likely to overestimate the importance of physical capital, the combined value of furnaces, crucibles, hardware and, where they existed, grinding wheels, never accounted for more than half of the total value of the furnace plant (Table 1). The projected costs of a new company formed by Murano masters and owners in 1779 are recapitulated in Table 2.[59] According to this estimate, raw materials and fuel comprised more than 72% of the total cost of finished crystal objects, and between 66% and 87% of the production costs of semi-finished mirror plates and bead rods. Moreover, large mirror plates cost about one and a half times more than small mirror plates (meaning those measuring no more than 68x51 cm). Finally, glass canes were the second-least expensive product after windowpanes, and labour costs weighed the least on their production. In sum, raw material and labour were the primary costs incurred by glass entrepreneurs. It is thus not surprising that the search for substitute raw materials drove competition and technological change. Labour costs varied greatly from branch to branch of the glass industry, as did labour organization and guild organization. In the 1779 budget cited above, production costs of glass beads and mirrors concerned the first production phase alone, as only glass rods and rough plates were prepared in the Murano furnaces. These semi-finished goods were passed onto other guilds that completed the necessary operations in the town centre of Venice. Here, lower production costs of these export goods were matched by abundant recourse to women and immigrant labourers who worked at the fringes of or outside guild rules and protection, especially after the plague of 1630–31.

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[59] This budget was probably overly optimistic insofar as sales were concerned, but comparisons with other sources indicate that it is quite reliable as far as the expected expenses are concerned. In the end, the state rejected this project.

3. Labour Organization In and Around Guilds

In the seventeenth and eighteenth centuries, the Venetian glass sector comprised four or five guilds, depending on the period of time in question.[60] Relations between these guilds reflected a geographical division of labour between Murano and Venice, and the social and economic hierarchies between different crafts. At the top of the pyramid stood the Murano glassblowers, who enjoyed some special privileges (including the exemption from the basic tax owed to the state by all the city's guilds). The Murano guild was in charge of the entire production process of all blown objects, whether made of crystal or common glass, as well as of the preliminary preparation of windowpanes, mirror plates, enamels and glass rods, which were then turned over to guilds based in the town centre. This division of labour between Murano and Venice reduced transaction costs and ensured the quality of semi-finished goods.

The Murano glassblowers' guild had a more strictly regulated labour stratification than its sister institutions in the town centre. Not only did it prescribe, as all guilds did, barriers to access mastership, but it also excluded those men not born on the island from this position. As in all other European towns, immigrants flocked to Venice in search of better opportunities, especially in times of high urban mortality. After the destructive plague of 1630–31, the government authorized all subjects of the Venetian mainland to enrol as apprentices in the guilds of the state capital.[61] The glassblowers' guild and two wool guilds were the only ones to which this decree did not apply. In Murano too, however, after 1638 individual workers who were not natives of the island were temporarily admitted as auxiliary personnel in jobs that did not require glassblowing.[62] Most of these immigrants were from Friuli, and the majority of them came from a village named Maniago, the origin of a typical Alpine migratory chain. Immigrants from Friuli, the eastern region of the Venetian mainland regional state, worked primarily in

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[60] The Murano glassblowers' guild (*arte dei verieri*) was formed in 1271 and abolished in 1808. The first guild to make beads was the *arte dei paternosteri e margariteri*, created in 1318; in 1647, a separate guild specializing in lamp-beads was born (*arte dei perleri e suppialume*). The mirror-makers' guild (*arte degli specchieri*) was established in 1570. All these three guilds were abolished in 1807. The smaller guild for the local retail of non-crystal common glassware operated from 1436 to 1768.

[61] ASV, *Senato terra*, registro 106, fol. 451r (18 April 1631).

[62] Zecchin, *Vetro e vetrai*, 1:185 and 2:50.

furnaces where mirror plates were made and rarely did they move up to become masters.[63]

To reinforce the hierarchy between immigrants and native workers, the Murano guild increased the privileges to which masters alone were entitled. After 1656, merchant-producers were forced to pay every unemployed master glassblower a yearly subsidy, which in 1690 was set at 70 ducats, a considerable sum for an artisan worker. This welfare policy reinforced the status hierarchy while it loosened up the economic hierarchy among waged labourers. In order to contain labour costs, merchant-producers hired qualified journeymen (including many from outside Murano) and had them work as masters, but denied them career promotions that would entail eligibility for the subsidy[64] Because in the Murano furnaces skilled workers' wages varied according to individual ability, and had some but not an exclusive correlation to rank, a few qualified journeyman earned more than masters in the same plant.[65] Immigrants from Friuli made up most of this overqualified labour force. They thus constituted a pool of unprotected workers in the heart of the guild's labour market. Their significance grew over time, to the point that in 1766 the new statutes of the Murano guilds mentioned only two groups of workers in mirror making furnaces: masters and "Furlani", that is, men from Friuli.[66]

A similar and even more radical pattern of labour market segmentation can be detected in the glass sector of the Venice town centre. By the late seventeenth century, most Venetian guilds had introduced new norms prolonging apprenticeship periods and again banning the admission of non-Venetian workers. These restrictions indirectly gave way to the employment of non-corporate and domestic labour. Immigrants from Friuli working in mirror making and women in bead making were the two pivotal groups of the putting-out system that developed in the urban economy. In this respect, Venice resembled other European cities, including eighteenth-century Vienna, where the artisan labour force

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[63]Several small and large glass producers in nineteenth- and twentieth-century Murano originally came from Friuli.

