

Fluid Currency: The Political Economy of Hydrology in Baroque Rome

4.663 History of Urban Form: Locating Capitalism:  
Producing Early Modern Cities and Objects  
Professor Lauren Jacobi, MIT, Spring 2014

## Water and the *Renovatio Romae*

The *Renovatio Romae*, or Renovation of Rome, began under the leadership of Pope Martin V in 1420, two years after the return of the papacy from Avignon following the Schism. Gradual growth since the Great Western Schism (1378-1418) had, aside from a sudden and dramatic interlude following the Sack of Rome by the troops of Charles V in 1527, allowed its population to increase to around 35,000-55,000 by the middle of the 1500s.<sup>1</sup> This augmentation, however, did not aid the sense of emptiness and abandonment that prevailed since the ancient walls of Rome were built for a healthy and dense city of a million. Rome, prior to the middle of the sixteenth century was, urbanistically speaking, a rather squalid arrangement of noble ancient churches and haphazard settlements nestled within the vast enclosure of its third century fortifications. Despite the growth of the previous century, its total number of inhabitants had been forced to remain low since the original water supply of the ancient city was destroyed by the barbarian invasions that aided in bringing down the Roman Empire. For the citizenry of the late Renaissance that drank from wells or the putrid confluence of the Tiber, the massive broken arches of the aqueducts of old served as poignant reminders that Rome once had an infrastructure capable of sustaining a much larger population. These concrete and mnemonic fragments of a distant imperial past pierced through forgotten layers of the urban substrata, making it known to its current inhabitants that Rome once was a magnificent city, and that it perhaps still had the potential to magnificent once again.

<sup>1</sup> Jean Delumeau, *Vita Economica e Sociale di Roma ne Cinquecento*, trans. by Sarah Cantoni (Florence: G.C. Sansoni Editore Nuova S.p.A, 1979). pp. 63-64; 87.

Many of its most lasting and visible effects, however, can be situated in the period following the Sack of Rome. The ruinous squalor of medieval Rome was gradually diminished by surgical interventions through its congested mass and the layering of baroque jewelry upon its worn superficie. This process of urban composition possibly reached its nadir and is thus perhaps most associated with the ambitious projects of Pope Sixtus V (1585-90). His vision and completion of new streets and urban vistas contributed greatly to the project of signifying Rome's triumph over past deprivation and furthermore contributed to its leadership's desires that the Eternal City be a controlled and ordered environment of resurgent value.<sup>2</sup>

The causalities of resurrection, however, should perhaps be associated more with the construction of another form of urban infrastructure: its water supply. Three major aqueducts were restored during the *Renovatio*. The ancient *Aqua Virgo*, or Acqua Vergine, was restored between 1560 and 1570 by Popes Pius IV and Pius V. This was followed by the reconstruction and unification of sections of the *Aqua Alexandrina* and *Aqua Marcia* (together renamed the Acqua Felice) between 1585 and 1587 during the papacy of Sixtus V, and the completion of the *Aqua Paola* from 1609-1612 under Paul V. Together, these new conduits brought a valuable and vital resource that resuscitated much of the previously undernourished or abandoned city, contributing to the goal of achieving its economic manageability and rebirth.<sup>3</sup>

Elaborating on the exhaustive work of Katherine Rinne, who attributed much of the urban rebirth during the Baroque period to the restoration of Rome's aqueducts, this

<sup>2</sup> Charles Burroughs, "Absolutism and the Rhetoric of Topography: Streets in the Rome of Sixtus V" in *Streets: Critical Perspectives on Public Space*, ed. by Zeynep Çelik, Diane Favro, and Richard Ingersoll, 189-202 (Berkeley and Los Angeles: University of California Press, 1994). pp. 189.

<sup>3</sup> Katherine Wentworth Rinne, *The Waters of Rome: Aqueducts, Fountains, and the Birth of the Baroque City* (New Haven: Yale University Press, 2010). pp. 1-10.

paper will frame the reintroduction of water into the uninhabitable zones of the city as a valorizing process. Playing with this Marxian theme, this conceptualization of valorization extends both to the land and property affected by the new water and to the water itself. Land was valorized by the addition of the natural resource of water. Water's pure (or intrinsic) utility value augmented the land's utility value and in this process enacting the land's value in exchangeability. The land of Rome was not the only substance to be valorized, however. The water itself underwent a process of valorization in which its artificial canalization, distribution, and manipulation brought about the ability for it to be considered suitable for exchange. The classification of the value in the water that was desired in the exchange remains uncertain, however. Water in its exchangeable state still possesses a two-fold value that encompassed both its utility and exchangeability. The inability to measure the former causes the difficulty inherent in measuring the former, however. Due to the mensurative drawbacks of water's distribution system, these values could not be quantified, thus revealing the imprecise nature of exchange that results in the process of distribution for a material of exchange.

Restoring the aqueducts resulted in the construction of numerous public and private fountains throughout the city. The construction of the Acqua Vergine allowed, by the papacy of Gregory XIII (1572-1585), for Rome to assume its identification as the city of fountains with the erection of these outputs of fluidity in the Piazza del Popolo, Piazza Colonna, two in the Piazza Navona, and so forth.<sup>4</sup> This particular water system allowed for the solution of Rome's most urgent problem: sustaining the consumptive needs of the city's most populated area.<sup>5</sup> The construction of the Acqua Felice during the papacy of

<sup>4</sup> Deleumeau, 88.

<sup>5</sup> Deleumeau, 88.

Sixtus V offered a different sort of benefit, however. Instead of providing water entirely for a district already filled with settled citizens, it projected a future group of users; life atop Rome's unpopulated hills would be possible and their permanent settlement feasible.<sup>6</sup> The city's vacant lands were designated for a development that could be construed as speculative, but possible due to the construction of a costly water infrastructure that would in turn make the properties atop the hills livable, sustainable of livelihood, and therefore valuable. This aspect of the *Renovatio* was, therefore, intended to be a controlled process of territorial valorization.

#### The Value in Water, The Valorization of the Land

That the extension of water from the Acqua Felice onto the hills of Rome was intended as an act of introducing something of value to previously desolate and deserted land is evident in the fountain that acted as both the system's terminus and its *mostra* (a term derived from *mostrare*, which means to exhibit.) This fountain was erected on the Quirinale to honor the prophet Moses who, by striking a rock with his staff, brought water to the Israelites when they wandered in the Desert of Sin following their exodus from Egypt.<sup>7</sup> (Fig 1.) The utilization of this biblical example within the 16<sup>th</sup> century Roman context poses a challenge in defining what sort of conceptualizations of utility value might have been used to describe water in the process of it being used to as physically enact an exchangeable value into the land.

<sup>6</sup> Deleumeau, 88. Helge Gamrath, *Roma Sancta Renovata: Studi sull'urbanistica di Roma nella seconda metà del sec. XVI con particolare riferimento al pontificato di Sisto V (1585-1590)* (Rome: L'Erma di Bretschneider, 1987). pp. 62

<sup>7</sup> Rinne, 128; Exodus 17, 1-7.

