PART I

Western learning and the Ming–Qing transition

The Jesuits and mathematics in China, 1582–1644

The story of Western learning (*xixue* 西學) in China begins where Joseph Needham's account of the mathematical sciences in *Science and Civilisation in China* closes, that is, when Jesuit missionaries entered China at the end of the sixteenth century.[1] For the whole duration of their presence (1582–1773), they put their science in the service of evangelisation: the knowledge and know-how that they displayed enhanced the prestige of their religion and served to attract the patronage of officials, as well as that of the imperial state.

The Jesuits' emphasis on science as a tool for proselytisation seems to be unique both among the missionary orders present in China in the seventeenth and eighteenth centuries,[2] and indeed among Jesuit missions around the world at the time.[3] In fact it could be argued that the Jesuits' science had a much more pervasive influence on China than their religion. Whereas Christianity remained a minority, and even marginal religion,[4] Western learning was known to all Chinese scholars interested in the mathematical sciences by the late seventeenth and eighteenth century, whatever their attitude towards it might have been. On the other hand, most Jesuit missionaries devoted their time and effort solely to evangelisation,[5] and only a few 'specialists' among them taught and practised the sciences.

Two factors contributed to shaping Jesuit science in China: on the one hand, the importance that the Society of Jesus gave to mathematics (in the usual sense of this term in early modern Europe)—what we might call the supply and, on the other hand, a renewal of interest in

1 '. . . for our present plan the year 1600 is the turning point, after which time there ceases to be any essential distinction between world science and specifically Chinese science . . . ' (Needham 1954–, 3: 437).

2 The other orders present in China up to 1800 included the Dominicans, the Franciscans, the Augustinians and the Lazarists; see Standaert 2001, 309–354.

3 See Romano 2002 and the other articles in the same volume.

4 For the period under discussion, it is estimated that there were up to about 200,000 Chinese Christians. This maximum figure was reached around 1700, when the Chinese population is assessed at about 150 million; Standaert 2001, 380–386.

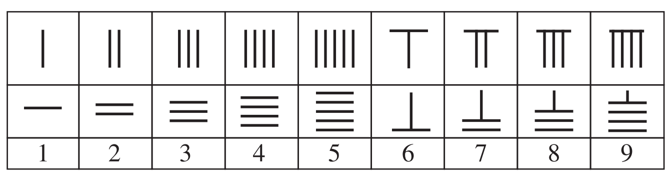
5 Brockey 2007 gives a vivid description of the itinerary and activities of the China Jesuits.

'practical learning' (*shixue* 實學) among late Ming scholars—what we might call the demand. Accordingly, this chapter briefly describes and situates mathematics in China around 1600 and then outlines some characteristics of science in Jesuit education; it goes on to discuss the Chinese translations of works on the mathematical sciences during the first decades of the mission and how they were integrated into scholarship by their Chinese translators. Lastly it gives an account of the astronomical reform on which the Jesuits worked from 1629 until the fall of the Ming dynasty in 1644.

1.1 Mathematics and literati culture in China *c*.1600

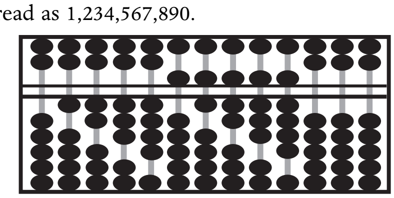
It is widely admitted that by 1600, some of the most significant achievements of the Chinese mathematical tradition had fallen into oblivion. The *Nine chapters on mathematical procedures* (*Jiuzhang suanshu* 九章算術, first century CE),[6] regarded by many as the founding work of the Chinese mathematical tradition and included in the *Ten mathematical classics* (*Suanjing shishu* 算經十書, 656), had effectively

Box 1.1 Calculating devices in imperial China: counting rods and the abacus



Counting rods use a decimal place-value notation: successive numbers are represented alternatively by horizontal and vertical rods. An empty place is left where we would write a zero in our notation. From 1 to 5, one uses the corresponding number of rods. From 6 to 9, a rod laid out in the opposite direction on top of the others represents 5.

The number displayed above can be read as 1,234,567,890.



The representation of numbers on the abacus is also based on a decimal place value notation. Here digits from 1 to 9 are represented, so that the number formed is 1,234,567,890 (if the third column from the right is chosen as the unit column).

6 Chemla & Guo 2004.

been lost. Furthermore the sophisticated 'celestial element' (*tianyuan* 天元) place-value algebra developed in the thirteenth century had been forgotten. The calculating device on which both were based, the counting rods, had fallen into disuse; the abacus had become the universally used calculating device.[7]

By contrast with this picture of decline in mathematics, some historians have described the sixteenth century as a 'second Chinese Renaissance'.[8] The last decades of the sixteenth century witnessed a strong renewal of interest in technical learning and statecraft.[9] The advocates of 'practical learning' emphasised the social role of literati, underlining that scholarship was of value only if it contributed to welfare and social harmony, while being grounded in verifiable evidence. The lowering of the cost of printing at the time allowed a significant broadening of the book market, which facilitated the circulation of knowledge. The renewal in many fields of scholarship is exemplified by such major works as Zhu Zaiyu's 朱載堉 *New explanation of the study of the [standard] pitchpipes* (*Lüxue xinshuo* 律學新說, 1584), Li Shizhen's 李時珍 *Systematic materia medica* (*Bencao gangmu* 本草綱目, 1593), and Song Yingxing's 宋應星 *Exploitation of the works of nature* (*Tiangong kaiwu* 天工開物, 1637). Cheng Dawei's 程大位 *Unified lineage of mathematical methods* (*Suanfa tongzong* 算法統宗, 1592) can be regarded as belonging to this trend and is representative of the state of mathematics in China by 1600. It was to remain a bestseller to the end of the imperial age (1911).[10]

Mathematics was a form of specialised knowledge, but there is no evidence that it defined a profession throughout the imperial era. When the *Ten mathematical classics* had been compiled, they formed the syllabus for the training of specialists at a College of Mathematics (*Suanxue* 算學); but this training, which concerned only a small group of individuals, does not seem to have outlived the Tang dynasty (618–907).[11] Since the Song dynasty (960–1279), literati culture was centred on the works that formed the syllabus of civil examinations: the *Five Classics*, traditionally regarded as compiled by Confucius, and the *Four Books*, which formed the core of Confucian teachings.[12] The selection of the former collection (among what were previously thirteen classics) and the creation of the latter collection was mainly the work of Zhu Xi 朱熹 (1130–1200), who came to be regarded as the leading figure of the Study of principle (*lixue* 理學), and as the

7 Discussions will be found in general surveys of Chinese mathematics in Western languages, including Li & Du 1987, Martzloff 1997 and Yabuuti 2000.

