

## 1 Warnings

### 1.1 Under the Loggia

It is market day, and you have been tasked to buy grains. As usual, you and the seller meet under the loggia, where a measurer stands next to a *staio*, a bucket-like standard for dry goods. If you were in late sixteenth-century Norcia, the officer would pour the cereals into the cylinders carved in stone adjacent to the Church of San Benedetto (Figure 1), three of which survived the 2016 earthquake as well as the catastrophes of the previous 400 years (Patrizi-Forti 1869: 514). You are in fifteenth-century Florence, however, and the measurer uses a metal *staio*, which he fills to the top as shown in this painting by Biagio d'Antonio and Bartolomeo di Giovanni (Figure 2). A notary sits nearby to record every purchase in a register since the government closely monitors grain sales. (Note: the painting does not show the notary, but then it depicts a biblical episode that is presented in the style of a Renaissance transaction.)

Afraid of famine, Florence's administrators forbade exports, set maximum amounts per person, and fixed the maddeningly volatile price of cereals and bread, day after day (Goldthwaite 1975; Epstein 2000: 157–64; Magni 2015). It wasn't just the sale of cereals that was heavily disciplined. In Renaissance Italy, the market was not a free place: its access was restricted; its operations followed specific times and protocols. In Florence, its management was in the hands of four *camerlenghi*, market supervisors recognizable by their white hats decorated with spikes dipped in red paint (Pecchioli Vigni 1971: 31–32). Other cities relied on other monitoring magistrates, their duties often merging with those of the *sensali*, brokers who performed quality checks, dealing with any disagreement between vendors and customers (Bolognesi 2007; De Luca 2010: 240). Marketgoers knew they had to remain vigilant. The risk of fraud, even small scams, was real. When buying grain, they were advised against filling the measure in one quick pour, which could cause the kernels to settle unevenly and result in pockets of air. Forgetting this, a merchant reports, meant “to lose two or three percent.”<sup>1</sup> The painting by Biagio and Bartolomeo gestures to this watchfulness by showing both buyer and measurer intently staring at the latter's hand as it levels the grain.

Preachers contributed to this climate of mistrust. Friar Bernardino of Siena accused merchants of using a smaller *staio* when selling and a larger one when buying.<sup>2</sup> His audience was large – a chronicle reports that the whole city showed up at his sermons (Polecristi 2000: 39–46) – and I sometimes wonder if his popularity led him to exaggerate his words, as if he were trying to inflame more hearts.

<sup>1</sup> Paolo da Certaldo, *Libro di buoni costumi*, 43.

<sup>2</sup> Bernardino da Siena, *Prediche volgari*, 2:1117.



**Figure 1** Bushels (*staia*) for grains, sixteenth century. Loggia dei Mercanti, Basilica di San Benedetto, Norcia. Photo: SibilliniWeb.it, around 2013.



**Figure 2** Biagio d'Antonio with the help of Bartolomeo di Giovanni, *The Story of Joseph*, ca. 1487. Detail. Cambridge, UK: Fitzwilliam Museum. Photo: author



**Figure 3** *The Merchant*. In Jacopo da Cessole, *Volgarizzamento del libro de' costumi e degli offizii de' nobili sopra il giuoco degli scacchi*, Florence, 1493

Still, suspicion about standards had grounds. For example, in 1532, an officer in Modena reported that upon inspection of thirty-four *staia*, twenty-two were faulty.<sup>3</sup> In the sixteenth century, Verona unknowingly used various standards of the *pie*de (foot) after the city lost its official length, which was not reconstructed until 1696 (Tucci 1974: 307). Even a manual about chess included a rant against the chaos in the marketplace and greedy traders who disregarded the measuring standards on which their sense of the self ought to depend.<sup>4</sup> One of its illustrations (Figure 3) visually argues for their identification.

