The printing industry in China, ca. 1368-1912: An international comparison

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1. Introduction

The human desire to produce written texts is something from time immemorial. Whereas the first signs of written texts concern numbers, the history of writing languages dates back to ca. 3200 BC in Mesopotamia and, independently developed in Mesoamerica around 600 BC. It may be questioned whether the development of written languages in China around 1200 BC was completely independent or that they copied traits from already literate societies in the Middle East. However, Keightley and Barnard (1983) have argued that neither the character system nor other characteristics of the Chinese written language seem to match the evidence from Mesopotamia hence concluding that it developed independently.

No matter who is right, initially in all societies writing was done by hand, requiring paper (or another material), ink and a feather. Yet, already relatively soon people moved on the more advanced forms of printing such as woodblock printing and the moveable printing press. Some have argued, in terms of modernity, that movable printing as taking place in Europe after its introduction by Gutenberg in 1450, was the most advanced, followed by woodblock printing in East Asia, and finally hand written manuscripts in most of the rest of the world. Hence, the movement in East Asia in the 19th century to increasing amount of movable type may be seen as a sign of advancement (Van Zanden 2013, pp. 323-340). This proposition, however, may be questioned. Long before the invention of the movable printing in Europe, discoveries had already been made in China. However, they never really penetrated the Chinese printing industry. This suggests that reasons other than mere “modernity” lie at the basis of the developments of the printing industry in early modern China and we thus have to look what underlying factors affected this “drive towards modernity”.

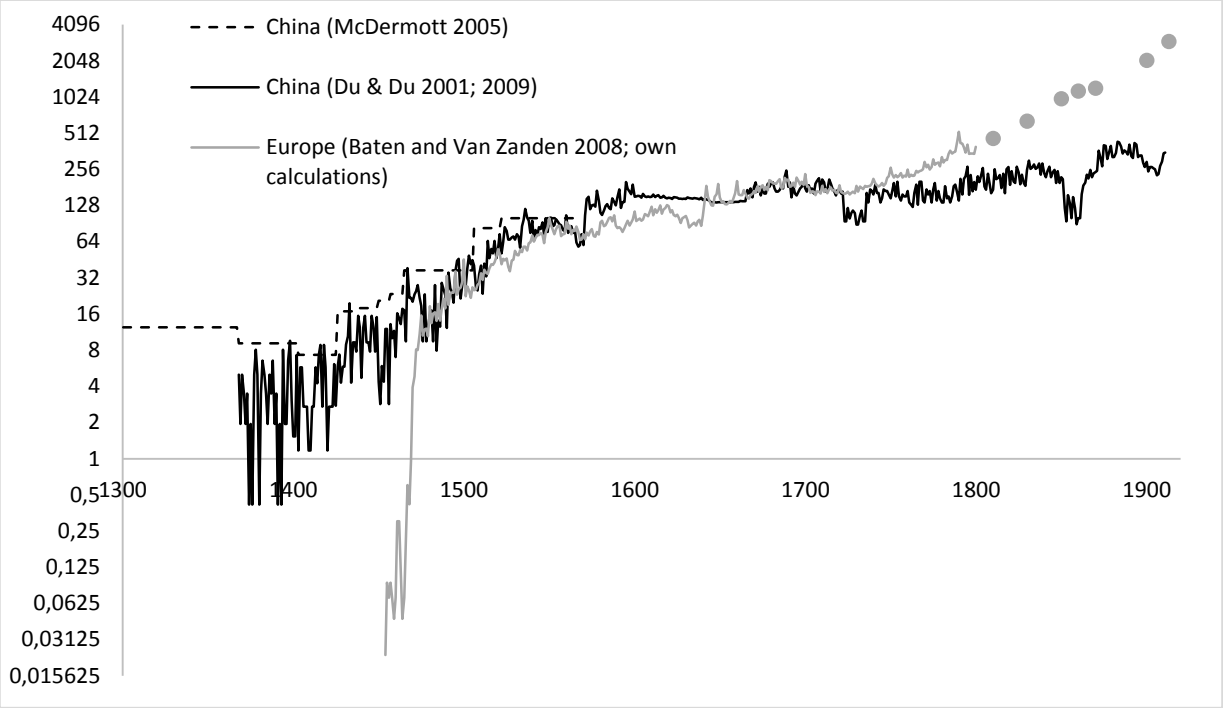
In this paper we will try to briefly address the underlying economic incentives for book production. In Section 2 we deal with the number of new titles and find that Europe outperformed China in terms of growth rates after the invention of the printing press when Europe started to move ahead of China. Yet, between 1500 and 1750, trend in diffusion in both Europe and china were remarkably similar. Only after ca. 1800 Europe forged ahead again. In Section 3 we try to explain this from a supply perspective and find a large reduction in costs in Europe in the 15th and 16th centuries, at least partly explaining the rise in book titles in Europe Yet, afterwards the cost price of books remains about equal in both Europe and China. Hence, this cannot explain the divergence in production that occurred in the 19th century. Therefore, in Section 4 we look at the demand side and find that the demand for books remains restricted to the same social classes. Yet, whereas the ratio of book prices by GDP/cap declines in Europe, it actually rise sin China in the 19th century, hence, partly explaining why China falls further behind. We end with a brief conclusion.