8 Gernet 1972, 370.

9 Cheng 1997, 496–530.

10 In what follows I use the facsimile reprint of the 1716 edition in Guo 1993, 2: 1217–1421; see also Li & Mei 1990; Guo 2000.

11 Siu & Volkov 1999, 88–90.

12 On the *Four Books* see Gardner 2007.

Table 1.2 The *Five Classics* and *Four Books*

The *Five Classics* (*Wujing* 五經)	The *Four Books* (*Sishu* 四書)
Book of change (*Yijing* 易經)	*Great learning* (*Daxue* 大學)*
Book of odes (*Shijing* 詩經)	*Analects* (*Lunyu* 論語)
Book of documents (*Shangshu* 尚書)	*Mencius* (*Mengzi* 孟子)
Book of rites (*Liji* 禮記)	*Doctrine of the mean* (*Zhongyong* 中庸)*
Spring and autumn annals (*Chunqiu* 春秋)	

* Extracts from the *Book of rites*

founder of what Chinese scholars have called the 'Cheng-Zhu school', after Cheng Yi 程頤 (1033–1107) and Zhu Xi, commonly referred to in English as 'Neo-confucianism'. The notion of principle (*li* 理) as developed by Cheng Yi is intrinsic to things rather than transcendental;[13] Zhu Xi recapitulated it as follows:

> When it comes to things under heaven, for each of them there must be a reason by which it is so and a rule according to which it should be so. This is what is called principle.[14]

The duality between 'what should be so' (*suodangran* 所當然) and 'why it is so' (*suoyiran* 所以然) would later provide a rationale for discussing the mathematical sciences. The Cheng-Zhu school redefined the investigation of things (*gewu* 格物), advocated in the *Great learning*—then attributed to Confucius—as a means of self-cultivation, in terms of 'fathoming the principles' (*qiongli* 窮理) that underlay these things; again these broad notions were to be applied in particular to fields that in modern terms pertain to the sciences.[15] By the fifteenth century, the Cheng-Zhu school and its interpretation of the Confucian teachings had gained the status of state orthodoxy, a status it retained throughout the period under discussion in the present book.

During the Song dynasty, numbers also came to play an increasing role in cosmology: Shao Yong 邵雍 (1011–1077), a contemporary of Cheng Yi, was the most influential representative of this trend. His approach to and use of numbers was inspired by divination techniques, which also influenced mathematics at the time.[16] For him however, numbers were categories rather than means of quantification; they

13 Cheng 1997, 447–452. 'Principle' is the received English translation of *li* 理; therefore I will use it in what follows, although 'pattern' is both more literal and appropriate: *li* does not precede things, but rather resides in them.

14 至於天下之物，則必各有所以然之故，与其所当然之則，所謂理也。*Queries on the Four Books* (*Sishu huowen* 四書或問), in *SKQS* 197: 222; Kim 2000, 19.

15 Gardner 2007, 4–6.

16 On mathematics and divination during the Song dynasty, see Hou 2006.

encapsulated the regularities of change.[17] Shao Yong gave new impetus to 'figures and numbers' (*xiangshu* 象數), a very broad tradition of investigation into the cosmic regularities in which numbers were thought to play a part; it included the study of the relationship between hexagrams, a topic relevant both to divination and to scholarly interpretations of the *Book of change*, but could also encompass subjects today regarded as pertaining to the sciences. For example, in his *Dream pool essays* (*Mengxi bitan* 夢溪筆談, 1088), the famous Song scholar Shen Gua 沈括 (1031–1095) discusses topics such as calendrical astronomy and astronomical instruments, mathematics, harmonics, the hexagrams and divination, under the heading 'figures and numbers'.[18] Thus the *Book of change* provided a kind of link between classical studies and disciplines that are now regarded as belonging to the sciences.

Mastery of the *Five Classics* and *Four Books* and the moral virtues they were supposed to reflect, was the key to success in examinations, and to recognition as a member of the literati class. Such recognition was easier to secure than a good position in the civil service: the examination system was organised in three stages, and it could take the best part of a man's life to reach the top. Passing the first examination, which took place every year at the local level, would secure the title of District Graduate (*shengyuan* 生員), which literati referred to informally as 'cultivated talent' (*xiucai* 秀才); it brought tax benefits with it. The next stage was an examination which took place every three years in provincial capitals: success in this made one a Provincial Graduate (*juren* 舉人, lit. 'recommendee'). Finally, a triennial examination was set in the capital; for the happy few who passed it, there followed a Palace examination that would determine their rank. They finally attained the title of Metropolitan Graduate (*jinshi* 進士, lit. 'presented scholar').[19]

Mathematics played no particular role in literati's social promotion. Nonetheless, throughout the last centuries of the imperial era, some cultivated it, so that the tradition was not entirely discontinued: although Cheng Dawei was never able to read the *Nine chapters on mathematical procedures*, he had access to all the problems it contained through the *Great classified survey of the Nine chapters on mathematical methods* (*Jiuzhang suanfa bilei daquan* 九章算法比類大全, 1450), which took them up. This tradition mattered to Cheng: far from claiming to innovate, he aimed at providing a compilation of earlier treatises that he had spent decades collecting. The *Unified lineage of mathematical methods* is regarded as the final representative of a tradition of 'popular mathematics' which emerged as part of merchant culture; it was based

17 Arrault 2002.

18 Shen 1975, 74–96.

19 Elman 2000, Magone 2001.

on abacus calculation, which is traced back to Yang Hui 楊輝 (fl. 1261), in the Southern Song dynasty.[20] Cheng's historical awareness is reflected in his book's title: *suan* 算 was the usual term to refer to mathematics, whereas *fa* 法 refers to the methods by which each problem was solved; *suanfa* occurred in the title of most works on the subject known to him. The phrase 'unified lineage' (*tongzong* 統宗) suggests that he saw himself as the heir of a lineage of scholars versed in mathematics.[21] In his view the lineage could be traced back much further than the Song, as he stated in the opening paragraph of the work:

> How did numbers begin? They began from the [River] Diagram ([*He*]*tu* [河]圖) and the [Luo] Writing ([*Luo*]*shu* [洛]書)! Fuxi 伏羲 obtained them and by this means drew the trigrams [of the *Book of change*]. Yu 禹 the Great obtained them and by this means ordered the sections [of the *Great Plan* (*Hongfan* 洪範)].[22] All the Sages obtained them and by this means operated things so as to succeed in affairs. Heavenly officials and earthly clerks deal with harmonics and calendar, military affairs and taxes in great detail, with minute quantities. All involve numbers, so all are grounded in the [*Book of*] *change* and the [*Great*] *Plan*. Here clarifications are aimed at mathematical methods; one brings to light the River Diagram and the Luo Writing at first, so that it can be seen that numbers have an origin (*yuanben* 原本).[23]