Skepticism surrounding measurement shaped the attitude of sixteenth-century Florentine historian Vincenzo Borghini. “The nature of weights and measures is both very uncertain and very unstable. They vary from moment to moment, place to place and thing to thing, so much so that to reduce them to a fixed and equivalent term is very difficult, if not impossible.”<sup>5</sup> As a way of conclusion, he stated: “neither now nor perhaps at any point have all things been measured in the same way.”<sup>6</sup>

<sup>3</sup> De' Bianchi, *Cronaca*, 3:382.

<sup>4</sup> Jacopo Da Cessole, *Volgarizzamento*, 86. While Jacopo was a contemporary of Dante, his treatise was reprinted into the late sixteenth century.

<sup>5</sup> Borghini, *Discorsi*, 1:138. <sup>6</sup> Borghini, *Discorsi*, 1:138.

Most scholars have brushed Borghini's sentiment off as pessimistic. Italian city administrators, after all, took steps to protect and maintain their measurement standards. They had them made in sturdy metals and kept in safes. They displayed standards in public, next to important buildings, to ensure that citizens were aware of them (Lugli 2019a: 65–94). As part of their assigned duties, officers went around town, shop after shop, to check that artisans' tools were accurate. In 1461, the silk guild of Milan requested that all scales be inspected within three days of a sale, thus detaching the purchase from the moment of exchange, which could be reversed were the instruments found imprecise (Santoro 1961: 88–89). Additionally, sellers and buyers developed a complex choreography of sayings, gestures, and regulations not only to guarantee fairness in their transactions but also to instill a sense of fairness (Romano 2015: 110–26). These practices were often reinforced by the decoration of marketplaces and civic buildings with allegories of justice as dependable rulers and monumental inscriptions against fraud (Frojmovič 1996: 35–36; Welch 2005: 79–81). Citizens believed the economic well-being of a city depended on the trust people placed in its ability to maintain order and honesty.

When reading a city's statutes, the governmental initiatives look impressive. Yet Borghini's sense of defeat is understandable given the variety of measurement throughout Italy. Every city employed different standards for different purposes. Land was measured with one unit, wood with another. Silk relied on standards that were separate from those for wool. Venice even developed one weight for gold and one for gold thread (Tucci 1974: 311). There was hardly any relationship between any two standards and, if there was one, it was not always straightforward. In Florence, the length used for measuring fields (*braccio da terra*) was 17/18 the length for cloth (*braccio da panno*). This proportion was awkward because each standard developed independently: Florentine land surveyors had little need to interact with cloth makers. The 17/18 proportion was also a mere simplification: it was first documented in the late fifteenth century when the city government began legislating on both standards and recorded them in a way they found easy to understand. Similarly, Milan's and Turin's "medieval" *piedi* are only known through documents drawn in the sixteenth and seventeenth centuries, respectively (Reguin 2018: 67–68).

Realizing the government's role in shaping the history of measurements exposes the ideology of any dismissal of premodern standards as maddening (Henschel 1855: 9; de Sanctis 1970: 191). This stance assumes the indispensability of a centralized government in managing a growing industry and commerce (Burckhardt 1890: 68–71). It also assumes that humanity's goal is freedom – the freedom to trade, in particular – and portrays state-sponsored standardization as essential to achieve this goal (Scott 1998: 27–36). Little does

it matter that this thinking only expresses the ambitions of those who profited from large-scale exchanges. Those who were satisfied with trading locally developed no interest in the measurements they were not using.

The historians who believe that the imposition of standards by governments was necessary for promoting internal homogeneity and global connectivity celebrate the metric system as the greatest achievement. While forced on the French population in the aftermath of the Revolution, it built on ideas developed during the previous two centuries (Tavernor 2007: 70; Crease 2011: 69–98). One significant moment was Flemish engineer Simon Stevin's proposal to base all measurement standards on decimal counting, which would make measuring compatible with mathematical operations. Stevin argued for this change in his 1585 pamphlet *De Thiende* (22–36). Immediately translated into French, *De Thiende* suggested that productivity could be improved by enabling faster computation. A second moment came with Gabriel Mouton's *Observationes* (1670), in which he proposed making the new standard incorruptible by deriving it from the shape of the earth (Alder 2002: 97). From its 1793 introduction to 1960, the meter was described this way, after which it was redefined in terms of wavelengths.