[64]In 1743, 16 out of the 125 masters of the Murano guild were listed as 'journeymen working as masters,' and the guild's employment roll included 202 workers with no specific qualifications ("operai"). ASV, *Inquisitori di stato*, busta 819.

[65]Trivellato, 'Salaires et justice.'

[66]Zecchin, *Il capitolare dell'arte vetraria*, 101–102.

comprised a small number of stable masters and large groups of unstable waged workers.[67]

Male immigrants from Friuli were numerous among the mirror-makers' apprentices in the seventeenth century.[68] They arrived in Venice lacking all skills and acquired them via formal and informal training.[69] The secondary operation necessary to turn a glass plate into a polished mirror required a small fixed capital (a desk, some stones, wooden and metal utensils, abrasive sands and mercuy for silvering). As a result, it was relatively easy for merchant-producers in and outside the guild to set up a laboratory and hire workers for a wage.[70] In 1675, the mirror-makers' guild passed a rule blocking the admission of all new apprentices.[71] In 1672 and 1673, the two guilds of glass bead makers had adopted the same rule.[72] It is not a coincidence that a few years later denunciations of poor quality standards in mirror plates increased.[73] Justified by allegedly shrinking sales, the policy of barring new apprentices opened the door to the employment of more workers who were not official members of the guild. In other words, guild labour policies oscillated between the need to cut labour costs and the need to uphold competitive quality standards. A natural compromise was found in those sectors that produced items for large, if not mass consumption. Immigrants from Friuli came to specialize in the manufacturing of the smallest mirror plates, measuring no more than 25x19 cm and weighting no more

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67 Emher, 'Worlds of Mobility.' On the coexistence of different forms of labour and production organization, including the putting-out domestic system, within the same urban economy, see Cerman, 'Forme di organizzazione protoindustriale.'

68 Zannini, 'Flussi d'immigrazione.'

69 Similarly, immigrants from the Bergamo area arrived in Venice without any skills and progressively specialized in silk weaving during the sixteenth century. See Molà and Mueller, 'Essere straniero a Venezia.'

70 The sentence against an Armenian merchant, who was accused of having one such workshop in his house in 1666 although he was not a guild member, is indicative of the simple infrastructure that was necessary to polish mirrors; BMC, *Mss. IV*, 35, fols. 271v–275v.

71 BMC, *Mss. IV*, no. 35, fols. 304r–305v. In 1699, during two months when the prohibition on accepting new apprentices was temporarily lifted, half of the 49 new apprentices who were enrolled in the guild came from the region of Friuli; ASV, *Cinque Savi alla Mercanzia. I Serie*, busta 463.

72 ASV, *Arti*, busta 437 (*Mariegola dei perleri e suppialume*, fol. 66r) and BMC, *Mss. IV*, no. 99, fols. 183–184.

73 BMC, *Mss. IV*, no. 35, fols. 304r–305v.

than 318 grams. The second phase of the preparation of small mirrors required low technical skills, but these items enjoyed large commercial success.[74] In 1756, the Venetian government granted workers from Friuli exclusive rights to make small mirrors and recognized them as a second-rank corporate group in the mirror-makers' guild.[75] Still, civil lawsuits indicate that their salaries were often below market rates.[76]

In glass bead making, women rather than immigrants supplied a large labour force excluded from guild protection but essential to guild production. In Venice, conforming to a general European pattern, women's positions in the urban labour market deteriorated in the course of the late Middle Ages.[77] In the sixteenth century, the statutes of all guilds of the glass sector, like those of the textile industry, limited the right to work to wives, widows, and daughters of guild masters.[78] Over time, women, including many who had no blood ties to guild masters, came to control specific operations in the process of glass bead making and particularly in the preliminary phases of sorting and cutting glass rods and the final job of stringing small beads in cotton and silk threads. Women also largely contributed to lamp-bead manufacturing.[79] These operations were carried out in domestic workshops, sometimes thanks to the mediation of a few women who acquired commissions from male merchants and distributed the semi-finished material among other female workers. Some women were active in the local retail market.[80] For the

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[74] On the resiliency of Venetian mirrors, especially small-size mirrors, in Mediterranean trade long after the new French products entered the market, see Pris, *Une grande entreprise*, 2:44.