Since the Song dynasty, the two charts mentioned here had been represented as layouts of numbers from one to ten and from one to nine respectively,[24] which became the object of mathematical investigation.[25] Thus Cheng also followed a tradition that went back to the Song in his attribution of the creation of mathematics to the Sages who founded Chinese civilisation.[26]

Like most of his predecessors known to him, Cheng referred to the canonical nine-fold classification of mathematics, although the book from which it was drawn was evidently unavailable to him. During the late Ming and early Qing, the phrase 'nine chapters' (*jiuzhang* 九章) mostly referred to that classification rather than to the classic work of that name. But again like most if not all authors before and after him, Cheng Dawei failed to fit all the mathematical knowledge at his command into the headings of the 'nine chapters': his work is divided into

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20 Here 'popular' should be understood as opposed to what pertained to literati culture; by the Ming dynasty the border between the two was at best quite fuzzy; Yabuuti 2000, 103–121; on Yang Hui see Lam 1977. Bréard 2010 provides a glimpse of some aspects of this 'popular mathematics'.

21 *Tongzong* has often been translated as 'systematic treatise'; see e.g. Li & Du 1987, 185.

22 Both these attributions were the traditional mythical ones. The *Great Plan* is a chapter of the *Book of documents*.

23 Guo 1993, 2: 1227.

24 See Illustration 14.2, p. 323.

25 Smith *et al.* 1990, 120–122; Hou 2006.

26 See e.g. the opening of the *Precious mirror of mathematics* (*Suanxue baojian* 算學寶鑑, preface dated 1513); Guo 1993, 2: 347–348.

Table 1.3 The 'nine chapters' and Cheng Dawei's *Unified lineage of mathematical methods*

'Nine chapters'[1]		*Unified lineage of mathematical methods*[2]
		1. Basic notions and terms; calculation rhymes
		2. The abacus; associated calculation rhymes
1. Rectangular fields (*Fangtian* 方田) [Areas of fields of various shapes; manipulation of fractions]	→	3. Rectangular fields (*Fangtian* 方田)
2. Millet and rice (*Sumi* 粟米) [Exchange of commodities at different rates; pricing]	→	4. Millet and cloth (*Subu* 粟布)[3]
3. Graded distribution (*Cuifen* 衰分) [Distribution of commodities and money at proportional rates]	→	5. Graded distribution (*Cuifen* 衰分)
4. The lesser breadth (*Shaoguang* 少廣) [Division by mixed numbers; extraction of square and cube roots; dimensions, area and volume of circle and sphere]	→	6. The Lesser breadth (*Shaoguang* 少廣)
		7. Division of fields by cutting off areas (*Fentian jieji* 分田截積) [Problems involving plane figures from which are removed portions of a given area or linear dimension]
5. Consultations on works (*Shanggong* 商功) [Volumes of solids of various shapes]	→	8. Consultations on works (*Shanggong* 商功)
6. Equitable transport (*Junshu* 均輸) [More advanced problems on proportion]	→	9. Equitable transport (*Junshu* 均輸)
7. Excess and deficit (*Ying buzu* 盈不足) [Linear problems solved usinig the 'rule of false position']	→	10. Excess and deficit (*Yingnü* 盈朒)[3]
8. Rectangular arrays (*Fangcheng* 方程) [Linear problems with several unknowns]	→	11. Rectangular arrays (*Fangcheng* 方程)
9. Base and altitude (*Gougu* 句股) [Problems involving the relation between the sides of a right triangle]	→	12. Base and altitude (*Gougu* 句股)
		13. Difficult problems (*Nanti* 難題) (rectangular fields; millet and cloth)
		14. Difficult problems (*Nanti* 難題) (graded distribution)
		15. Difficult problems (*Nanti* 難題) (lesser breadth)
		16. Difficult problems (*Nanti* 難題) (excess and deficit; rectangular arrays; base and altitude)
		17. Difficult problems (*Nanti* 難題) (various methods)

1 Translations and description of contents based on Cullen 2007, 28; extensive discussions of the methods that give their titles to the chapters are found in Chemla & Guo 2004.

2 Guo 1993, 2: 1217–1421.

3 Variant title.

seventeen chapters. It opens with the discussion of the River Diagram and Luo Writing quoted above. Chapter 1 contains some general prescriptions for the study of mathematics, a list of the 'nine chapters', short definitions of more than seventy terms used thereafter, lists of powers of tens and units, tables of addition, subtraction, multiplication and division for the abacus, and brief explanations of some terms referring to common operations such as the simplification of fractions or the extraction of cubic roots. Chapter 2 focuses on the abacus, starting with an illustration. Chapters 3 to 17 contain 595 problems presented in the traditional form: question, answer and resolution method. Chapters 3 to 6 and 8 to 12 take up the traditional nine chapters, whereas Chapter 7 introduces a particular type of problems: 'Cutting off the area of a straight field' (*Zhitian jieji* 直田截積). Chapters 13 to 16 contain 'Difficult problems' (*Nanti* 難題), again ordered according to the 'nine chapters'; Chapter 17 gives various methods and number diagrams such as magic squares. Some of the 'difficult problems' as stated as poems:

Moonlight on the Western River[27]

A borrows seven inkstones from the B family, and returns him three fine-haired (*maozhui* 毛錐) handles, compensating in coins four full hundreds and eighty; it's exactly even, and done.
Yet C borrows nine brushes from B, and returns him three items from Duanxi 端溪; one hundred and eighty are compensated to B, it's even; how much should the prices of these two kinds (*se* 色) be?[28]
Answer: The price of a brush is 50 pieces (*wen* 文) the price of an inkstone is 90 pieces.
Method: Lay out the numbers of the problem:[29]

[For reasons of formatting, the layout given here in the original text is reproduced in Box 1.4.]

First, taking the positive 7 inkstones of the right column as factor, multiply all the numbers obtained in the left column (middle and lower).

Yet taking the positive 3 inkstones of the left column as a factor, in return multiply all the right column. The middle negative 3 brushes give 9. Subtract from the negative 63 brushes of the left column, the remainder is negative 56 brushes as divisor.

The price positive 480 gives positive 1440, add the opposite of the price of the left column negative 1260, together one obtains 2700 as dividend. Divide it by the divisor, one obtains the price of a brush: 50 pieces.