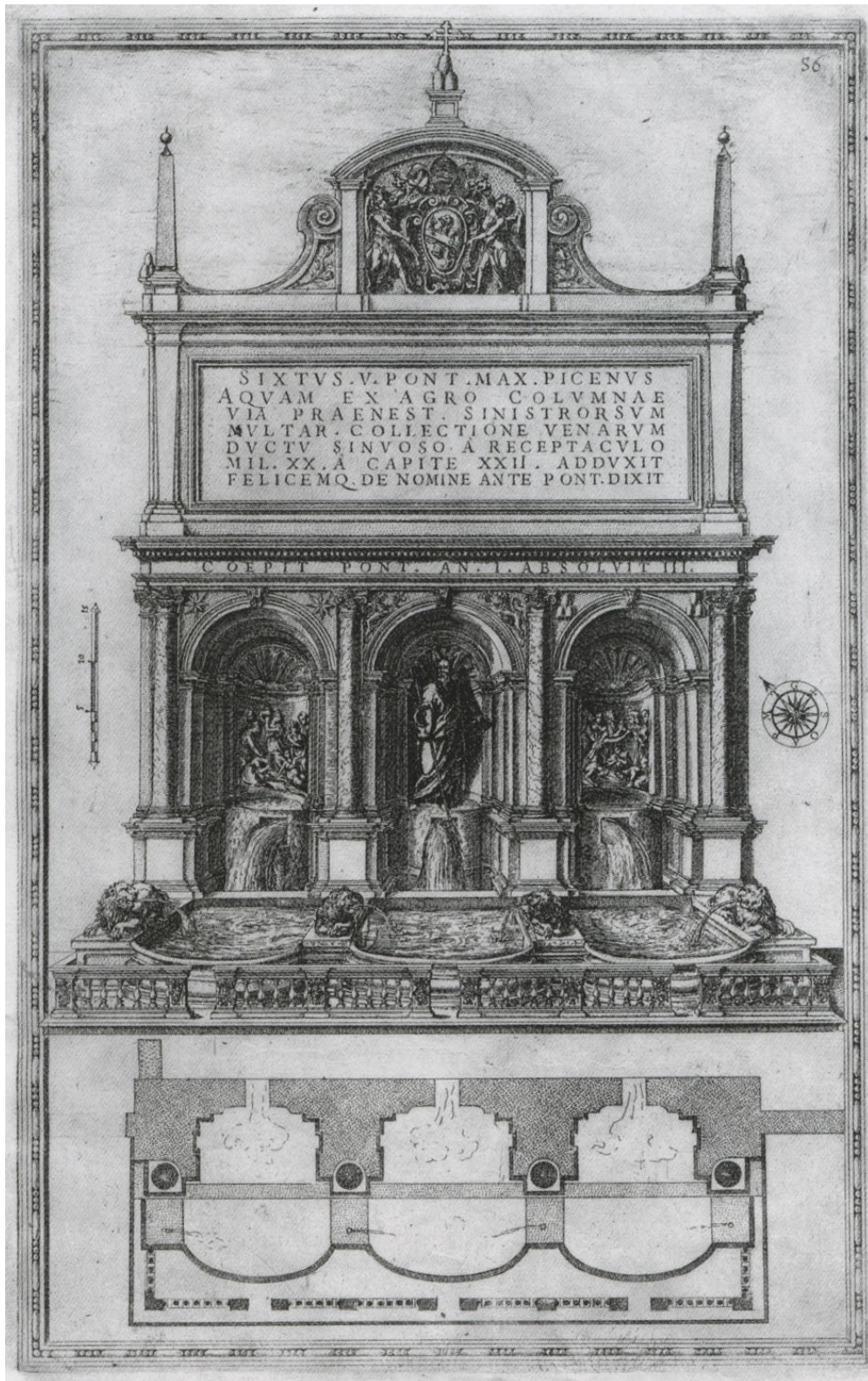


Fig 1. The Moses Fountain. (Domenico Fontana, Moses Fountain, in Fontana, *Della trasportatione dell'obelisco Vaticano et delle fabbriche di Nostro Signore Papa Sisto V* [Rome, 1590], 56)

In my desire to find other terminologies that would have been understood in 16<sup>th</sup> century Rome and which could aid in explaining the nature of value itself as well as describe the values inherent in water in 16<sup>th</sup> century Rome, I have found a combination of Platonic and Aristotelian thought as well as Scholastic economic theory through San Bernardino of Siena (1380-1444) of use since they layer further possible qualities to the Marxian interpretations of utility value and exchange value used elsewhere in this paper. Basic understanding of the natures of intrinsic value (inherent in an object) and instrumental value (carried and exchangeable for with the object) appear in the writings of Plato, and Aristotle expands further on this with his explanation of the two-fold (διττη) nature of uses in things that include their ability to be used (e.g. the use of the shoe is its “wear”) and their use in exchange.<sup>8</sup> For San Bernardino of Siena, whose perception of value certainly followed a path that focused on its utility, value was composed of three elements: usefulness (*virtuositas*); scarcity (*raritas*); and pleasurable or desirability (*complacibilitas*).<sup>9</sup> The value of water in the Sinai for the parched people of God can be

<sup>8</sup> For the Aristotelian point of view, any use value inherent in the object would have to be predicated by a need, which appears to place the origin of value somewhere between this relationship. Likewise, use in exchange would have to be founded on a pre-existing demand. Van Johnson, “Aristotle’s Theory of Value” in *The American Journal of Philology*, Vol. 60, No. 4 (1939): 447-448.

<sup>9</sup> Raymond De Roover, *San Bernardino of Siena and Sant’Antonino of Florence: The Two Great Economic Thinkers of the Middle Ages* (Boston: Baker Library, Harvard Graduate School of Business Administration, 1967). 18; S. Bernardino *De Evangelio aeterno*, sermon 32, art. 3, cap. 3 and sermon 35, art. 1, cap. 1 (*Opera omnia*, IV, 138-39, 190). *De Evangelio aeterno* was printed several times in the 15<sup>th</sup> century, and was included in a Venetian edition of his complete works, *Opera Omnia*, published in 1591, as well as in later Parisian and Lyonesse editions from the 17<sup>th</sup> century. That S. Bernardino’s basic qualities for defining value may have continued to be held from the era of the Scholastics onward by those acquainted with Economic thought and who believed in these theories (and for that matter, by anybody in Rome), is not fully known by me. It is important to note, however, that the usefulness (*virtuositas*); scarcity (*raritas*); and pleasurable or desirability (*complacibilitas*) of Bernardino do loosely harmonize with later claims by economists and moral philosophers, implying a continuity of thought. The moral philosopher Adam Smith (1723-1790) listed in his *Wealth of Nations* (1776) the measurable component of life value, or wealth, as degrees of “necessaries”, “conveniences”, and “amusements” Adam Smith, *The Wealth of Nations*. (New York: Bantam Dell, 2003), 43; likewise the physiocrat Richard Cantillon (1680-1734) in his *Essai sur la Nature du Commerce en Général* would state that wealth (here best understood as a sum of values) was “nothing but the Maintenance (*nourriture*), Conveniences (*commodities*), and

defined by its fulfillment of these three requirements, but with an emphasis on the first two. Its usefulness is paramount and unquestionable: The Israelites did not want to die along with their children and livestock; its scarcity was obvious: they were driven to question even the presence of God in the desert.<sup>10</sup> The value of water in the Mosaic narrative was therefore a utility-value based on its dearth and its absolute necessity in preserving life.<sup>11</sup>