[75] ASV, *Inquisitori di stato*, busta 824 and *Censori*, busta 38. In 1773, 165 men from Friuli were recorded in the official rolls of the mirror-makers' guild; Sagredo, *Sulle consorterie*, 267.

[76] ASV, *Inquisitori di stato*, busta 824.

[77] Herlihy, *Opera Muliebria*, 185–191; Howell, *Women, Production, and Patriarchy*; Wiesner, *Working Women*; Ogilvie, *A Bitter Living*.

[78] On women's work in silk and wool production in medieval and early modern Venice, see Molà, 'Le donne nell'industria serica veneziana;' Panciera, 'Emarginazione femminile;' Della Valentina, *Operai, mezzadi, mercanti*, 131–138. See also Bellavitis, 'Donne, cittadinanza e corporazioni.'

[79] For a detailed illustration of women's work in Venetian glass bead manufacturing, see the volume *Perle e impiraperle*. On one of the most popular Venetian glass beads more specifically, see Moretti, 'The Chevron Bead.'

[80] Evidence comes from private account books, such as that of the merchant Matteo Marinoni for the years 1642–1649 (ASV, *Giudici di petizion Rendimenti di conto*, busta 978), and *post-mortem* inventories of members of the *perleri* guild in the eighteenth

most part, however, since they were deprived of all guild guaranties to an even greater extent than male immigrants, women represented a reserve of cheap labour that could shrink and expand according to contingent demand. At the same time, women were the sole bearer of skills transmitted outside any formal apprenticeship and thus indispensable to the large urban domestic industry of glass bead making.

Given that most primary sources were produced by guilds themselves and that women generally lacked stable employment, it is very difficult to measure the size of the female labour force. All evidence, however, indicates its sizeable and growing dimension in eighteenth-century Venetian glass bead manufacturing. In a rare official document of 1774, a guild acknowledged that it employed 1,400 women to string beads.[81] More often, we need to rely on indirect information. In 1752, the French consul in Venice was struck by the fact that about 2,500 people were employed in glass bead production.[82] Many women must have been included in this count. The same assumption explains later calculations. An estimate of the city's labour force drafted in 1808, after the suppression of all guilds, calculated that 6,064 workers were employed in glass bead production in 1780. Considering that in the official survey of guild membership of 1773 lamp-bead makers numbered only 295 and seed-bead makers 196, we have to assume that waged women with loose or no ties to guild members made up the overwhelming majority of those 6,064 workers.[83]

In sum, waged women excluded from all corporate institutions and male immigrants from Friuli who were granted second-rank status by the mirror-makers' guild were the backbone of the manufacturing of glass beads and small-size mirrors respectively. Their role explains to a large extent why Venetian industries remained competitive on international markets. Entrepreneurs like Giorgio Barbaria were all too aware of the importance of these reserves of cheap labour and took advantage of the relaxation of guild norms. Barbaria was repeatedly investigated by guild and state courts for not respecting wage rates and working regulations.[84] Moreover, though as a member of the *perleri* guild he was

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century (ASV, *Giudici di petizion. Inventari*, buste 404.28, 437.23, 467.27).

[81] Cecchetti, *Monografia*, 222.

[82] Quoted in Georgelin, *Venise au siècle des lumières*, 182.

[83] The estimates for 1780 are in Costantini, *L'albero della libertà economica*, 54–57; the guild lists of 1773 are in Sagredo, *Sulle consorterie*, 273–274.

[84] Lawsuits against Barbaria's use of non-corporate labour are in ASV, *Censori*,

entitled to produce only lamp-beads, Barbaria invested primarily in the making of seed-beads (*conterie*).[85] As we will now see, seed-beads were an expanding item in Venetian exports at the time.

4. Demand and Foreign Markets

Serial data of the custom taxes levied on most imports and exports passing by the port of Venice provide both aggregate and detailed information for the last three decades of the eighteenth century. Table 3 and 4 summarize a survey that I conducted for the years data are available for all important glass commodities exported from Venice. Monetary values are given for the most standardized items (beads, mirrors and windowpanes). For other goods (such as blown glass, glass paste, and enamels), weight, quantity of exports, and sometimes value are recorded. Unfortunately, some inconsistencies in these records make it impossible to establish the exact share of glass items on the total value of goods exported from Venice. The available data, however, suggest that in the last three decades of the eighteenth century, glass beads, mirrors and windowpanes together accounted for between 10% and 20% of all the Venetian export trade.[86] These records are much more reliable when it comes to evaluating the relative importance of different glass items. In terms of value if not weight, glass beads were the most important Venetian glass export. They were shipped primarily to the Levant and Western Europe (defined as the Iberian and French Atlantic coasts and Northern Europe). Mirror plates served primarily the internal

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buste 21.21 and 39. In 1785, a guild inquiry found him to be among the least law-abiding members ("li più inobedienti alle leggi"); *ibidem*, busta 40.