Add the left column price, positive 480, to the opposite of the price 150 of negative 3 brushes, together one obtains 630. Divide it by 7 inkstones, one obtains the price of an inkstone: 90 pieces. This matches the question.[30]

27 *Xijiang yue* 西江月 is the title of a tune to which the poem could be sung. The form is that of a *ci* 詞 of fifty characters, divided into two lines of twenty-five characters each. If one translated this problem into modern notations each line would yield one of the two linear equations.

28 甲借乙家七硯, 還他三管毛錐, 貼錢四百整八十, 恰好齊同了畢。丙卻借乙九筆, 還他三箇端溪, 百八十貼乙齊, 二色價該各幾。

29 Guo 1993, 2: 1402.

30 Guo 1993, 2: 1402–1403.

Box 1.4 Layout for the inkstones and brushes problem in the *Unified lineage of mathematical methods* (Guo 1993, 2: 1402)

left inkstones positive 3	right inkstones positive 7 as factor	左 硯 三 正	右 硯 七正 為 法
middle brushes negative 9 one obtains negative 63	middle brushes negative 3	中 筆 負 九 得 十負 三六	中 筆 負 三
lower price negative 180 one obtains negative 1260	lower price positive 480	下 價 負 八一 十百 得 百負 六一 十千 二	下 價 正 八四 十百

The method used here is that of rectangular arrays (*fangcheng* 方程), which gave its name to the eighth of the *Nine chapters on mathematical procedures*. Following the tradition stemming from this work, Cheng uses positive (*zheng* 正) and negative (*fu* 負) numbers in rectangular array problems and exclusively there. In his chapter on this subject, he glosses these terms: 'Positive is a positive quantity; negative is an owed quantity.'[31] There he also gives the algorithm followed in the problem quoted above in the form of a 'rhyme for rectangular arrays of two kinds' (*er se fangcheng ge* 二色方程歌).[32]

31 正者正數。負者欠數。 Guo 1993, 2: 1359.
32 Guo 1993, 2: 1359.

The difficulty of the inkstones and brushes problem lies in the literary style in which it is stated: it took an educated reader to know that 'fine-haired' is a type of brush, and that Duanxi (Guangdong province) was famous for its fine inkstones. The answer and the solution, on the other hand, are stated in the plain prose used for all problems in the work. The fact that this problem already appeared in the *Great classified survey of the Nine chapters on mathematical methods* exemplifies the claim apparent in the title of Cheng Dawei's work: as his predecessors had done before him, he is taking up problems from various sources, while providing his own version of the methods to solve them.[33]

The last chapter of the *Unified lineage of mathematical methods* gives 'Miscellaneous methods' (*Zafa* 雜法) that include diagrams such as magic squares and finger calculation mnemonics; the chapter closes with a bibliography of earlier mathematical works, from the Song edition of the *Ten mathematical classics* to works published in Cheng Dawei's lifetime, spanning five centuries. It does not seem that Cheng Dawei actually saw any of the *Ten mathematical classics*. Neither is there any discussion of the use of counting rods in his work.

1.2 Mathematics in the Society of Jesus

Such, then, was the mathematical culture prevalent in China when the Jesuits first arrived. Founded in 1540, the Society of Jesus had soon started setting up colleges across Europe. Many sons of the elites of Catholic countries were educated in them, as were most members of the Society. The latter often trained to be teachers, and for some of them this remained their main occupation. The content and structure of the education provided by the Society were crucial in shaping Jesuit culture, in Europe as well as in China. Having previously studied the *trivium* (grammar, logic and rhetoric), students entering a Jesuit college would typically begin with further training in rhetoric. This was followed by three years devoted to logic, philosophy and metaphysics. Early in the order's history, natural philosophy (or physics) and mathematics were both grouped under philosophy. According to the Aristotelian classification, physics and mathematics addressed two of the ten categories, quality and quantity, respectively. Physics provided a qualitative explanation of natural phenomena; it was based on the four elements theory, according to which all matter was composed of earth, air, fire and water. In the scholastic tradition, mathematics consisted of the four disciplines of the *quadrivium*, namely arithmetic, music, geometry and astronomy.

Mathematics was somewhat redefined in the Jesuit curriculum compared with common contemporary usage. The Roman College,

33 Guo 1993, 2: 266.

founded in 1551, set the standards for the Society's educational network. The *Ratio Studiorum* (*Plan of studies*, final version 1599), which defined the Jesuit educational system, gave a new importance to mathematics.[34] Christoph Clavius (1538–1612) was instrumental in establishing it as a subject independent from philosophy. The architect of the Gregorian Calendar Reform of 1582, he taught mathematics at the Roman College from 1565, and was the first to hold the chair of mathematics there, and to assert its status as a science.[35] According to him, 'It is so ordained by nature that eminence in any subject, even of the least importance, causes the eyes of everyone to converge on oneself.'[36] Whereas excelling in learning in general had been a concern of the Jesuits since the foundation of the society, it was the reappraisal of the 'mathematical arts' in sixteenth-century Italy that prompted them to include those arts into the subjects in which they should strive to be eminent.[37]

While establishing mathematics as a subject in the Jesuit curriculum, Clavius defined its structure and produced textbooks for its teaching. Following Proclus, the fifth century CE philosopher who wrote an influential commentary on Euclid's *Elements of geometry*, Clavius divided mathematics into 'pure' and 'mixed', the former consisting of arithmetic and geometry, the latter of six major branches (which were further divided into more disciplines): natural astrology (astronomy), perspective, geodesy, music, practical arithmetic and mechanics. This structure, while evocative of that of the *quadrivium*, broadened the scope of mathematics and extended its fields of application. This is in keeping with the broader conclusion of several historians that 'Jesuit science was concerned mainly with the promotion of areas related to "applied mathematics"'.[38] The works authored by Clavius, first and foremost his editions of and commentaries on Euclid's *Elements* and Sacrobosco's *Sphere*, as well as his textbooks on arithmetic and algebra, formed the basis of mathematical education as he defined it for the Society.[39]

In natural philosophy, the authoritative reference stemmed from commentators working at the Portuguese College of Coimbra. The *Conimbricenses*, as they and their writings are often called, consisting of five volumes of editions of and commentaries on Aristotle's work, including *Physica*, *De Cælo*, *Meteorologica*, *Parva naturalia*, *Ethica Nichomachæ*, *De Generatione et corruptione*, and *De anima*, were published between 1592 and 1602; they were reprinted and used by teachers in Jesuit colleges throughout Europe.