The comparison of Sixtus V to Moses could be considered a stretch, however since the utility-value bestowed upon the Israelites through the resource of water was the means for the preservation of life itself, an apex value by its most explicit definition since they were on the brink of death through dehydration. The utility-value through water bestowed upon the both current and future Romans by Sixtus V offered the basis or means for a more generally defined value in livelihood and livability. This sort of value attached to the waters of the Pontiff can equally be defined by their capability of answering the needs of practicality by ameliorating the condition of scarcity. Also inherent in the aqueous value of the new waters of Rome was a greater proportion of the element of pleasure and desire that completes the full make-up of Bernardino's definition of value. The full benefits of the Acqua Felice, which Sixtus named in honor of himself (he was born Felice Peretti), but which also meant the "Waters of Happiness," were goals to be attained through the manipulation of value-type of this basic resource. Following a Marxist explanation, then, one could state that the use-value of the waters flowing into

Superfluities (*agrémens*) of Life. Richard Cantillon, *Essai sur la Nature du Commerce en Général*. Translated by Henry Higgs, C.B. (London: Reissued for the Royal Economic Society by Frank Cass, 1959), 2-3.

<sup>10</sup> Exodus 16, 1-2; 17, 1-7.

<sup>11</sup> De Roover, 17 – According to De Roover, S. Bernardino, in his definitions of the essence of value, would adhered more to a current utility-theory of value.



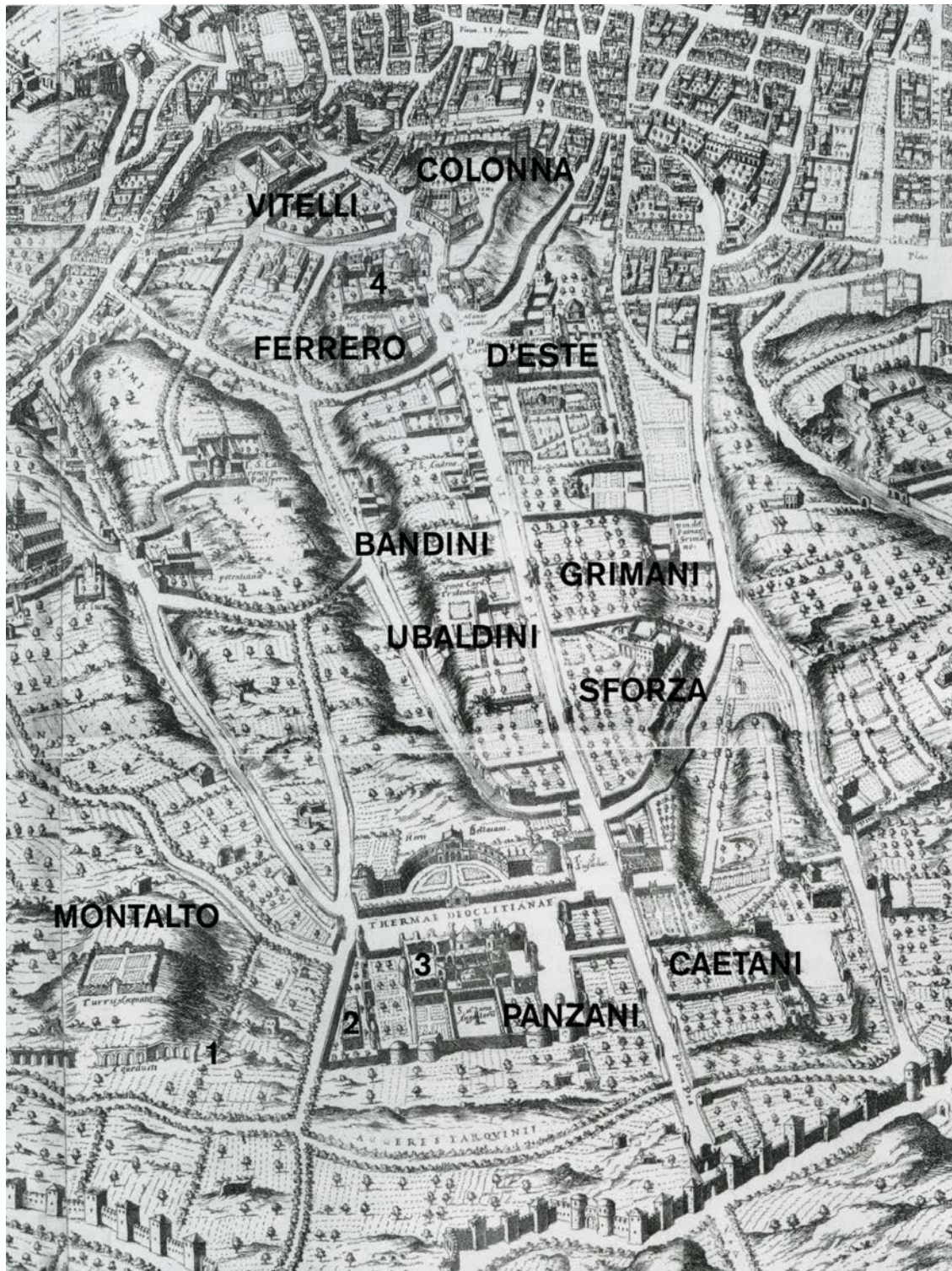


Fig 2. Properties owned by cardinals and noble families in Etienne Du Pérac's map of Rome, 1577.

and within the Acqua Felice were provided to act as a substratum for future exchange values that could be determined upon exiting its canalization and entry into the open public and private spheres of ownership.<sup>12</sup>

The valorization of the Quirinale and adjacent lands through the introduction of water ensured a process of development that could claim to offer benefits both to those that already owned the lands as well as those who intended to move to them. The water that streamed forth from the Moses fountain irrigated the preexisting vineyards of the hills, but also the neighborhoods surrounding the pilgrimage churches of Santa Maria del Popolo and Santa Maria Maggiore, the favored church of the pontiff.<sup>13</sup> These areas were also subjected to the major street building efforts that occurred during his papacy, allowed for new building sites and frontages that could be subdivided and sold at a premium due to their access to fresh water.<sup>14</sup> A pleasurable profit for the proprietors in this region of the city (fig. 2) ensured their livelihood while ample drinking fountains for residents and religious pilgrims made the Quirinale and other newly saturated hills both