[85]Barbaria was denounced for this reason at least once, in 1792; ASV, *Inquisitori di stato*, busta 820.

[86]Custom records of Venetian exports survive in two separate series, one with details on each item (detailed series), and one with the aggregate data in monetary values (aggregate series). The latter was published by Campos, 'Il commercio esterno veneziano.' I calculated the share of glass exports out of the total of Venetian exports by adding the monetary values of all glass items and dividing them by the annual value of the aggregate series. These aggregate series, however, do not coincide with the corresponding values calculated on the basis of the unit prices of specific items given in the detailed series. More systematic comparisons will be possible once a computerized version of both archival series, which was begun by the late Massimo Costantini and financed by the Italian Ministry of Culture, is completed and made available to the public. I thank Alessandra Sambo, of the Venetian State Archives, for allowing me access to the index of the custom levies that she compiled.

and Italian markets, but were also dispatched to the Levant, Europe and North Africa. Windowpanes were low in value but in high demand in Italy and the Levant.

These data, combined with information about the consumption of raw materials and the number of crucibles in Murano's furnaces, support two important conclusions. First, in the last three decades of the eighteenth century, Venetian glass production as a whole was twice the size it had been at the end of the sixteenth century, a period which is generally considered to have been a high-point for the Murano industry. Second, in the course of two centuries, the internal composition of Venetian glass production changed substantially in favour of bead and mirror manufacturing. In Murano, in 1592 24 furnaces consumed about 572 tons of ashes every year.[87] In contrast, by the 1770s the annual consumption of ashes was nearly 1,200 tons.[88] Moreover, we know the different products for which Sicilian ashes were used in 1780: 190 tons for crystal glass, 715 tons for windowpanes and mirror plates, 765 tons for glass beads and enamels.[89] The number of crucibles assigned to the making of each type of glass from 1678 to 1792 confirms this shift from a sector that in the late seventeenth century was still dominated by blown glass to one in which mirrors and beads were predominant (Table 5).

Descriptive information is consistent with the quantitative data. Reformers, travelers, and diplomatic representatives of the time were all impressed by the demand for Venetian glass beads. In 1728, strolling along the street of Murano where all the glass-furnaces were burning, Montesquieu was surprised to find as many as eighteen of them producing what he designated as "verres et verroteries pour les Nègres," that is, cheap glassware and glass beads for the African slave trade.[90] In 1752, the French consul estimated the annual glass bead production at a little more than one million ducats.[91] Assuming that some glass beads must have been sold in Venice and others smuggled, the figure matches the one derived from the custom records. The French consul also expressed

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[87] Corti, 'L'industria del vetro.'

[88] ASV, *Censori*, busta 38.

[89] Zecchin, 'I fondenti dei vetrai muranesi.'

[90] Montesquieu, *Oeuvres complètes*, 2:986. In another passage of his travel accounts, he added: "Il se fait un grand commerce en Europe de certaines perles de verre qui se font à Murano & se façonne à Venise, qui s'envoyent en Italie & dans le reste même de l'Europe, pour les Sauvages & Nègres"; *ibidem*, 995.

[91] Georgelin, *Venise au siècle des lumières*, 182.

his government's interest in beads. France was only one of the many European states, including Austria, Portugal, and England, which attempted to manufacture glass beads domestically. Only in Holland, however, were glass beads made in great quantity.[92] Otherwise, they remained a Venetian specialty. From the middle of the seventeenth century, glass beads helped to balance the decline in the export of Venetian textiles to the Levant.[93] More importantly, glass beads found rich outlets in Atlantic Europe, from where they were re-exported to colonial markets. After the 1630s, the Dutch, Portuguese, and English always included glass beads on board their ships to West Africa, together with Indian cotton textiles and cheap linens, copper and brass wire, iron bars, pewter containers, tobacco, pipes, gunpowder, knives, fire arms, cowry shells, spirits and brandy.[94] As Joseph Conrad's character Captain Kurtz noted, in the late nineteenth century a stream of such items "set into the depths of darkness, and in return came a precious trickle of ivory."[95] In North America, the Hudson Bay Company listed beaver prices in bunches of seed-beads: the "standard of trade" of 1748 established the value of one skin of beaver at half pound of beads ("large Milk, of colours of all sorts").[96] In order to maximize their profits, British merchants (or their intermediaries) had to know exactly what beads to offer Native American consumers. The letters of factors and governors of the Hudson Bay Company complained recurrently about the inadequate assortment of glass beads shipped from London during the first half of the eighteenth century.[97] Today, this knowledge is lost. Samples of the bulk of glass beads that boarded European ships are on display in

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[92]Sleen, 'A Bead Factory,' and Baart, 'Glass Bead Sites.'

[93]Sella, *Commerci e industrie a Venezia*, 66.