Within two centuries after its debut, almost every country in the world followed France in adopting the meter because it came with closely related standards. (The mass of one liter of water, which is the volume of one cubic decimeter, corresponds to one kilogram.) The domino effect, however, did not happen naturally. Especially at the beginning, it was actively promoted through diplomacy and enforced violently. Napoleon imposed the metric system across his whole empire, including the Italian states, where local governments and intelligentsias welcomed it as a rational replacement for their abstruse standards.

For example, in 1809, citizens of Tuscany adopted the metric system and started thinking of their *braccio da panno* as 583 millimeters.<sup>7</sup> This conversion has never been questioned for two reasons. First, the official standards of the old *braccio* were destroyed when the meter was instituted. (This process of elimination and substitution occurs whenever a new standard is introduced and unfortunately leaves us with only one side of the story.) Second, the metric system has become the gold standard of measurement: it is routinely retouched to meet the latest findings in physics.<sup>8</sup> This care and the trust it engenders have led most historians to view metric conversions as mere technical changes rather than profound cultural transformations (Tucci 1974). When scholars open their studies by reporting that the Florentine *braccio* corresponded to 583

<sup>7</sup> *Tavole di riduzione*, 1809: 13–14. The metric law dates to December 19, 1808. See Zangheri 1987.

<sup>8</sup> The last revision took place on May 20, 2019.

millimeters, they ignore that Florentines did not see millimeters.<sup>9</sup> Florentines divided their *braccio* into 20 *soldi* and each *soldo* into 12 *denari*, so most of them ignored anything smaller than one *denaro* – “the little one,” as they called it – which can only be approximately rendered as 2.4 millimeters.

When you become aware of how widespread such present-biased distortions are, Borghini’s doubts gain traction. In his work, which was published in the same year as Stevin’s pamphlet, Borghini asks if we put too much trust in measurement. We tend to think of standards as enduring tools, but they are slippery. As constructions by humans, after all, they are just as flawed. Most historians counter this skepticism; even the most cautious among them accept that past measurements standards can be reconstructed in some form. Not doing so would bring the very project of history to collapse. For what historical picture can anyone offer if measurements, the very means to provide a tangible sense of the past, remain out of reach?

This Element takes seriously the idea that measurements are not self-evident, recognizing that the rationality they express is coextensive with the cultural desires that generated them. As a result, it accepts that many aspects of the Renaissance, just like its measurement standards, are lost to us. This is why I occasionally speak in the first person: it is a reminder that both history writing and measuring involve subjective judgments, even if they often claim to be and are mistaken for absolute truths.

This survey explores objects, practices, and ideas that can help us understand the roles of measurements of fifteenth- and sixteenth-century Italy. Although the topic of quantification is huge, for it is a fundamental aspect of life, this study is deliberately slim. Therefore, the following pages provide only an overview and offer points of comparison for further study on the subject, much like how standards serve as a reference for unknown objects.

This Element, however, is not a random collection of examples; it is organized around two main themes. The first theme is to recognize measurement as a discipline that developed practices and concepts that existed outside and across the fields of knowledge to which it was applied. This approach is unusual because many scholars view measurement as a technique to achieve something else. Architecture historians study geometry as a framework for form and style, economists consider estimates to quantify revenues, and philologists study measuring exercises in manuscripts to construct codicological lineages, not because they think measuring may add anything to their lives. In each case, measurement is often treated cursorily, with its procedures dismissed as elementary and its diagrams given little attention. In contrast, this Element sets out to present measurements as producing a distinct culture. Throughout the fifteenth

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<sup>9</sup> There are, of course, exceptions like Marina 2006: 545–46.

and sixteenth centuries, many built careers out of its mastery and tried to solve its limitations, eventually developing the standards that we use today.