34 Pralon-Julia *et al.* 1997.
35 Baldini 1992, Romano 1999, Rommevaux 2005, esp. 24–25.
36 Quoted by Gorman 1999, 172.
37 Gorman 1999, 172.
38 Feldhay 1999, 113.
39 Feldhay 1999, 109–113; see also Engelfriet 1998, 30–32.

Jesuit education in Europe was not entirely uniform: there were local variants in the mathematics taught, and, as with any school curriculum, a number of updates occurred.[40] Thus, since the 1620s, the Ptolemaic system defended and taught by Clavius, in which the Earth lay motionless at the centre of concentric crystalline spheres, was gradually replaced by the Tychonic system, in which the Sun, while revolving around the Earth, was the centre of the orbits of the planets. By and large, the tradition Clavius had established was continued in the sense that many later teachers produced textbooks modelled largely on his, though departing from Clavius in their pedagogical approach.[41] The number of textbooks entitled *Elements of geometry* produced in the seventeenth century, within and without the Society, was such that the phrase, and even the name of Euclid came to refer to a genre—that of geometry textbooks—rather than merely to editions and commentaries of the Greek classic. Including innovations that originated outside the Society was also part of Jesuit policy. Thus whereas Clavius' *Algebra* was one of the last representatives of the medieval tradition of cossic algebra, in which the unknown and its powers are denoted by abbreviations of their names, Vieta's new notations were introduced into teaching in the 1620s.[42]

Clavius, author of the Gregorian calendar, played a considerable role on the Roman, and indeed on the European, 'scientific scene'. However, during the seventeenth century, the authority and prestige of the Society, which he seemed to personify in this field, decreased significantly.[43] In the 1680s, while the Royal astronomers assessed Jean de Fontaney (1643–1710), the Professor of mathematics at the Jesuit College in Paris as a 'good observer', he had taken no part in the definition of the standards according to which he was assessed.[44] Matteo Ricci (1552–1610), the first Jesuit to enter China, had studied with Clavius at the Roman College and brought with him the latter's mathematics; some of his successors in the China mission would present mathematics as it evolved in Jesuit colleges over the next century.

1.3 Teaching and translating

The China mission was part of the Portuguese Assistancy of the Society: following the Treatise of Tordesillas (1494), all Asian missions were under the patronage (*padroado*) of the Portuguese crown.[45] The port of Macao, founded by the Portuguese in 1557, served as their Eastern base. While their Japanese mission was flourishing in the late

40 On Portugal, see Leitão 2002; on France see Romano 1999, 183–354; 2006.

41 Feldhay 1999, 111 & 114; Baldini 2000, 77.

42 Reich 1994; Feldhay 1999, 116–126.

43 Gorman 1999.

44 Hsia 1999, 38–42.

45 Alden 1996.

sixteenth century, the Jesuits' efforts to settle in China were unsuccessful until 1582, when Michele Ruggieri (1543–1607), after three years of study of the Chinese language, culture and customs, obtained permission to reside in China. The next year, he established the first Jesuit residence in China in Zhaoqing 肇慶 (Guangdong province), together with Matteo Ricci.[46] The latter has come down in history as the 'founding father' of the Jesuit mission in China.[47] He is usually credited with two related features of the Jesuit strategy there: evangelisation 'from the top down', and the use of science in the propagation of the faith. Recent research has shown, however, that Ricci's itinerary from Zhaoqing to Beijing (1583–1601) was mainly determined by the necessity to get protection from the central authority in order to establish permanent residences in China. Similarly, it was only in order to explain to the somewhat incredulous scholars who visited him where he came from that he first drew a Chinese version of his world map; this was the first translation of a non-religious work. In other words the political organisation and culture of the society they met was no less instrumental in shaping the Jesuits' strategy than their own background and aims.[48]

Ricci very soon started to make use of his master Clavius' textbooks. According to his own account, in 1589 he taught first arithmetic, then the first book of the *Elements* and the *Sphere* to Qu Rukui 瞿汝夔 (1549–1611), a literatus who became one of his sympathisers and advisers, and eventually converted.[49] After Ricci settled in Beijing in 1601, he taught mathematics to Xu Guangqi 徐光啓 (1562–1633) and Li Zhizao 李之藻 (1565–1630); both were high officials who converted and became active protectors of the Jesuit mission. In collaboration with Ricci, they produced works based on some of Clavius' textbooks:[50]

- The *Elements*: the first six books of Clavius' 1574 edition, translated as *Elements of geometry* (*Jihe yuanben* 幾何原本), 1607, Ricci and Xu Guangqi.[51]
- The *Astrolabium*: translated as *Illustrated explanation of the sphere and the astrolabe* (*Hungai tongxian tushuo* 渾蓋通憲圖說), Ricci and Li Zhizao, 1607.[52]
- The *Sphere*: translation of Clavius' commentary of Sacrobosco's *Tractatus de Sphaera* as *The meaning of Heavenly and Earthly forms*

46 Brockey 2002, 19–31.

47 The literature on Matteo Ricci is too abundant to list here. Spence 1984 is both inspiring and reliable.

48 Standaert 1999a, 358–360.

49 Jami 2002a, 161–162.

50 Martzloff 1995.

51 Clavius, *Euclidis Elementorum Libri XV...*, Rome, 1574; on the translation, see Engelfriet 1998.

52 Clavius, *Astrolabium*, Rome, 1593; see Ahn 2007, 209–256.

(*Qiankun tiyi* 乾坤體義), 1608, by Ricci and Li Zhizao; essay on isoperimetric figures inserted in his commentary translated as *The meaning of compared [figures] inscribed in a circle* (*Yuanrong jiaoyi* 圜容較義), 1614, Ricci and Li Zhizao.[53]

- The *Arithmetic*: a compilation with several earlier Chinese mathematical treatises, *Instructions for calculation in common script* (*Tongwen suanzhi* 同文算指), 1614, Ricci and Li Zhizao.[54]

To this list one should add *The meaning of measurement methods* (*Celiang fayi* 測量法義, 1608), a brief treatise on surveying completed by Ricci and Xu Guangqi at the same time as the *Elements of geometry.* It was most likely based on Ricci's lecture notes, as it is different from Clavius' *Geometria practica*, published in Rome in 1604.[55]

The structure of mathematics as a whole according to the *quadrivium*, and the Aristotelian duality between number and magnitude as the two instances of quantity that underlay this structure, were presented by Ricci in his preface to the *Elements*:

> The school of quantity (*ji he jia* 幾何家) consists of those who concentrate on examining the parts (*fen* 分) and boundaries (*xian* 限) of things. As for the parts, if [things] are cut so that there are a number (*shu* 數) [of them], then they clarify how many (*ji he zhong* 幾何衆) the things are; if [things] are whole so as to have a measure (*du* 度), then they point out how large (*ji he da* 幾何大) the things are. These number and measure may be discussed (*lun* 論) in the abstract, casting off material objects. Then those who [deal with] number form the school of calculators (*suan fa jia* 算法家); those who [deal with] measure form the school of mensurators (*liang fa jia* 量法家). Both [number and measure] may also be opined on with reference to objects. Then those who opine on number, as in the case of harmony produced by sounds properly matched, form the school of pitchpipes and music (*lü lü yue jia* 律呂樂家); those who opine on measure, in the case of celestial motions and alternate rotations producing time, form the school of astronomers (*tian wen li jia* 天文曆家).[56]

Rather than describing mathematics as the *quadrivium*—with which most Chinese readers would have been wholly unacquainted—this passage is actually proposing to subsume four different disciplines, all of which corresponded to known technical fields in late Ming China, under the broader albeit hitherto unknown field of the 'study of quantity'; here *jihe* renders the Latin *quantitas*. In this light, the title chosen by Ricci and Xu for their translation must have intended to refer not only to

53 Clavius, *In sphæram Joannis de Sacro Bosco commentarius*, Rome, 1570; Ahn 2007, 160–162.

54 Clavius, *Epitome arithmeticæ practicæ*, Rome, 1583; see Takeda 1954; Jami 1992; Pan 2006.

55 Engelfriet 1998, 297; Ahn 2007, 146–149.

56 Guo 1993, 5: 1151; comp. Engelfriet 1998, 139; Hashimoto & Jami 2001, 269–270.

geometry, but more broadly to the whole of the *quadrivium*. The claim here is also that the *Elements* provides foundations for a discipline that includes the Chinese tradition of *suanfa* 算法 ('mathematical methods' as in the title of Cheng Dawei's work) as one of its parts. On the other hand, *jihe* 幾何 means 'how much' in classical Chinese. It occurred in every single ancient mathematical text, as many times as there were problems. In the *Unified lineage of mathematical methods*, however, *ruogan* 若干 (a synonym) is the word used, whereas *jihe* appears in the list of terms defined at the beginning: it is glossed by 'same as *ruogan*'.[57] The distinction between the two instances of quantity, rendered by *shu* 數 (number) and *du* 度 (magnitude) respectively, would have been entirely new to late Ming Chinese readers: for them *shu* was more evocative of numerology and the study of the *Book of change* than of procedures of *suanfa* to which Ricci and Xu wanted their translation to relate.

That the above rationale might have seemed somewhat unfamiliar to Chinese readers should not, however, obscure two major points. First, the translations based on Clavius listed above aroused interest; indeed they were often done in response to the perceived curiosity of Chinese scholars about the fields they covered. Secondly, bringing together mathematics, surveying, astronomy and harmonics was not foreign to their tradition: surveying was one of the main themes of mathematical problems, and astronomy and harmonics were discussed in the same section of quite a few dynastic histories. Also, one finds many examples of scholars known both as mathematicians and astronomers. Thus Li Chunfeng 李淳風 (602–670) was the head of the imperial observatory when he compiled the *Ten mathematical classics*; he was also the author of the 'Chimera virtue' astronomical system (*Linde li* 麟德曆), in use from 665 to 728.

Although Euclidean geometry is the best-known branch of mathematics taught by the Jesuits, not everything presented in their mathematical works was unfamiliar to Chinese readers. In the *Instructions for calculation in common script* Ricci and Li Zhizao took up problems from earlier Chinese works and showed how these could be solved using written calculation. Thus rectangular array problems appear in a section entitled 'Methods with miscellaneous sums, differences and multiplications' (*Za hejiao cheng fa* 雜和較乘法). A note in small characters refers to the Chinese method, equating it to one of the methods translated from Clavius' *Epitome arithmeticae*:

57 Guo 1993, 2: 1230.

What used to be called rectangular array is also the same as repeated borrowing for mutual comparison (*diejie huzheng* 疊借互徵).[58] Many use the latter as it is more convenient.[59]

The third problem in this section reads:

Question: 3 brushes are exchanged against 7 inkstones, with a contribution to the inkstones of 480 pieces. Apart from this, 3 inkstones are exchanged against 9 brushes, with a contribution to the brushes of 180 pieces. What are the prices of a brush and of an inkstone?[60]

Box 1.5 Layout for the inkstones and brushes problem in the *Instructions for calculations in common script* (Guo 1993; 4: 187)

inkstones positive 3	inkstones positive 7	硯 正 三	硯 正 七
positive 21		十正 一二	
brushes negative 9	brushes negative 3	筆 負 九	筆 負 三
negative 63	negative 9	十負 三六	負 九
price negative 180 pieces	price positive 480 pieces	價 負 一 百 八 十 文	價 正 四 百 八 十 文
negative 1260	positive 1440	二負 百一 六千 十	百正 四一 十千 四

The solution to this problem is the same as in the *Unified lineage of mathematical methods* and it uses the same terminology, but each step is explained in more detail. This would have suggested to readers that procedures hitherto carried out using the abacus could still be used if

58 The double false position method.
59 Guo 1993, 4: 186.
60 Guo 1993, 4: 187.

one adopted written calculation. The presence of this and many other problems in the *Instructions for calculation in common script* result in a 'dissolution' of Chinese procedures into Western learning: rectangular arrays no longer forms a category of its own, but is demoted to one of several 'methods with miscellaneous sums, differences and mutliplications'. It has, in some sense, been disqualified, losing both the specificity and the generality that it had in earlier Chinese treatises.

The translations mentioned above were part of the Jesuits' larger enterprise of 'apostolate through books' in China. This was rendered possible by the flourishing of printing and publishing.[61] The Jesuits' teachings were thus presented as a coherent whole in a compendium edited by Li Zhizao in 1626, the *First collection of heavenly learning* (*Tianxue chuhan* 天學初函).[62] It was divided into two parts: principles (*li* 理, nine works) and concrete things (*qi* 器, ten works). The first part opens with a description of the European educational system, entitled *Outline of Western learning* (*Xixue fan* 西學凡, 1621). Like Ricci, its author, Giulio Aleni (1582–1649), had been a student of Clavius at the Roman College. The work presents the structure of disciplines that was then most common, mathematics consisting of the *quadrivium* and being one subdivision of philosophy.[63] The next six works of the collection discuss mainly ethics and religion. The last work of the first part is an introduction to world geography. Illustrated by several maps, including an elliptical world map, the *Areas outside the concern of the Imperial Geographer* (*Zhifang waiji* 職方外紀, 1623, by Giulio Aleni) describes the Earth as part of the universe created by God, and Europe as the ideal realm where Christianity has brought long-lasting peace.[64]