<sup>12</sup> Karl Marx, *Capital, Volume I*, trans by Ben Fowkes (London: Penguin Books, 1990), 293. A fluid value of pure and un-commoditized utility, as a mandatory prerequisite and impetus of a more measured and quantifiable value of exchange, can be likened to the Aristotelian conceptualization of the criteria for substantiality, where matter (as essence) acts as the basis or substratum for an actualized, formal (and therefore definable) substance. Aristotle, *Metaphysics*: Book VII *Zeta*, 1-4. This is likewise relatable to an Aristotelian state of potentiality. This potentiality ([δύναμις] – which translates as “I am able”) can be understood as contributing to the Marxian conception of use value’s bearing and contribution toward, but not enacting, of the value in exchangeability) and its precedence and consequential causality for a related state of actuality for any substance. Aristotle, *Metaphysics*, Book V, <http://www.perseus.tufts.edu/hopper/text?doc=Perseus%3Atext%3A1999.01.0052%3Abook%3D5%3Asection%3D1019a>; This Actuality ([ενέργεια] – or energetic [work] state embodied by the enactment of exchangeability) is defined by Aristotle “the phrase being-at-work, which is designed to converge in meaning with being-at-work-staying-complete.” Aristotle, *Metaphysics*, Book IX <http://www.perseus.tufts.edu/hopper/text?doc=Perseus%3Atext%3A1999.01.0052%3Abook%3D9%3Asection%3D1047a>

<sup>13</sup> Rinne, 129.

<sup>14</sup> Rinne, 129.

useful and desirable.<sup>15</sup> The value of water transcended pure utility in its basic purpose of ensuring survival; its abundance or surplus had allowed it to become a source of both pleasure and desire as well as exchange.

### The Instrument of Exchange: Water, Coin, and the Conduit

The valoral and functional situation of water between utility and exchange beckon a brief investigation into the economic mechanics and conceptualizations of water. Because of the long tradition in economic theorization to resort to analogy by assigning a fluid nature to economic systems, in particular to currency, this portion of the paper attempts to relate monetary theory contemporary with the aqueducts reconstruction to its physical infrastructure and the material that it carried. Rinne specifically describes the water made available by the new and restored aqueducts of the *Renovatio* as “coin” or as a literal “liquid currency that could be bought, traded, sold, or given away within a highly structured and carefully monitored marketplace.”<sup>16</sup> This claim is problematic however, since it attempts to ascribe certain economic functions and requirements to a material that cannot fulfill them. I will attempt to analyze this claim by reverting to Aristotelian language and differentiating between the matter and substance of water where matter (as essence) acts as the basis or substratum for an actualized, formal (and therefore definable) substance.<sup>17</sup> The introduction of the matter of water (a natural resource with an intrinsic utility value) makes the conditions for exchange possible; it provides a material basis

<sup>15</sup> Rinne, 129. Aside from the pontiff’s personal properties, other holdings belonged to the Colonna, Vitelli, Ferrero, D’Este, Bandini, Grimani, Ubaldini, Sforza, Caetani, Panzani, and Montalto families. See figure 2 from Rinne, 116.

<sup>16</sup> Rinne, 181.

<sup>17</sup> Aristotle, *Metaphysics*: Book VII Zeta, 1-4.

upon which subsequent valorization and formal manipulation can bring it, by consequence now in the form of substance (and with an extrinsic exchange value), to market.<sup>18</sup>

Because the Scholastic teaching of Saint Thomas Aquinas (1225-1274) attached the term instrument (*instrumentum*) to money in its function in exchange, and latter followers such as the philosopher and proto-economist Nicholas Oresme (1323-1382) labeled it as a tool that permits all things to be measured together as well as an instrument of equalization or balancing instrument, coins can be defined as the measure of values in exchange.<sup>19</sup> Water can function in exchange only when it is defined as a substance and is represented as such. Although the matter of water does possess these qualities that would make it desirable, and capable of creating its own demand in trade and exchange, this matter can only be exchanged when taking into account the measurability of its formal definition or substance.<sup>20</sup> Its utility-value, which is arguably definable by its qualities as matter rather than as a form and substance, escapes the ability to be measured and therefore exchanged as such. In that the Aristotelian concept of matter is the essence or substratum of the form or substance of being, it can be said that the utility-value of the water of the *Acqua Felice*, which is understandable as matter, cannot be measured. On

<sup>18</sup> If the substance of water is to be understood as pure merchandise, than Rinne's claim can be held as valid. These views on the nature of currency as merchandise were upheld by Martín de Azpilcueta (1491-1586), the 16<sup>th</sup> century Spanish theologian, economist, and member of the Salamanca school who held that "money, inasmuch as it could be sold, bartered, or commuted by means of another contract is merchandise..." Martín de Azpilcueta, "Commentary on the Resolution of Money (1556)," trans. by Jeannine Emery. In *Sourcebook in Late-Scholastic Monetary Theory: The Contributions of Martín de Azpilcueta, Luis de Molina, S.J., and Juan de Mariana, S.J.*, ed. by Stephen J. Grabill, (Lanham, MD: Lexington Books, 2007), 70. This view of the exchangeable and equalizing relation between money and merchandise appears to be valid only in the context of exchanging one particular type of coinage belonging to one sovereign territory for another's, such as in the case of silver *reales*, for a gold *doubloon*, which is the exchange of one substantial representation of a particular matter for another.

<sup>19</sup> Joel Kaye, *Economy and Nature in the Fourteenth Century: Money, market exchange, and the emergence of scientific thought* (Cambridge, UK: Cambridge University Press, 1998), 137-138; 170-171.

<sup>20</sup> Aristotle, *Metaphysics*, <https://faculty.washington.edu/smcohen/320/zeta17.htm>

the other hand, the exchange value, to which the utility value acts as substratum, and which can therefore be labeled as substance, can be measured. Thus it can be said that the true currency of water is that which measures this exchange value of water. The matter of water is not coin; that which gives it form is. To understand what gave the water form, how it was quantified both statically and actively, and how exchange value could be derived from it as substance it is important to analyze the basic methods and instruments of the water's containment, distribution, and most importantly, its measurement.<sup>21</sup>

Numerous objects of containment, distribution, and measurement existed in Rome's new aqueduct systems. For the Acqua Vergine and the Acqua Felice, water flowed into the city through both ancient and rebuilt conduits and into *castelli*, or holding and distribution basins.<sup>22</sup> The positioning of these large receptacles of water at the high point of the urban distribution system ensured that the force of gravity would allow water to flow to all lower points within the system. (Fig 3) From these spaces of conservation, water was meted out and distributed throughout the city to public and private fountains via an elaborate system of receptacles and pipes.<sup>23</sup>

<sup>21</sup> The methods and instruments by which Rome's newly acquired water was spread throughout the city for the purposes of the *Renovatio* were not, as Rinne has pointed out, scientific in their engineering. During the 16<sup>th</sup> century, a good deal of written work had been published on the mechanics of hydraulics and the engineering of water works, including the recently discovered ancient texts of Frontinus and Vitruvius, as well as the technical treatises of Leon Battista Alberti and Leonardo da Vinci. In addition to gaining some understanding of the material properties of water itself, a renewed interest and knowledge of the force that prompted its movement existed during this time period as well. Basic theorization of hydrology and gravity (concepts which did not yet exist in name during the time) had been surmised since antiquity. The work of Aristotle is again of use in analyzing this pre-Newtonian age since it carried the idea of "natural" place, which in the case of the matter of elemental water stated its natural location to be above the earthen shell of the world. For water, this notion of place (*τόπος*), was definable only in respect to it being a containable; its natural place was within the inner surface of its containing body. It can be argued, then, that in its containment, the matter of water was given a form that contributed to its conceptualization as a substantial body. Rinne, 57.