2. The spread of the book

The invention of the printing press in Europe around 1450 indeed revolutionized European book production. It is therefore to be expected that also the diffusion of book production in Europe in that period went much faster than in China. Unfortunately, no direct evidence exist on the number of printed book titles in either china or Europe. Yet, for Europe, Baten and Van Zanden (2008) calculated the number of existing imprints for the major European countries based on title catalogs from libraries for1454 to 1800. For the period 1800 to 1913 we took the data from Steinberg (1996, 243), Thomson (2005), Colclough and Weedon (2010) and Suarez and Woudhuysen (2010) with missing observations being interpolated. A similar method in the case of China was applied by McDermott (2005, 55-107) who, based on the existing imprints in the National Library of China in Beijing and the National; Central Library in Taipe, arrived at a series for book titles between 1131 and 1566. Yet, whereas the European data can be assessed as relatively accurate, the problem with the Chinese data is not only that both included libraries only contain subsets of titles, but also that many books have been burned or otherwise disappeared over the past centuries.

Before we estimate the amount of imprinted books in China though, we should clarify the types of printed books in China. Three types may be subdivided. First, the official books printed by the different levels of government, such as classic textbooks, official calendar, gazetteers, etc. The second type was called private or family books printed by the gentry group, such as private notebook, pedigree of a clan, etc. The third type was called common books printed by the book merchants, such as novel, fiction, song collection, textbooks for primary schools, etc. During the Ming and Qing China, the government and gentry books were quite well classified and stored in libraries. The same was not true, however, for common books. Hence, a number of catalogues for government and gentry books still remain in the literature yet few common books were catalogued. Recently, Du Xinfu (2001, 2009) collected the titles of 3 types of books from records of different gazetteers in both Ming and Qing. But his collections had few official and common books. So we had to expand this datset with the titles of official books from *Chinese Local Histories: A Collection of 8577 Annotated Titles*. Even though our collection only covers part of the extant gentry publications and official books, there is still no a priori reason to assume the trend would be different from the other books. Indeed, as shown by McDermott (2005), the ratio of common books to the other classes of books in the surviving imprints remains virtually constant over time. One problem does exist though. Between 1600 and 1650 there is a

Figure 1. Index of number of total book titles in China and Europe ca. 1300-1910 (1550=100, log 2 scale)



drop of ca. 87% in the number of gentry publications. This is not unlikely since the collapse of government will have strongly reduced the number of these publications. Yet it is unlikely that a similar drop has occurred for common books. Since McDermott (2005) showed that common books made up ca. 66% of the surviving imprints, and assuming that the share of common books remained stable between 1600 and 1650, we can calculate that the actual drop between 1600 and 1650 should be only 10%. Hence, restricting the drop in publications in those years to 10%, we arrive at our index of book production in China (see Figure 1).

One can see in Figure 1 that the number of imprints grew fast in Europe after the invention of moveable printing in the 15th century. Yet, between the 16th and 18th century the speed of diffusion is roughly identical as reflected by similar curves in Figure 1. Only after the 18th century we witness a further divergence between Europe and China.