This is, however, only the Element's secondary theme. For the main one, keep on reading.

## 1.2 The Florentine *Braccio*

An historian, Borghini studied the Florentine nobility and encountered documents that quantified their estates in feet, a puzzling standard since, in his time, fields were measured in *braccia da terra*. Borghini (*Discorsi* 1:85) read in a medieval chronicle that the old foot was named after Liutprand, the king who ruled over parts of Tuscany in the eighth century. (Today, historians debate whether such a standard even existed as they acknowledge Liutprand's reliance on oral arrangements, on which see Chiavari 1981.) Borghini must have known a foot was once displayed on the San Pancrazio gate. Florence's archives preserve nine documents, dating from 1083 to 1207, that define a foot standard this way (Manni 1734: 125–83; Uzielli 1899: 23).

Gateways carrying standards were common in Borghini's day. For incoming merchants, these displays marked the threshold to a distinct trading ground. For the customs officers who spent their days by those barriers, they were the standards by which they quantified imported goods and calculated duties. Only a few portals still preserve them. Volterra's San Francesco gate is incised with the *canna* (Caciagli 1978). Fano's Roman arch carries the outlines of roof tiles and two lengths (Fiorini 2015: 80) (Figure 4). Florence's San Pancrazio gate, however, was demolished three centuries before Borghini was born (Sznura 1975: 70–72). Borghini's source, Giovanni Villani, was the sole chronicler to provide a cursory definition: the foot was “a bit less than the *braccio* we currently employ.”<sup>10</sup>

Around the time Villani was writing – that is, 1325 – the foot had fallen into disuse as the Florentine government started relying on the *braccio da panno* of the Arte di Calimala, the guild of merchants who imported cloth from northern Europe (Filippi 1889: 125; Atwell 2006: 195–96). A contract of 1321 for a house sale shows that surveyors used the *braccio*.<sup>11</sup> By turning a corporative standard into the city's standard, the government took advantage of a well-looked-after tool by which Florence was known internationally. Florence was not alone in reshaping its identity around its commercial successes: Italian cities like Verona and Bologna also elevated their most illustrious corporations' tools to the rank of civic standards (Lugli 2019a: 80–87). Such assimilations came about because guilds were enmeshed with civic administrations: their members took on leadership roles and contributed to shaping the

<sup>10</sup> Villani, *Nuova Chronica* 3.9.    <sup>11</sup> Manni 1739–86, vol. 21, *giunta* 4, p. 50.