<sup>23</sup> Rinne, 57.

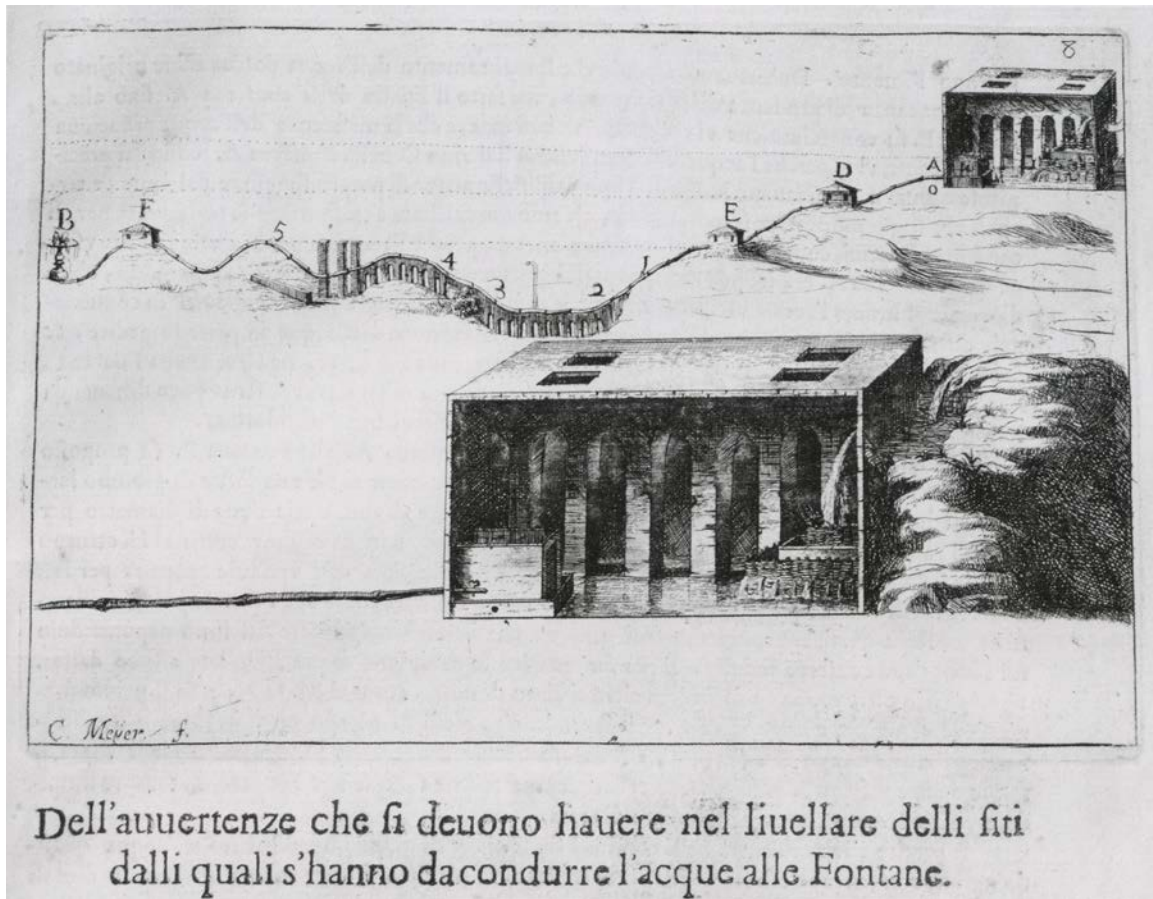


Fig 3. The principles of gravity flow are shown here in this diagrammatic representation of the storage units and conduits of an aqueduct system.

The means by which the water was officially measured and therefore exchanged was through an expression of its volume, measured in *oncie*. With a standard unit of measurement in place, relative wealth in terms of water could be measured amongst those who had access to the distribution system of Rome.<sup>24</sup> However, the simple measurability of matter does not necessarily imply its equivalence or suitability for coinage. Rather, the

<sup>24</sup> Rinne, This was a necessity when repairs to the system had to be made, as noted in the records of the 1623 tax that drew actual currency from the subscribers to the other great aqueduct of the *Renovatio*, the *Acqua Vergine*.

mensurative and distributive capability of an object, in this case an object that gives form and therefore substance to the valued matter, would appear to serve this function better.<sup>25</sup>

Arguably, the object most suitable for this task is the very pipe that carries it.

Although an actual standardization of the physical pipe appears to not have occurred until slightly after the three main aqueducts were completed (by the early 17<sup>th</sup> century), a growing understanding of a standard measurement for the pipes that were utilized allowed engineers to calculate flows and outputs of water during their construction. The pipe, like the coin, was intended, by design, as facilitators of a measured exchange or transferal.<sup>26</sup> Both objects act as the *instrumentum aptum* of this exchange of what Oresme, would have referred to as “natural riches.”<sup>27</sup>

The diameter of distribution pipes, known as *fistolas*, was taken into account in the process of measuring fluid outputs.<sup>28</sup> It was known that ancient Romans were able to quantify water delivery by utilizing the cross-section of a water channel in their

<sup>25</sup> Nicholas Oresme, “De Moneta” in *The De Moneta of Nicholas Oresme and English Mint Documents*, trans. by Charles Johnson (London: Thomas Nelson and Sons Ltd., 1956), 5. That it must be able to distribute a value can be taken from Oresme’s claims that money be transportable. In this sense, it had to be able to be carried over a physical landscape to allow for a broad distribution of the value within for the needs of exchange.

<sup>26</sup> Oresme, 5; By the 17<sup>th</sup> century, pipe sizes were standardized to reflect the different pressure of each water system so that all one-oncia pipes carried the same amount of water. Rinne, 123

<sup>27</sup> Kaye, 170; Oresme, 5, In the case of coinage, these “natural riches” meant either the gold or silver in the coin itself (an intrinsic value that could be circulated) or as Oresme more likely meant a natural commodity that was in itself impractical to utilize in a transaction. The pipe was also designed to transfer “natural riches,” in this case the matter of water with its inherent utility value, from its official infrastructural (and therefore prohibited) bounds and into the realm of public and private consumption. In both cases of transferal the facilitating object transforms the substance of natural riches from a state of Aristotelian potentiality into a state of actuality.