[94]Davies, *The Royal African Company*, 172–178, 219 (with quantitative data about exports in appendix); Miller, *The Way of Death*, 66–67, 77, 603; Hancock, *Citizens of the World*, 200. In 1789, London slave merchants supplied themselves with glass beads and cowry shells from a so-called "bead store house"; Rawley, *The Transatlantic Slave Trade*, 186. On glass bead trade in general, see Dubin, *The History of the Beads*. The Dutch and Portuguese also shipped glass beads to East Africa; Newitt, *A History of Mozambique*, 157–158, 180–182.

[95]Conrad, *Heart of Darkness* (1902), 158.

[96]MacKey, *The Honourable Company*, 85. A prime beaver skin (either parchment or coat) was usually valued at a pound of beads; Carlos and Lewis, 'Trade, Consumption, and the Native Economy,' 1045.

[97]Davies, *Letters from Hudson Bay*, 105, 157, 278, 297, 315, 325. See also Ray, 'Indians as Consumers,' 265.

ethnography and anthropology museums, old beads are available for purchase at exorbitant prices in antique stores, and many trinkets and imitations are for sale in tourist and how-to shops. For Venetian merchants of the eighteenth century, however, more or less accurate knowledge of foreign demand of glass beads made a great difference. This is why someone like Giorgio Barbaria actively searched for direct access to markets and information that were not within easy reach of most of his competitors in Venice.

5. Conclusion

In the fifteenth century, Venice became the world leader in glass production thanks to its superior techniques and refined raw materials. Its dominance was challenged by radical innovations introduced in England, Bohemia, and France during the last quarter of the seventeenth century. These innovations are usually deemed to have caused the decline of Venetian glass production. Traditionally, historians have taken the alleged fate of the Venetian glass industry to be representative of a much broader economic decline, which transformed the city from a production to a distribution and consumption centre. Many also see Venice's downward trajectory as emblematic of the lost fortunes of southern European urban economies in the seventeenth and eighteenth centuries. Recent historical scholarship, however, portrays a more nuanced picture and suggests that the decline of Venetian manufacturing after the second decade of the seventeenth century has been exaggerated and poorly understood.[98] Venetian overseas trade certainly diminished in the long run. But different sectors of the city's economy performed differently. While adjusting to new patterns of demand and competition, glass manufacturing sustained a significant portion of the Venetian export trade at the time of what Rapp called its "relative decline." Indeed, by the second half of the eighteenth century, the Venetian glass sector had doubled in size compared to two centuries earlier.

This expansion was made possible by changes in the composition of the goods that were produced in Murano and Venice, and by the segmentation of the labour market that was employed in this diversified sector. Responding to foreign competition as well as to growing local demand for consumer goods, Venetian glass manufacturing grew by

[98] For recent overviews, see Pezzolo, 'L'economia' and Panciera, 'L'economia.'

producing less fine crystals (now made more inexpensively in Bohemia and England), more small mirrors (in contrast to the large mirrors made in France), and exorbitant amounts of cheap glass beads destined for European colonial powers for re-export, which remained largely a Venetian prerogative. In other words, Venetian guilds reacted to competition by specializing.

This conversion in the commodity composition was both the result and the cause of profound transformations in the urban labour market, and especially in the labour relations that governed mirror polishing and glass-bead making in the Venice town centre. A parallel economy dominated by informal labour relations and growing numbers of what in Paris were called *faux ouvriers* emerged. Unlike in Paris, however, these waged workers were not for the most part employed by entrepreneurs to whom the state had offered special incentives in order to relieve them from tax and welfare burdens.[99] In the Venetian glass sector, a putting-out system developed at the margins of the corporate labour market and employed male immigrants from Friuli at finishing mirrors and women at rounding off, making, and stringing glass beads. It would be wrong to use contemporary terminology and label these workers "illegal" labour. In practice, they were an integral part of the labour force and the corporate world because they often worked back to back with guild members in the same workshop and merchant-producers enrolled in guilds counted on them to lower production costs and help keep export-oriented merchandise competitive.

Sheilagh Ogilvie recently exposed the extent to which "the social capital generated by guilds was used in ways that harmed women" and other marginal groups.[100] In the long run, she argues, gender discrimination, and the marginalization of vulnerable segments of the labour force more generally, had detrimental effects on economic development overall. Guild organization of the Venetian glass sector kept women and men from Friuli in a subordinate position, and the legacy of these unequal working relations undoubtedly cast an enduring shadow over the structure of the labour market even in the industrial period. How-

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[99] For such privileged plants in Paris, see Kaplan, 'Les corporations.' The Parisian model was adopted especially by the textile sector in a selected number of plants in the Venice city centre and more frequently in the Venetian mainland. See Panciera, *L'arte matrice* and Della Valentina, *Operai, mezzadi, mercanti*, 146–151.