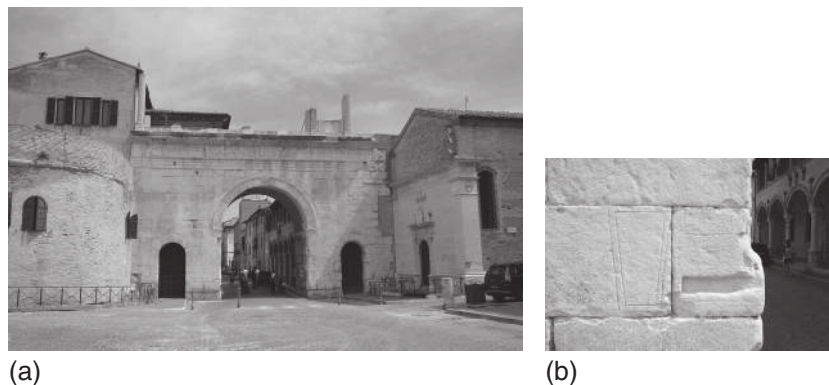


**Figure 4** Standards of the roof tile and fragments of two lengths,  
 Porta Romana, Fano. Photo: author

city's affairs (Molho 1968: 26). In 1323, the Arte di Calimala supplied the city of Florence with a contingent of 200 soldiers (Giuliani 2006: 17–18). It is therefore unsurprising that two years later the Florentine statutes (*Statuto del podestà* 4.32) ordered their *braccio* to be reproduced in “two or three places at least” so citizens could familiarize themselves with it. Today, one of these places is said to be a wall on Via de' Cerchi, a few steps away from Palazzo Vecchio, the town hall (Figure 5). There is no documentation on it, and the display is unique. I never came across an official standard framed by bricks, as is the case here. Official standards tend to be cut in hard stone (like in Assisi, Padua, and Vicenza), not friable clay. I wonder if the tourist attraction may be the repurposed bottom of a one-braccio-wide door or window frame.

After the endorsement by the Florentine government, more artisans are recorded employing the Calimala *braccio*. It became the standard of the Arte della Lana, the guild of wool cloth makers, which employed around one-third of the Florentine workforce and appointed seventy-two measurers alone.<sup>12</sup> Soon after, the *braccio* appears in architectural contracts (Ascani 1997: 150–56). A document from 1357 indicates it was used for the planning of Florence's cathedral (Guasti 1887: 94; Trachtenberg 1997: 295). By the fifteenth century, only land was measured by a different length, the *braccio da terra*, a standard believed to originate from the San Pancrazio foot (Uzielli 1899: 14), even if there is no evidence for it. In his mathematical digest, Luca Pacioli (*Summa*, 1494, f. 6 v) defines it for the first time as 17/18 of the *braccio da panno*. When applied to the *braccio da panno* of 583 millimeters, it produces a *braccio da terra* of about 551 millimeters.

<sup>12</sup> *Statuto dell'Arte della lana*, 65. The stats come from Villani, *Nuova Chronica* 12.94.