<sup>28</sup> Leon Battista Alberti, *On the Art of Building in Ten Books*, trans. by Joseph Rykwert, Neil Leach, and Robert Tavernor (Cambridge: MIT Press, 1988), 340. Alberti, in Book Ten of his *On the Art of Building*, describes the function of the water pipe in this function of measured control. Here, he describes the system of pipes along with the outlet (calix): “The *calix* controls the amount of water discharged, according to the rate of flow and the size of the piping that discharges it. The more plentiful and rapid is the supply of water, the less obstructed its course and the higher the pressure, the greater will be the discharge of water; whereas, if the flow is sluggish, the quantity discharged will be reduced. The amount will increase by having the piping level and straight. It is well known that the piping through which water flows is worn down by the passing of water, so to speak, and that no metal has a greater resistance than gold...”

calculations.<sup>29</sup> The restorers of the water system utilized this method of measurement for the pipes where the quantity of water had to be determined for its users. (Fig 4 and 5) A distribution pipe with the diameter of 1/10 of a *palma* (2.2 centimeters) was determined the standard size of hardware to which the standard 16<sup>th</sup> century fluid unit of measurement, the *uncia*, should be pegged.<sup>30</sup> Under ideal circumstances, this size of pipe could deliver a quarter liter of water per second.<sup>31</sup> These instruments of connectivity, containment, and measurement were unscientific in their capabilities of precision, however.<sup>32</sup> Experimentation was typically the guide for the 16<sup>th</sup> century Roman engineer when it came to quantifying the fluid matter that passed through or was held by the pipes since the formula for measuring water flow that had existed since antiquity was an incomplete method of assessing the system to which it was assigned.<sup>33</sup> This calculation did not account for the velocity of the water that flowed through said channel, however, rendering any prediction of the actual quantity of water received an estimate.<sup>34</sup> The standardized pipe, then, was an implement of imprecise quantification; exterior forces that remained out of its ability to define rendered it a mere index, rather than a rod, of value measurement.

<sup>29</sup> Rinne, 59

<sup>30</sup> Rinne, 59

<sup>31</sup> Rinne, 59.

<sup>32</sup> Rinne, 59.

<sup>33</sup> Rinne, 59

<sup>34</sup> Rinne, 59.



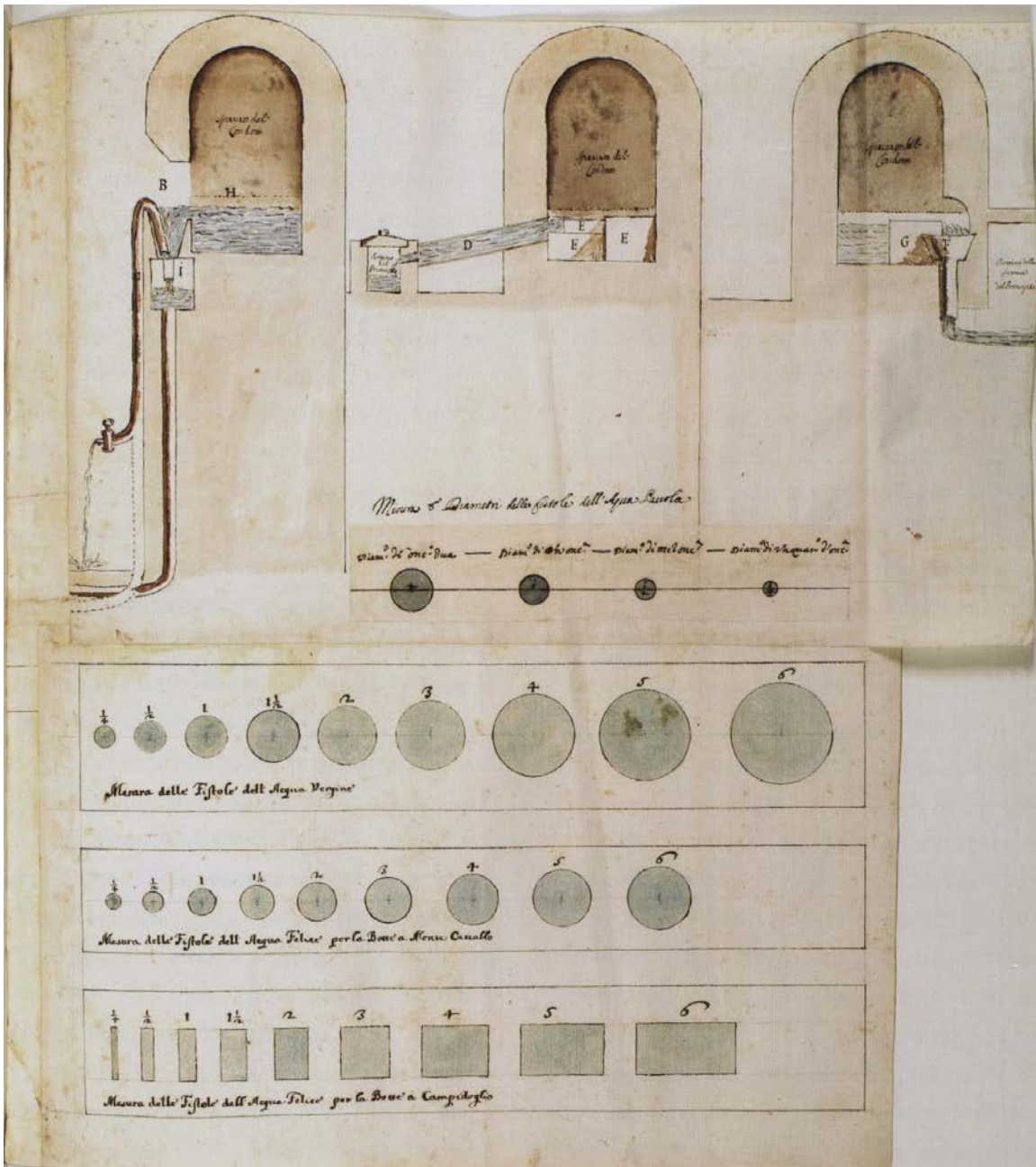


Fig 4. “Misura e diametric delle fistole.” Comparison of water pipe widths utilized in the Acqua Vergine (top) and the Acqua Felice. Katherine Rinne notes “Although there was no accurate formula for measuring water flow in the late 16<sup>th</sup> century, it was clearly understood that the greater the difference between the elevation at the springs and at the final destination the greater the pressure of the water flow, hence the greater volume. This accounts for the different sizes for pipes that carried the same amount of water. Rinne, 124.