[100] Ogilvie, 'How Does Social Capital Affect Women?' 343. See also Ogilvie, 'The Use and Abuse of Trust.'

ever, it is important to distinguish between Ogilvie's criticism of historians and social scientists who still today conceive guilds and village communities in consensual and idealized terms, and her criticisms of guilds as inefficient and inegalitarian economic institutions. Craft guilds were not always the most efficient solution to problems of economic production and distribution, but it would be anachronistic to separate their social and economic functions. In early modern Venice, guilds did not simply mirror the patriarchal, anti-Semitic, and xenophobic values that imbued society at the time. They also existed precisely to enforce these values, and to maintain and manage those inequalities that were perceived to be 'natural' at the time, including those between the genders. Craft guilds were thus essential, not an accessory to the socio-economic fibre.

Moreover, craft guilds certainly had an impact on technological change, but one that was more diversified than is generally assumed. In early modern Venice, guild statutes and norms did not lay down "meticulous rules about three elements of production that we might term 'the three p's': prices, procedures, and participation"—as the accepted wisdom recently reiterated by Joel Mokyr would have it.[101] Both Murano glassblowers and Venetian guilds regulated "participation" as they actively excluded from career advancements and welfare privileges immigrants and women who were instrumental to the guilds' own prosperity. At the same time, guilds allowed for competition among their members over "prices" and "procedures." This competition led to numerous "micro-inventions," to use Mokyr's terminology,[102] which should not be mistaken for conservatism. Most "micro-inventions" aimed at reducing the costs of circulating capital and raw materials in particular. They also conceivably increased productivity, though this effect is difficult to measure. This pattern of technological change may not have spurred industrial development, but in the eyes of contemporaries it was the most rational, considering that raw materials weighted more than fixed capital and labour on production costs. The same pattern of technological change prevailed in pre-industrial Europe. English patents of invention from 1660 to 1800 show that the majority of inventors were driven by the desire to save working capital: only between 7.3% and 21.6% of all English patents over this period were

[101] Mokyr, *The Gifts of Athena*, 259.
[102] Mokyr, *The Lever of Riches*, 13 and *passim*.

labour-saving (although admittedly the proportion increased over time).[103] This dominant tendency should not lead us to conclude that guilds opposed all labour-saving innovations. In the grinding processes, which employed unskilled labour, the Murano guild welcomed the use of new machines. It rejected the new French mirror-making method, but it is doubtful, if it had been adopted, whether Venice would have been able to compete with France in the production of large mirrors; instead, Venetian merchant-producers expanded their investments in small mirrors and succeeded in controlling that market. As recent studies demonstrate, a complex interplay of economic and political factors accounted for guilds' attitudes toward labour-saving innovations in any given context. In many parts of Europe, for example, guilds adopted a new mechanical loom for the making of silk ribbons in the seventeenth and early eighteenth centuries.[104] Craft guilds no doubt exerted choices that directed the pattern of technological and organizational change as well as the structure of the labour market, and thus helped to shape the course of economic development. These choices responded to a variety of pressures that came from inside and outside the guilds, including the economic interests of those who had a voice in guild leadership, naturalized notions of socio-economic hierarchy and patriarchy that pervaded society at large, and local geographical conditions. Any scholarly effort that wishes to avoid romanticizing or demonizing the pre-industrial artisanal world should understand what it was, what it aspired to be, and how it evolved over time.

Yale University

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[103] MacLeod, *Inventing the Industrial Revolution*, 170.
[104] Pfister, 'Craft Guilds and Industrial Development,' 298–307.

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Table 1. Monetary value as estimated in the inventories of four Murano furnaces made between 1685 and 1691.

	MIRROR PLATES (1685)			CRYSTAL GLASS (1689)			COMMON GLASS (1690)			COMMON GLASS (1691)		
	Monetary value lire	soldi	%	Monetary value ducats	grossi	%	Monetary value ducats	grossi	%	Monetary value ducats	grossi	%
Raw materials	709	12	12.39	219	20	40.18						
Firewood	365		6.37							6	1	5.92
Physical capital	1,424	16	24.87	76	16	13.97	22	13	51.72	16		15.76
Furnace	950		16.59							25		24.63
Semi-finished products	2,149	3	37.52	251	4	45.84	21		48.28	54	12	53.69
Cash	130	7	2.27									
TOTAL	5,728	18	100.00	547	16	100.00	3	13	100.00	101	12	100.00

(*) Including a grinding-wheel and other instruments for grinding pebbles.

Source: ASV, *Podestà di Murano*, busta 206

Table 2.
Weekly production costs in different types of furnaces in Murano according to a 1779 projected budget.