Yet, even though Figure 1 tells us something about the rate of diffusion, it does not inform us about the degree to which printing had penetrated both societies. If we were purely to look at the number of imprints as given by Baten and Van Zanden (2008) and McDermott (2005) in the first half of the 16th we arrive 2,500 and 15 imprints per annum respectively. Yet, as pointed out before, it is likely that the number of imprints are underestimated for China. An alternative way of proxying the number of imprints at the start of the 16th century in China is to accept McDermott's estimate that 2/3rd of all books were common books and the remainder government and gentry publications. If we further assume that the Du&Du (2001; 2009) dataset covers ca. 1/3rd of the total gentry and government publications, we arrive at 415 imprints per annum. In per capita terms this implies 3 and 38 imprints per million inhabitants for China and Europe respectively.

This suggests that from a relatively similar amount of imprints in the 15th century, Europe quickly forged ahead after the adoption of the printing press while China stagnated (see Table 1). This begs the question why China did not implement the printing press, even though it had been invented in China

Table 1. Book titles per capita (Index, 1550=100)

	China	Europe
1500	47	52
1550	100	100
1600	124	101
1700	169	187
1820	60	227
1850	70	389
1880	87	394
1910	108	758

centuries before. Rather, a hybrid mixture between imprints and manuscripts stayed in existence well into the 17th century. This may have two reasons. First, a supply effect: the costs of printing were relatively high in China making its diffusion slow. Second, the demand for books was low in China. Both topics will be briefly dealt with in the following Sections.

3. A supply side explanation: the cost of printing

In this Section we deal with the different costs of printing in Europe and China, i.e. was there an incentive to print books? From this perspectives, the inputs in the creation of a book may be considered costs, while the price of a book may be its benefit.

In order to print a book, one needs a writer, wood carver, ink, paper, a printer and binder. For 1700 these costs are reported in Table 2. Please note that we assumed that a) one volume makes up 30 pages, b) one page ca. 330 words, and c) 30 copies of a volume were printed. Hence, for

Table 2. Cost for book production in China in 1700

	cost	cost per one volume	Percentage costs
writing one page	0.120	0.004	11%
carving 1 wood block	0.523	0.017	46%
ink (30 pages, including board rent)	0.001	0.001	3%
paper (30 sheets)	0.008	0.008	22%
printing (30 sheets)	0.004	0.004	11%
binding (30 pages)	0.002	0.002	5%
total costs per volume	**i**	**0.037**	**100%**
total benefit per volume	**i**	**0.100**	

Sources: Banknote and book printing branch (1991); Yi (1993a); Dennis (2010)

woodblocks, which were used more than once, we have to divide the price by 30 (i.e. for writing and carving). From Table 2 we can distill that both paper and wood carving are the major costs in the printing of a book. The Table shows that the former made up ca. 22% of the printing costs. Indeed, according to Yi (1993), paper made in China up no more than ca. 7% of the actual costs of a book, the remainder being woodblock carving, ink, proofreading etc. Yet, it looks like this is an underestimate the higher estimate being more plausible as around 1930 it remained close to 20% (e.g. Liu and Yeh 1965).The latter, woodblock carving, made up even close to 46% of total costs. This is also confirmed by Filippone (2008, Table 2 & 3) who finds for the European middle ages that parchment made up ca. 20% of total costs of producing a book.