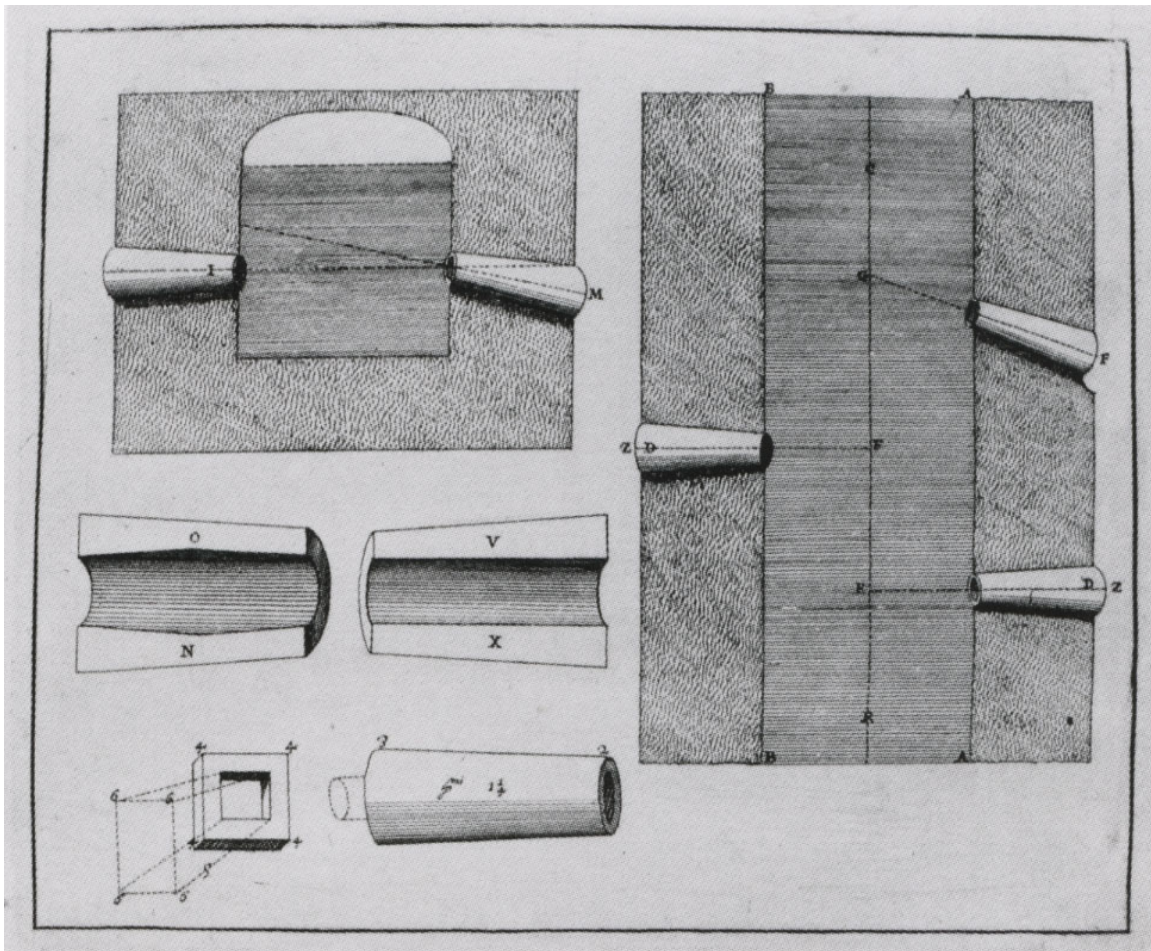


Fig 5. The exit pipe of the system could also affect the pressure of the fluids that passed through them. Angling them could increase this pressure as shown in this illustration from Carlo Fontana's *Utilissimo trattato dell'Acque Correnti* (Rome, 1696).

### Instruments of Measure? – The Imprecision of Fluid Political Economy

The reliance on a standardized pipe to determine a quantitative value and its inability to do so with absolute accuracy draws important parallels between political economy and its management of value through currency with hydrology and its management of water through plumbing. The imprecision of the pipe as an object of value measurement paralleled the indeterminacy of value intrinsic to the coin's nature. The indeterminacy of value measurement afforded by both pipe and coin is due to their relation to the system

that they form part of. Both function as connectors within linear and distributive systems.<sup>35</sup>

This connective quality functioned in unison with its mensurative quality along a linear, divisible, and expandable continuum of value.<sup>36</sup> I would add, however, that the coin (and by extension the pipe) as a connective and measuring instrument acted within an extended linear flow of non-monetized utility or use value. The environment in which this value, not fully bounded by the constraints of the instrument intended to contain it and allow for its measured distribution as an exchange value, possesses an expanded fluidity through which value could be managed or allowed to flow. For the coin, effects on value within the expanded linear system can therefore be attributed to exterior (and sometimes unknown) causality, such as any fluctuation in quantity of precious metals. These can either deflate or inflate the purchasing power of a coin when its purchasing power is tied to the intrinsic value of the material on which it is stamped.<sup>37</sup>

External yet connected fluxes in value within the total expanded system will, as can be expected, be felt in the contained system; coinage in the late medieval period, according to Kaye in his definition of the “*technological form of money in exchange*” took into account that coinage had to be “capable of expressing constantly shifting and diverse values in common numerical terms.”<sup>38</sup> To be able to do this, the coin’s form and even materiality had to, to some extent, be relieved of the duty of expressing exactitude since to do so would be equivalent to attributing it a supernatural power that

<sup>35</sup> Kaye, 171. Joel Kaye notes in his book *Economy and Nature in the 14<sup>th</sup> century*, coinage, according to Aristotelian and Scholastic thought also possessed a connective quality.

<sup>36</sup> Kaye, 171.

<sup>37</sup> Azpilcueta, 70. As is the case mentioned by Azpilcueta in reference to either abundance or dearth of gold (in minted form) and its effects on the value of currency.

<sup>38</sup> Kaye, 171.

could predict not only rain and famine, but even all sources of wealth's extraction and loss. Ultimately, the coin was only an estimate of what flowed along the fluid continuum of value. The quantity of value itself increased and diminished within bounds of certain latitudes.<sup>39</sup> The coin merely expressed that range of value output for which it could be exchanged.

The water pipes of the restored aqueducts of Rome likewise could only be expressions of a range of value output and exchangeability. The pipe's function and performance within the aqueduct system, and the output of water that it derives from this system is dependent on the total sum of factors within the system. As mentioned before, many of these qualities of the system were discretely measurable, such as the width of conduits, the inclination of their slope, etc. Other factors, either external, enclosing, or integral to the fluid continuum, such as mineral deposit, natural leakages, tampering with the conduits, or even basic knowledge of the water velocity itself, could not be so easily accounted for.<sup>40</sup> In addition, the near impossibility of collecting past and current data of the seasonable variances of the aqueducts sources of water left the total quantity of water within the system at any given point of the year a matter of some guesswork.<sup>41</sup>

These unknowns and indeterminables had yet to be integrated into a totalizing equation that could predict an accurate measured ratio of water received, contained, and expelled or exchanged by the system. Any of the above mentioned causes could affect the quantity of water that flowed out of a pipe and into a fountain for public or private use. The quantity of the outward flow could be anyone's guess, and even with deliberate intervention in the planning of its flow could yield surprising and disappointing results.