	COMMON GLASS			CRYSTAL GLASS			WINDOW PANES			LARGE MIRRORS			SMALL MIRRORS			GLASS RODS		
	(2 furnaces 7 crucibles)			(2 furnaces 5 crucibles)			(1 furnace: 4 crucibles)			(2 furnaces 13 crucibles)			(2 furnaces 5 crucibles)			(2 furnaces 7 crucibles)		
	lire	soldi	%	lire	soldi	%	lire	soldi	%	lire	soldi	%	lire	soldi	%	lire	soldi	%
Raw material	3,240		57.51	3,360		66.25	436	12	42.88	1,227	18	40.51	980		49.97	2,502		74.07
Fuel	880		15.62	560		11.04	240		22.58	920		30.35	440		22.44	440		13.03
Fixed capital	165	8	2.94	84		1.66	66		6.48	196	8	6.48	78		3.98	101	10	2.99
Labor	1,365		23.93	1,068		21.06	275	12	27.06	687		22.66	463	4	23.62	335		9.92
TOTAL	5,633	8	100.00	1,018		100.00	1,018	4	100.00	3,031	6	100.00	1,961	4	100.00	3,378		100.00

Source: ASV, *Censori*, busta 42 and BNM, *Mss. It. Cl. VII, 2211=10049*, fol. 136a.

Table 3. Quantity and value of the major glass commodities exported from Venice, 1770–1795.

SEED BEADS Unit price: 38.58 *ducats* per 100 pounds							
Destination	**1770**	**1771**	**1784**	**1785**	**1793**	**1794**	**1795**
Venetian state	163,928	236,973	363,963	132,503	217,204	303,825	168,394
Italian states	176,091	256,020	218,668	130,092	421,565	407,542	166,427
The Levant	608,627	458,597	601,473	336,483	465,503	606,211	708,176
North Africa	63,920	9,999	0	50,630	141,880	2,800	8,000
Western Europe	554,240	597,199	326,912	669,116	454,657	224,960	222,378
Germany	103,418	64,313	102,312	58,247	106,426	103,871	35,765
Total in pounds	**1,670,224**	**1,623,101**	**1,613,328**	**1,377,071**	**1,807,235**	**1,649,209**	**1,309,140**
Value in ducats	644,383	626,203	622,432	531,283	697,243	636,275	505,075

LAMP BEADS Unit price: 79.42 *ducats* per 100 pounds							
Destination	**1770**	**1771**	**1784**	**1785**	**1793**	**1794**	**1795**
Venetian state	31,438	51,041	79,599	56,598	65,569	95,587	83,573
Italian states	45,147	50,222	36,523	35,872	150,352	56,013	59,753
The Levant	121,958	103,964	123,793	159,322	97,975	83,959	166,335
North Africa	7,775	2,395	766	10,050	29,187	6,945	0
Western Europe	60,570	66,016	60,787	49,987	6,817	49,831	30,672
Germany	30,527	21,946	13,286	11,788	21,135	10,279	12,414
Total in pounds	**297,415**	**295,584**	**314,754**	**323,617**	**371,035**	**305,614**	**304,542**
Value in ducats	236,205	234,751	249,976	257,015	294,674	242,717	281,575

Table 3. *continued*

WINDOW PANES Unit price: 4.05 *ducats* per 100 pounds							
Destination	**1770**	**1771**	**1784**	**1785**	**1793**	**1794**	**1795**
Venetian state	431,818	359,425	519,101	418,512	509,578	525,286	452,673
Italian states	898,879	1,343,653	1,138,596	943,887	932,772	584,939	675,710
The Levant	461,993	396,081	425,810	444,941	405,345	139,595	43,425
North Africa	500	4,750	0	5,708	1,000	2,000	
Western Europe	7,278	12,125	8,076	75,767	54,210	10,758	155
Germany	4,318	1,175	332	0	370	3,600	2,767
Total in pounds	**1,804,786**	**2,117,209**	**2,091,915**	**1,888,815**	**1,903,275**	**1,266,178**	**1,174,730**
Value in ducats	72,919	87,966	84,520	76,314	76,898	51,158	47,463

MIRRORS Unit price: 81 *ducats* per 100 pounds							
Destination	**1770**	**1771**	**1784**	**1785**	**1793**	**1794**	**1795**
Venetian state	89,011	84,725	85,621	68,859	121,631	103,254	124,654
Italian states	319,301	275,254	141,544	140,679	142,900	116,451	180,745
The Levant	32,750	41,374	21,519	30,905	38,239	25,197	50,531
North Africa	1,336	916	60	0	3,054	3,040	290
Western Europe	6,150	5,104	28,304	36,385	6,799	4,502	5,797
Germany	4,996	7,871	1,589	1,965	1,935	1,806	1,677
Total in pounds	**453,544**	**415,244**	**278,637**	**278,793**	**314,558**	**254,250**	**363,694**
Value in ducats	367,371	336,348	225,696	225,822	254,792	205,943	294,349
Sources: ASV, *Cinque Savi alla Mercanzia. Registri bilanci*, registri 3, 76, 115–118, 122–124.							+

Table 4. Quantity and value of other glass commodities exported from Venice, 1770–1794.