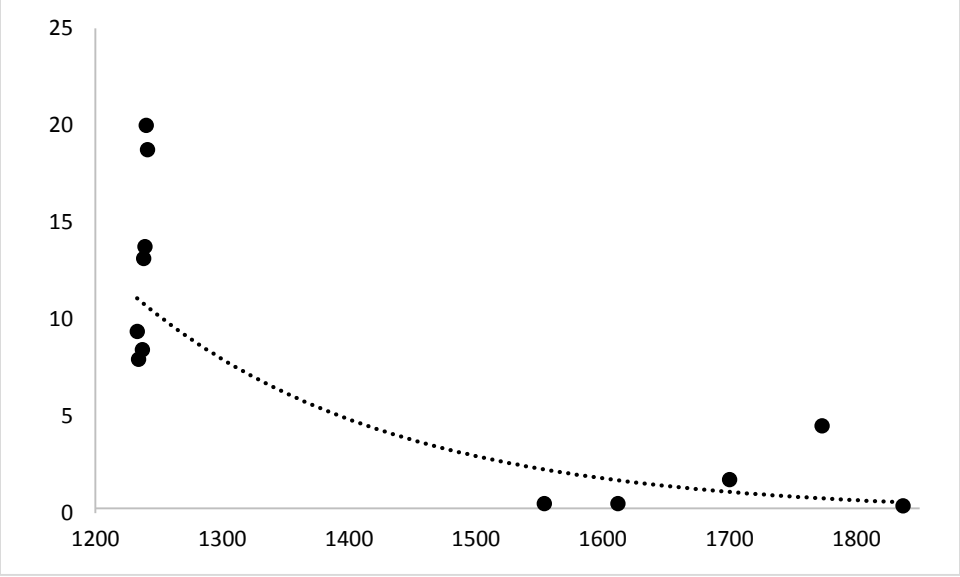
Yet, the prices of both important inputs changed considerably over time. In China, paper was largely made of the, very cheap, bamboo from the Eastern Jin onwards (Tsien 1985). The way paper was manufactured consisted of moving around rags in the water, after which the fibres were collected on a mat. This process did not change much over time, even when the demand for printing increased during the Song dynasty. In Europe, this process of hand pounding was soon changed using water mills. The first recorded paper mill was set up in 1151 in Xàtiva in Spain (Fuller 2002). This was quite a difference since it reduced the cost of hand pounding of rags, which were, before the use of wood pulp mainly from used textiles. It was expanded in the 19th century with steam engines making paper using wood pulp. In addition, the innovation of the printing press combined with oil based ink, which did not soak the paper, allowed Europe to print on both sides of a sheet of paper, hence reducing the cost of paper even further.

If we are to compare the development of prices of paper in Europe and China, we find that in China prices declined from ca. 2.2 grammes of silver per 100 sheets in 1147 (Yi 1993) to ca. 1 gramme in the 17th century (Dennis 2010). Hence, we do witness a strong decline in prices. Yet, this decline was even stronger in Europe. For example, the first paper price in England in 1356 was no less than 37

grammes per 100 sheets of paper while in the 17th century it had declined to 16.8 grammes in England, or 7.5 in Poland, a difference that remained in place until the 19th century (Wolanski 1993; 1996; Clark 2005). Hence, even though we have to keep in mind that in Europe two sides of the paper were printed, hence reducing prices by 50%. In addition, we have to keep in mind that we use silver prices, which are much higher in China than they were in Europe if converted into grain equivalents. Hence, expressed in grain equivalents and divided by 2 to correct for double printing in Europe, 100s sheets of paper cost in the mid-17th century in China 0.031 hl of rice versus 0.17 hl of rye in Europe. Nevertheless, it is clear that the price of paper in Europe was much higher than the paper made of cheap bamboo in China.

The second major cost in printing consisted of woodblock carving which was very laborious and, hence, expensive. Fortunately, we do have some data on wages for carving one woodblock. In Figure 2

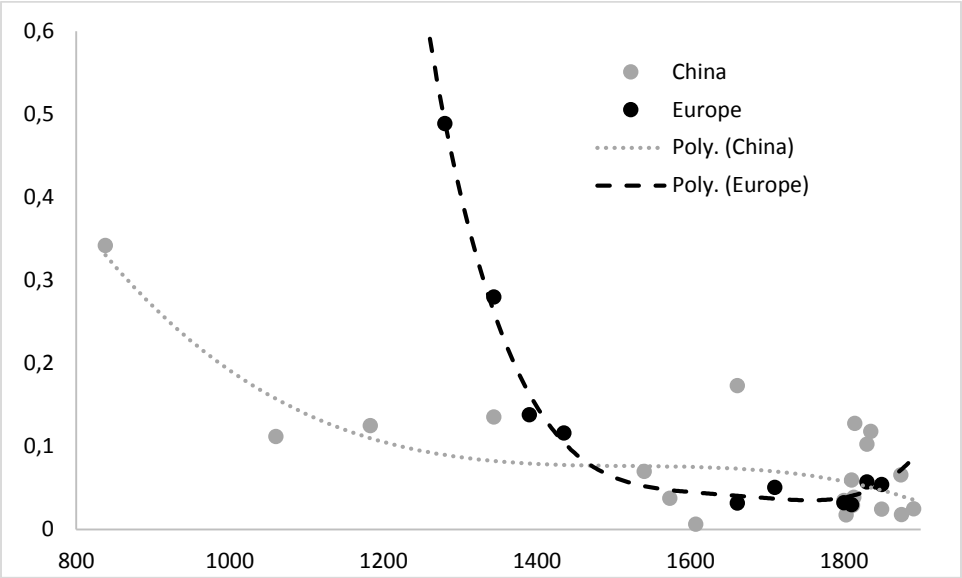
Figure 2. Cost (in liang per 1000 words) for carving woodblocks.