<sup>39</sup> Kaye, 183.

<sup>40</sup> Rinne, 59.

<sup>41</sup> Rinne, 60.

For an example of this, we return to the Moses fountain. The original site for the *mostra* of Papal beneficence and control on the Piazza Santa Susanna contributed to its inability to produce the intended quantity of water output. When the pressure of this terminus for the Acqua Felice was tested, the water could not rise to the anticipated 15 or 16 palmi (3.6 meters) above street level.<sup>42</sup> Despite careful calculation of the topographical situation of the distribution tank and necessary widths of its water channels, the water only rose to 3.1 palmi (69 centimeters).<sup>43</sup> The whole site had to be leveled and the terminus with the Moses fountain was placed another 900 meters away at the Piazza del Quirinale. This was an embarrassment to the papal engineers, an inconvenience to the local proprietors of land around the Piazza Santa Susanna who expected to profit from this planned source of water, and an obvious reminder that the restored water systems were ultimately incalculable systems.

The fountain, in particular the *mostra* of the Acqua Felice, can perhaps be understood as the face or surface of the system of pipes; the visage struck upon the matter of value in the coin. In the restored water system of 16<sup>th</sup> Century Rome, the fount of fluid value and the imagery related with that object acted as the ultimate point or interface between the pipes of the system and its basin.<sup>44</sup> The enclosed and private portion of the system that was meant to be controlled is the location where the utile matter of water was given form and substance and thereby measured. The basin served as the open and public portion within the controlled system. It was open for consumption and was where exchange

<sup>42</sup> Rinne, 128.

<sup>43</sup> Rinne, 128.

<sup>44</sup> Alberti, 339. Alberti refers to the outlet at the very end of the watercourse, where the water discharged, as a calix. This term means chalice in Latin, leaving the understanding of function for this opening rather vague. Although he also refers to an outlet as being a place of destination, therefore a receptacle in which the water flows into, he elsewhere refers to it as an aperture, or tap. Might the tap itself be considered to possess certain abilities of containment?

value of the substance of water was ultimately enacted out of base use value.<sup>45</sup> The need to both standardize pipe and place an image of standard upon its opening size paralleled the narratives explaining the reasoning behind the standardization and marking of money that would have been known to the 16<sup>th</sup> century Europeans encountering this fountain. Oresme, had supported the wisdom of the practice stamping coinage “ with a design, known to everybody to indicate the quality and true weight of the coin so that suspicion should be averted and the value readily recognized.”<sup>46</sup> This method of inscribing an object of quantified exchange value with a legitimate indicator of its own official measurement was intended to give the tool an authoritative quality. It indicated the existence of a recognizable value that could drawn from a trustable object.

However, if the face of Moses/Sixtus was intended to *mostrare* or show, and therefore legitimate a recognizable and trustable exchange value, here understood as the collectable output of the water system, we see that this act was in name and representation only rather than function. The imagery of patronage and validation of value could not guarantee the value or quantity within. Too many incalculable factors existed that reinforced the limits of power and control through a system of infrastructure. It is safe to conclude then, that the ability of the pipe and fountain along with the coin to measure with accuracy is beyond their control and subject to exterior forces such as gravity, fluid velocity, pressure increase, and a variety of obstructions for the former, and monetary and commodity value fluctuations for the later.

<sup>45</sup> Alberti, 337. Alberti refers to the outlet of an aqueduct as the intended destination of the water, “where it is to be discharged or to be put to a particular use.”

<sup>46</sup> Oresme, 8-9

## Sources Cited

- Alberti, Leon Battista. *On the Art of Building in Ten Books*. Translated by Joseph Rykwert, Neil Leach, and Robert Tavernor. Cambridge: MIT Press, 1988.
- Aristotle, *Metaphysica*  
*Meteorologica*
- Azpilcueta, Martín de. “Commentary on the Resolution of Money (1556),”  
Translated by Jeannine Emery. In *Sourcebook in Late-Scholastic Monetary Theory: The Contributions of Martín de Azpilcueta, Luis de Molina, S.J., and Juan de Mariana, S.J.*, edited by Stephen J. Grabill, 3-107. Lanham, MD: Lexington Books, 2007.
- Brutsaert, Willfried. *Hydrology: An Introduction*. Cambridge: Cambridge University Press, 2005.
- Burroughs, Charles. “Absolutism and the Rhetoric of Topography: Streets in the Rome of Sixtus V” in *Streets: Critical Perspectives on Public Space*, edited by Zeynep Çelik, Diane Favro, and Richard Ingersoll, 189-202. Berkeley and Los Angeles: University of California Press, 1994.
- Cantillon, Richard. *Essai sur la Nature du Commerce en Général*. Translated by Henry Higgs, C.B. London: Reissued for the Royal Economic Society by Frank Cass, 1959.
- Delumeau, Jean. *Vita Economica e Sociale di Roma ne Cinquecento*. Translated by Sarah Cantoni. Florence: G.C. Sansoni Editore Nuova S.p.A, 1979.
- De Roover, Raymond. *San Bernardino of Siena and Sant’Antonino of Florence: The Two Great Economic Thinkers of the Middle Ages*. Boston: Baker Library, Harvard Graduate School of Business Administration, 1967.
- Kaye, Joel. *Economy and Nature in the Fourteenth Century: Money, market exchange, and the emergence of scientific thought*. Cambridge, UK: Cambridge University Press, 1998.
- Gamrath, Helge. *Roma Sancta Renovata: Studi sull’urbanistica di Roma nella seconda metà del sec. XVI con particolare riferimento al pontificato di Sisto V (1585-1590)*. Rome: L’Erma di Bretschneider, 1987.
- Johnson, Van. “Aristotle’s Theory of Value” in *The American Journal of Philology*, Vol. 60, No. 4 (1939): 445-451.
- Marx, Karl. *Capital, Volume I*. Translated by Ben Fowkes. London: Penguin Books, 1990.

Oresme, Nicholas. "De Moneta" in *The De Moneta of Nicholas Oresme and English Mint Documents*. Translated by Charles Johnson. London: Thomas Nelson and Sons Ltd., 1956.

Rinne, Katherine Wentworth. *The Waters of Rome: Aqueducts, Fountains, and the Birth of the Baroque City*. New Haven: Yale University Press, 2010.

Smith, Adam. *The Wealth of Nations*. New York: Bantam Dell, 2003.



MIT OpenCourseWare  
<http://ocw.mit.edu>

4.663 History of Urban Form: Locating Capitalism: Producing Early Modern Cities and Objects  
Spring 2014

For information about citing these materials or our Terms of Use, visit: <http://ocw.mit.edu/terms>.