The second part of the *First collection of heavenly learning* includes five of the six works based on Clavius' textbooks and teaching mentioned above (the *Meaning of Heavenly and Earthly forms* was not included). It also includes three works by another former student of Clavius, Sabatino de Ursis (1575–1620), dealing respectively with hydraulics, the altazimuth quadrant and the gnomon. A short treatise written by Xu Guangqi after he had completed the translation of the *Elements* with Ricci is also included.[65] Only one work pertaining to 'concrete objects' does not stem from the student lineage of Clavius. The author of the *Summary of questions about the heavens* (*Tianwen lüe* 天問略, 1615), Manuel Dias Jr (1574–1659) does not seem to have studied outside

61 Standaert 2001, 600–631.

62 On this compendium, see Ahn 2007; for the date of *Tianxue chuhan*, I follow Standaert 2001, 141.

63 Standaert 2001, 606.

64 Aspects of the Christian worldview were also introduced in the Jesuits' presentation of some aspects of European medicine; Standaert 1999b.

65 Engelfriet 1998, 301–313, Engelfriet & Siu 2001, 294–303.

the Portuguese Assistancy: he had completed his studies in Goa and taught theology at Macao before entering China. His *Summary of questions about the heavens* was mainly an account of Aristotelian-Ptolemaic cosmography, which Clavius had defended and taught in Rome; internal evidence suggests that in writing his work, Dias may have relied on the fourth edition of Clavius' commentary on Sacrobosco's *Sphere*.[66] An appendix at the end of the work reported Galileo's invention of the telescope and the observation that he had made with it.[67] This was in keeping with the Society's policy of including innovations in its teaching in Europe. On the whole, the works on 'concrete objects' in the *First collection of heavenly learning* all pertained to the mathematical sciences construed and constructed by Clavius for Jesuit colleges.

No less important in the Jesuits' enterprise was Aristotelian philosophy. Here the main source was the *Conimbricenses*; a number of works published in the late Ming drew on them.[68] They were far from encountering the same success as mathematical works, and their influence on Chinese philosophy remained marginal: they were much more obviously in conflict with Chinese cosmology. By the end of the seventeenth century the term 'heavenly learning' (*tianxue* 天學) had long been supplanted by 'Western learning' (*xixue* 西學) to refer to the Jesuits' teachings, and the latter expression covered only the mathematical and technical subjects. Rather than a split between science and religion—a dichotomy alien to the actors—this can be seen as resulting from a selection from the Jesuits' teachings of what was compatible with Confucian orthodoxy and best served imperial interests. The story of Western learning under the Kangxi Emperor shows how this selection was brought into play.

Education and mission were the two main domains invested in by the Society of Jesus, both of them on a worldwide scale. In China the Jesuits were never in a position to set up colleges as they had done in Europe, Goa and Macao. However, most China missionaries had had some teaching experience before arriving in China. Once there they reinterpreted that role of teacher in a Chinese context, establishing master to disciple relationships with the scholars interested in their teaching.[69] In that sense the mathematical sciences were instrumental in their successful construction of an identity in Chinese literati circles.

66 Leitão 2008; Magone 2008.
67 Standaert 2001, 712–713.
68 See Standaert 2001, 606–608; Peterson 1973 focuses on natural philosophy; Wardy 2000 discusses the translation of Aristotle's categories from the point of view of the philosophy of language.
69 Jami 2002a.

1.4 Jesuit science, 'practical learning' and astronomical reform

As mentioned above, the first Chinese translators of mathematical and technical works were also the most eminent converts.[70] To them, 'principles' and 'concrete things' formed a coherent whole: the latter would serve to improve the material life of the people, whereas the former would serve to improve their morality. In their view, heavenly learning could thus provide a response to the concerns of scholars of 'practical learning'. On the other hand, their understanding of heavenly learning was qualitatively different from that of most scholars who were acquainted with it only through books: they had actually studied with Jesuit masters. Thus, Li Zhizao, who, in addition to the *Instructions for calculation in common script* and other works that he included in the *First collection of heavenly learning*, worked on the translation of various parts of the *Conimbricenses*, including Aristotle's 'Categories', would have had quite a clear picture of the landscape in which the 'study of quantity' fitted.[71] It is worth noting this point, as most of the works translated by the Jesuits were originally textbooks rather than writings intended for individual reading without the guidance of a teacher.

Xu Guangqi's scholarship was by no means limited to his translations. Indeed his most famous work, a major outcome of the late Ming intellectual trend of 'practical learning', is a treatise on agronomy, the *Complete treatise on agricultural administration* (*Nongzheng quanshu* 農政全書, 1639).[72] An extensive survey taking into account major previous works on the topic, it owes very little to Western learning. Xu also wrote on military defence, tackling such varied topics as the economic organisation of the army, the layout of troops and the use of Western artillery. In mathematics, he went further than translating, seeking to interpret some Chinese mathematical texts in the light of what he had studied with Ricci.[73]

Li Zhizao's interests encompassed geography and, as mentioned above, Aristotelian philosophy; they were not limited to heavenly learning either. He was also the author of the *Memorial on ritual and music at local schools* (*Pangong liyue shu* 頖宮禮樂疏), a treatise on the history of ritual used in sacrificial ceremonies to Confucius.[74] This suggests how heavenly learning related to the purposes of Confucianism, even in its ritual dimension: music was a crucial element in the proper performance of the rites. In the *quadrivium* it was linked

70 On these converts, see Standaert 2001, 404–420.

71 Kurtz 2008.

72 Bray & Métailié 2001.

73 Engelfriet 1998, 297–316; Engelfriet & Siu 2001.

74 Standaert 2005, 90–96; the work is reproduced in *SKQS* 651: 1–415.

to arithmetic—precisely the topic on which Li Zhizao worked with Ricci.

While putting their learning into the service of statecraft, those few officials who had converted also engaged in politics. Thus, implementing Western artillery was part of Xu Guangqi's failed attempt to reform the army in order to counter the progress of the Manchu invasion, around 1630.[75]

Astronomy too was in need of reform. The calendar had always been of utmost political and symbolical importance in China. Issued in the emperor's name, it ensured that human activity followed the cycles of the cosmos. At the beginning of the dynasty, the Ming (1368–1644) had taken up their predecessors' astronomical system, and by the end of the sixteenth century the need for astronomical reform was felt acutely amongst officials; several proposals were put forward.[76] In 1613, Li Zhizao presented a memorial to the throne, recommending that three Jesuits should assist the work for a reform that had been proposed three years earlier. His proposal seems to have been among the causes of what is known as 'the Nanjing persecution' (1616–1617): beside hostility to Christianity from officials, the Jesuits' description of the heavens as consisting of a number of concentric crystalline spheres was regarded by some of them as highly subversive. In Chinese cosmology, correspondences between Heaven and Earth played a major role, so that 'dividing the heavens' could be understood as an allusion to the division of the empire.[77] During the Tianqi reign (1621–1627) the eunuchs had the upper hand, and it was not until 1629 that Xu Guangqi, then a Vice-Minister of Rites (*Libu zuoshilang* 禮部左侍郎), was in a position to successfully request an astronomical reform.