we see a steep decline in the cost of woodblock carving between the 13th and 16th century. The question why this decline occurred is less easy to answer. Yet, McDermott (2005) suggested that the fineness of woodblock carving declined over time, hence reducing costs.

The decline in the cost of both paper and woodblock carving, both major cost factors in producing a book, suggest that over-all prices of books declined considerably. Figure 3 shows the prices of books of 30 pages as expressed in hectoliters of grain (rice in the case of China and rye in the case of Europe). Indeed, we do find a decline in the cost of books in China in the Tang and Sung dynasties with a

Figure 3. hectoliter of rice/rye per volume in China and Europe compared



stagnation afterwards. In Europe, however, the decline was much stronger, no less than 80% between 1300 and 1500. And the prices of books as expressed in grain were not much different from 1500 onwards.

Hence, the fast increase of the imprint in Europe in the 15th century almost certainly can be associated with the extremely rapid decline of the cost of books in the same period. In China, where the book price declined much less in this period we do not witness a similar rise. This is not surprising, since technique did not change much as the Chinese script did not allow for easy implementation of the moveable print. For example, as late as 1820 a one volume hand written cost 0.5 liang, which is almost the same as a volume from a clay moveable printer. On the other hand, a woodblock printed volume cost as little as 0.08 liang which explains the persistence of the imprint. Yet, also in Europe book prices did not declined much in the period between ca. 1550 and 1900 while we do witness an acceleration of printing in the late 18th and 19th centuries. This suggests that the rise of the imprint in 19th century Europe must be mainly demand driven which will be briefly discussed in the following Section.

4. A demand side explanation: societal demand for books

It has been argued that for Europe the demand for books increased in the 15th century (e.g. Buringh 2014) while also in China some increase in demand occurred (McDermott 2005) even though, as we can see from Figure 1, this growth was relatively moderate compared to the 19th century. One way of analyzing the demand is therefore to test what was the character of this demand and how did it change from the 17th to the 18th and 19th centuries.

Societal demand can be purely economic, or institutional. The former essentially means that there is an income effect, i.e. people buy more books once their income increases. Table 3 shows that

Table 3. Index of book prices/GDP per head (1850=100)

year	China	Europe
1000	47	3,305
1500	32	436
1600	20	104
1700	19	147
1800	50	73
1850	100	100

In China people were able to roughly buy the same number of books for their income between ca. 100 and 1800 AD. However, in Europe we witness a strong decline. Hence, it seems likely that part of the increase in imprints in Europe in the 19th century is caused by a rising income. This is corroborated by a rie in books per head as indicate din Table 1.

However, this explanation does not exclude a rising demand from cultural or other reasons. One way of testing this factor is to use the so-called Bass (1969) diffusion equation. This equation allows us to calculate what part of the diffusion is caused by imitation (i.e. people within the same social group also buying books) or innovation (i.e. new social groups demanding books). We use a Bass diffusion equation with m potentially adopters of books. The time of each of these individuals until adoption depends on a random variable with distribution function $F(\tau)$, which is the fraction of the population m that has already adopted the new innovation at time t (i.e. $F(\tau) = N(t)/m$), and a density $f(\tau)$ making the hazard function (i.e. the chance of adoption):

$$\frac{f(\tau)}{1-F(\tau)} = p + qF(\tau) \qquad (1)$$

Here, *p* is independent from the fraction of the population which already adopted the innovation, hence it may be classified as adopting something new (i.e. innovation) while *q*, being dependent on the number of people who already adopted, may be classified as a process of imitation (the same social groups demanding more books). Equation (1) can be rewritten as the following differential equation:

$$\frac{dN(t)}{dt} = \left(p + \frac{q}{m}N(t)\right)\left(m - N(t)\right) \quad (2)$$

This implies that the growth in the number of adoptions depends on the cumulative number adoptions at time *t*, $N(t)$, and a constant.