	1770	**1771**	**1784**	**1785**	**1793**	**1794**
Small liquor bottles	no. 1,365	no. 1,788	–	dozens 8	dozens 33	dozens 4
Coach crystals	L 15,094	L 10,298	L 11,909	L 10,513	L 10,343	L 10,618
Manufactured crystals	L 10,242	L 6,235	L 6,039	L 7,797	L 9,402	L 9,173
Glass pastes	L 858	L 75	–	L 150	L 199,171	L 187,845
Window round glass	L 23,409	L 8,278	–	–	* L 700	** L 200
Enamels	L 12,272	L 16,615	L 8,722	L 16,981	L 22,170	L 22,426
Blown glass in cases	no. 1,597	no. 1,414	no. 1,464	no. 1,295	L 1,869	L 2,233
Mixed crystals	D 10,284:5	D 9,843:7	D 12,981	D 11,106	L 19,881	L 19,444

* all in Germany ** all in the Venetian territories of Albania
L = pounds D = ducats
Sources: ASV, *Cinque Savi alla Mercanzia. Registri bilanci*, registri 3, 76, 115

Table 5. Number of crucibles assigned by the Murano guild to each type of glass production, 1678–1792.

	1678	**…**	**1700**	**1701**	**1702**	**1703**	**1704**	**1705**	**1706**	**1707**	**1708**	**1709**	**1710**	**1711**	**1712**	**1713**	**1714**	**1715**	**1716**
Blown glass	114		41	43.5	40	50	33+	37	36	45	27+	25	26	32	16	25+	48+	23	19+
Mirrors and windowpanes	82		80	70.5	42.5	52.5	80	83	75	54	56.5+	72.5	68.5	72	76+	89.5+	56	83	54+
Glass beads and enamels	35		47	26+	26	32	22	23	34	33	24	12	14	15	13.5+	14	22	22	23+
TOTAL	**231**		**168**	**140+**	**108.5**	**134.5**	**135+**	**143**	**145**	**132**	**107.5**	**109.5**	**108.5**	**119**	**105.5**	**128.5**	**126**	**128+**	**96+**
	1717	**1718**	**1719**	**1720**	**1721**	**1722**	**1723**	**…**	**1725**	**1726**	**1727**	**1728**	**1729**	**1730**	**1731**	**…**	**1733**	**1734**	**1735**
Blown glass	25	23+	42	33	31	29	33+		36	45	27+	25	26	32	16		20	–	30
Mirrors and windowpanes	72+	71	67.5	70	108	83+	80		75	54	56.5+	72.5	68.5	72	76+		84	71	73
Glass beads and enamels	23	19	16	28	24	43	22		34	33	24	12	14	15	13.5+		42	18	43
TOTAL	**120+**	**113+**	**125.5**	**131**	**163**	**155.5**	**160+**		**158**	**145.5**	**131.5**	**141.5**	**149**	**160.5**	**132.5**		**146**	**89+**	**146**

Table 5 – *continued*

	1736	**1737**	**1738**	**1739**	**1740**	**1741**	**1742**	**...**	**1744**	**1745**	**...**	**1748**	**1749**	**...**	**1751**	**1752**	**1753**	**1754**	**1755**
Blown glass	–	–	–	–	22	21	24		38	38		–	22+		23+	27	25	26	24+
Mirrors and windowpanes	68	86.5	70	64	788	94+	106		62	57		94	122		128	109	116	111	79
Glass beads and enamels	41	39	31	31	40	26	25		29	32+		29+	32+		42+	42	46	39	49
TOTAL	**109+**	**125.5**	**109+**	**95+**	**140**	**141**	**155**		**129+**	**127+**		**123+**	**176+**		**193+**	**178**	**187**	**176**	**152+**
	1765	**1766**	**1767**	**1768**	**...**	**1770**	**...**	**1779**	**...**	**1783**	**1784**	**1785**	**1786**	**1787**	**1788**	**1789**	**1790**	**1791**	**1792**
Blown glass	27	27	27	29		27		34		29	28	24	30	30	23	26	24	27	27
Mirrors and windowpanes	70.5	71	86.5	93.5		104.5		101		118	106	125	105	85	96	123	121	131	111
Glass beads and enamels	40	37	37	35		38		42		46	31	41	41	36	43	51	45	49	48
TOTAL	**137.5**	**135**	**150.5**	**157.5**		**169.5**		**177**		**193**	**165**	**190**	**176**	**151**	**162**	**200**	**190**	**207**	**186**

Sources: for 1678-1755 see ASV, *Capi del Consiglio dei Dieci. Notatorio*, filze 37-51, except 1743 in ASV, *Inquisitori di stato*, buste 819 and 826; for 1765-1792 see ASV, *Censori*, buste 42 and 47, except 1770 in ASV, *Inquisitore alle arti*, busta 97

The sign + indicates that data are incomplete and therefore the total is an underestimation.