Late Ming Christians were aware that the 'foreignness' of heavenly learning was an obstacle to its adoption. Taking up the idea put forward by the Song philosopher Lu Jiuyuan 陸九淵 (1139–1193), they argued that all men have 'the same heart and the same principles' (*xin tong li tong* 心同理同).[78] However when it came to the adoption of European astronomy by the imperial state, this universalistic argument did not suffice. When he submitted his proposal for astronomical reform, Xu Guangqi, who had long emphasised the similarities between the European and Chinese traditions of scholarship, had to resort to another rationale. First, he argued that the Jesuits' teachings were only a tool that Chinese scholars could use to retrieve the lost learning of Antiquity.[79] Secondly, he pointed out that China had a long

75 Standaert 2001, 695; Huang 2001.
76 Peterson 1968; Wang Miao 2004.
77 Dudink 2001.
78 Cheng 1997, 483–486.
79 Hashimoto & Jami, 2001, 270–276.

tradition of resorting to foreign specialists to calculate its calendar. Just like the Muslims, whose astronomy had been introduced at the beginning of the dynasty, the Europeans were to be regarded as a mere foreign tribe: they were no threat to Chinese civilisation. Borrowing from them was a means to restore order, at a time of severe social, political and military crisis. In astronomy, he proposed to 'melt their material and substance to cast them into the mould of the Great concordance' (*rong bifang zhi caizhi ru Datong zhi xingmo* 鎔彼方之材質入大統之型模)—Great concordance being the name of the Ming astronomical system. Xu's rationale for the adoption of heavenly learning was thus phrased in terms of the categories and concerns that he shared with all the Chinese scholars of his time.

Xu Guangqi's proposal was approved, and he was commissioned to set up and supervise the Calendar Department (*Liju* 曆局), where two Jesuits were to be employed.[80] During the following years, this Bureau produced a number of works on mathematical astronomy that were presented to the emperor as they were completed, between 1631 and 1635. These formed the *Books on calendrical astronomy of the Chongzhen reign* (*Chongzhen lishu* 崇禎曆書). The two Jesuits appointed to work on the astronomical reform were Johann Schreck (1576–1630) and Johann Adam Schall von Bell (1592–1666). The latter had studied mathematics at the Roman College under Christoph Grienberger (1561–1636), who had succeeded Clavius at the chair of mathematics. The former, by contrast, had not followed the standard Jesuit curriculum. A medical doctor and a renowned scholar, he was a member of the famous Accademia dei Lincei when he decided to enter the Society of Jesus in 1611. He was the author of the first Chinese treatise introducing European anatomy, as well as a two-volume Latin work on Chinese natural history entitled *Plinius Indicus*.[81] When Schreck died in 1630, Giacomo Rho (1692–1638) took up his position; like Schall, Rho had been a student of Grienberger at the Roman College.

Following changes in the Jesuit curriculum as well as in response to the hostility previously aroused on the part of some officials, Schreck, Schall and Rho used the Tychonic system at the Calendar Department. This was simply called 'new' (*xin* 新) as opposed to the 'old' (*gu* 古) Ptolemaic system.[82] Schall had first discussed the 'new' system in 1626 in an *Explanation of the telescope* (*Yuanjing shuo* 遠鏡說). This work was included in the *Books on calendrical astronomy of the Chongzhen reign*, as

80 Hashimoto 1988, 34–46; Hashimoto & Jami 2001, 271–276.

81 Standaert 2001, 787–788, 804; the Latin manuscript is no longer extant. For a biography of Schreck, see Iannaccone 1998.

82 Dudink 2001; Hashimoto 1988, 74–163.

were other works completed before the creation of the new Calendar Department. However, Clavius remained one of the sources used. Thus the *Complete meaning of measurement* (*Celiang quanyi* 測量全義), completed by Rho in 1631, relied partly on Clavius' *Geometria practica*, while its last chapter, devoted to astronomical instruments, was based on Tycho's *Astronomiæ instauratæ mechanica* (1602).[83] In some cases, adaptations of earlier Jesuit works were made: Euclidean geometry was later added to the *Books on calendrical astronomy* in the form of a work entitled *The main methods of geometry* (*Jihe yaofa* 幾何要法, completed in 1623, printed in 1631), which Giulio Aleni had derived from the *Elements* by retaining some the constructions proposed by Clavius that Ricci and Xu Guangqi had translated into Chinese.[84] Mathematics, it should be noted, did not appear as a separate discipline in the *Books on calendrical astronomy.*[85]

Although the *Books on calendrical astronomy of the Chongzhen reign* seem to have been regarded as completed by 1635, the new astronomical system it proposed was never implemented by the Ming dynasty. After Xu Guangqi's death in 1633, it seems that the Jesuits' other protectors amongst high officials were not in a position to carry through the reform according to his initial proposal. The project of astronomical reform, however, had a deep impact on the circulation of Jesuit science in China. Until 1629, their publications were done privately, thanks to the finances of the mission and to the support of some Chinese scholars. Once the Jesuits produced mathematical and astronomical works in the service of the emperor, these works' contents could no longer be presented as evidence in favour of their religious beliefs which they were trying to promote. On the whole, they did more than merely combine the two 'specialisations' of their order, namely mission and education. The personal influence of Clavius as a role model seems to have been overwhelming in their activity. Not content with transmitting his teaching, they took up in Beijing the role he had played on the Roman scene: providing the highest power—spiritual in Rome, temporal in Beijing—with the mathematical expertise needed in order to reassert its standardising and unifying authority. By modelling their action on that of Clavius both within and outside the Society of Jesus, they succeeded in drawing attention to themselves by excellence in the mathematical sciences; the tactics he had devised for Europe turned out to bear fruit in China.

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83 Standaert 2001, 714–715.

84 Jami 1997.

85 On Xu Guangqi's classification of the books that form the *Books on calendrical astronomy of the Chongzhen reign*, see Hashimoto & Jami 2001, 273–274.