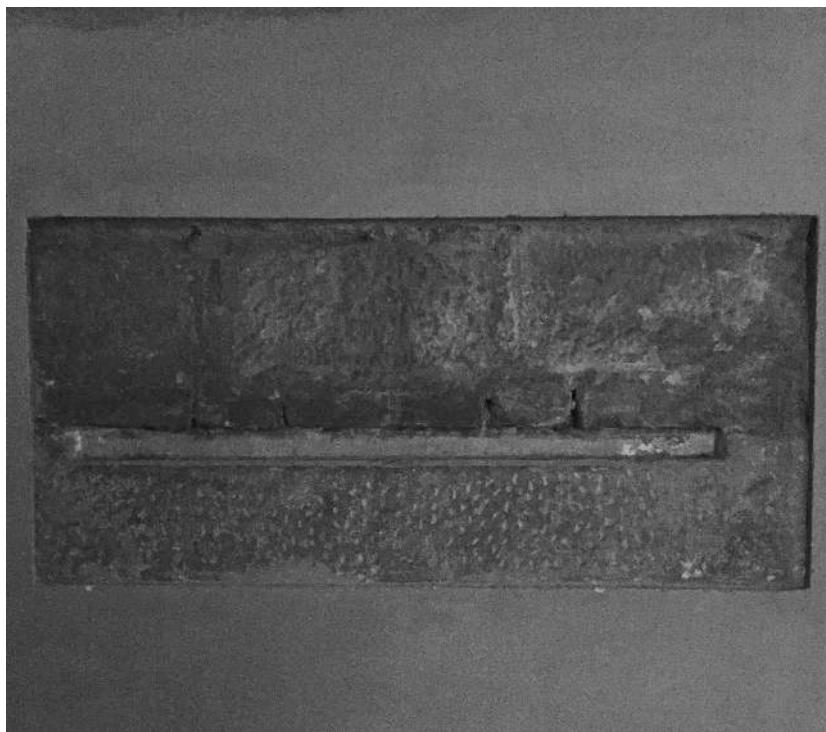


**Figure 5** Standard of the Florentine *braccio*. Florence, via de' Cerchi. Photo: author

Here we go again: I am joining the crowd and turning old standards into millimeters, hanging on to values provided by Napoleon's administration. It is a most fallacious operation also because the metric conversions do not relate to the Renaissance tools. Instead, they convert the standards employed after 1782, when Grand Duke Peter Leopold had them retouched in preparation for their introduction across the whole of Tuscany.<sup>13</sup> The revamping fell to the mathematician Leonardo Ximenes (1716–86), who owned a state-of-the-art *toise*, France's main pre-metric length standard, a gift by the mathematician Charles Marie de la Condamine.<sup>14</sup> Ximenes may have had blind faith in his new tool, but his report (*Del Vecchio e nuovo gnomone*, 1–10) offers a bleak picture. He reports that, upon commencing his investigation, he found four lengths that were identified in Florence as the city's official *braccia*, none of which matched another. Ximenes quickly dismissed two – bent, stretched out, probably mislabeled – to focus on the

<sup>13</sup> *Tavole di ragguaglio*, 1782. Peter Leopold's edicts are in *Relazioni*: 281 (March 13, 1781, and July 11, 1782). Peter Leopold's process of standardization continued his father's, on which see Guarducci 2009, 143.

<sup>14</sup> The event is recounted in De la Condamine, *Extrait*: 348 and 400.

others, mounted by the entrance of the Bargello palace, one above the other at eye level: the *braccio da panno* and *braccio da terra*. It is important to remark that Ximenes did not measure them in their entirety. Their extremities were eroded, their bodies irregular. He determined their lengths by measuring fractions of each and multiplying them accordingly. He repeated the operation a few times and then averaged out his findings to make the two dimensions correspond to Pacioli's proportion of 17/18. The *braccio da panno*, he concluded, was 258.454 Parisian *lignes*, the *braccio da terra* 244.095.<sup>15</sup>

Now: what monstrous form of quantification is this? Ximenes cobbled together heterogeneous procedures (direct measuring, multiplication, calculation of the mean) and even corrected his findings to satisfy Pacioli's ratio, thus bending a scientific (read: self-sufficient) operation to a pragmatic (that is, political) goal. Measuring should be an open-ended process, a jump in the dark, whose results ought to be accepted for what they are rather than confirm someone's desires. Yet, no one noticed Ximenes's aberrant practice besides the scientists who, following the unification of Italy in 1861, reconverted all of Italy's pre-metric standards (*Tavole di ragguaglio*, 1877, 675–76). When dealing with Tuscany, the members of the Royal Commission for Weights and Measures admitted to being at a loss for, in the absence of dependable, pre-metric standards, they were forced to rely on Ximenes's work. Unfortunately, historians of Tuscany do not acknowledge this problem.

### 1.3 Metaphysics

The standards displayed outdoors were particularly prone to weathering and needed to be replaced regularly. City statutes outlined the procedures for their substitution, which involved high-ranking officers inspecting the stone slabs every few months (usually six) and repairing them if necessary (Guidoni 1989: 376). According to the statutes of Florence (*Statuta populi et communis Florentiae* 4.77), it was the responsibility of the *Capitano del popolo*, the police chief, to examine standards for grain, wine, oil, pulse, and salt within the first month after his appointment. Even if it was assumed that the replacement standard was carefully made, it was still made at a different time and by hand, possibly using different tools, which means that it would not be identical to the original standard. Additionally, each time a standard was replaced, the government did not update the private standards employed by artisans, who continued to use them, believing their tools were equivalent to the matrix even if they were not derived from it.

Slippages also occurred during every use. How much grain does a *staio* actually hold, after all? If you press the grain, you can fit more in. If you mound it, you can fit even more. So how do you ensure a *staio* consistently holds the same amount of

<sup>15</sup> In a *toise* there are 864 *lignes*.