The problem is that this cannot be simply estimated by OLS in this form because of the presence of multicollinearity and a time series bias. Yet, this can be solved by using a discrete time model (Satoh 2001). First we modify equation 2 as a Ricatti equation by setting

$$a = mp$$

$$b = \frac{q-p}{2}$$

$$c = -\frac{q}{m}$$

From this we obtain

$$\frac{u(t+\delta)-u(t-\delta)}{2\delta} = a + b\big(u(t+\delta) + u(t-\delta)\big) + cu(t+\delta)u(t-\delta) \text{ (3)}$$

, where δ is the constant time difference length. This results in the following regression equation:

$$M_n = A + BN_{n-1} + C(N_{n+1} - N_{n-1}) + \varepsilon_n \text{ (4)}$$

, where $M_n = N_{n+1}N_{n-1}$, $A = \frac{m^2 p}{q}$, $B = \frac{m(q-p)}{q}$, and $C = \frac{m(q-p-1)}{2q}$. Given the estimated coefficients, we can obtain the coefficients of innovation and imitation as follows:

$$\hat{p} = \frac{-B+\sqrt{B^2+4A}}{2B-C} \text{ (5)}$$

$$\hat{q} = \frac{B+\sqrt{B^2+4A}}{2B-C} \text{ (6)}$$

The innovation and imitation coefficients are reported in Table 4. The most important conclusion is that in both China and Europe the diffusion of books mainly occurred via increased spread among the same social groups, i.e. via imitation. Secondly, contrary to Europe, China does have some effect of

Table 4. Innovation an imitation coefficients for China and Europe

	China		Europe	
	innovation	imitation	innovation	imitation
1400-1500	0.036	0.021		
1500-1600	0.029	0.093	0.000	0.053
1600-1700	0.007	0.000	0.004	0.178
1700-1800	0.002	0.234	0.000	0.177
1800-1850	0.013	0.240	0.000	0.230

adding new groups (i.e. innovation) thus suggesting a more changing social structure. Finally, the coefficients are roughly similar in size with the exception of the 17th century. Hence, it is clear that the European rise in imprints in the 15th century was mainly due to falling costs, while the rises in the 19th century were mainly due to a rise in per capita income. The decline in China in the 17th century, however, seems to be mainly driven by a combination of a reduction in income as well as a reduction in social demand, possibly as a result from changing social structures due to the fall of the MIng dynasty.

5. The printing industry

What does this tell us about the development of the printing industry? We already saw that the growth in Europe in the 15th century was mostly due to a reduction in printing costs, a development that

occurred in China almost two centuries before. This led to book prices in Europe that were about half those in China. Yet, after an initial development, both China and Europe embarked on a remarkably similar diffusion path where most books were demanded by the social groups already well acquainted with books, i.e. priests, aristocracy and gentry.

But how id the interaction of supply and demand lead to the development of the printing sector in China? Of course we do have information on the trend in total output (see Figure 1). However, we also need information on the value added/output ratio in order to calculate constant price value added. This

Table 5. Value added/output ratio in the printing industry in China, 1170-1933

	Gross VA added/output ratio
ca. 1170	80%
ca. 1600	73%
ca. 1700	90%
1933	31.4%

information is contained in Table 5. It is important to stress here that the value for 1933 is based on a combination of traditional and modern industries. Had we chosen only traditional industries, we had arrive at a value added/output ratio of 57%. In any case we may argue that the value added/output ratio changes over time: whereas it up to the 19th century was more in the order of 80%, it had dropped to ca. 32% in 1933.

Table 6. Value added in printing in 1933 yuan

year	value added	year	value added	year	value added	year	value added
1360s	1.10	**1510s**	13.92	**1660s**	11.45	**1810s**	21.21
1370s	1.09	**1520s**	20.12	**1670s**	13.89	**1820s**	16.88
1380s	1.33	**1530s**	24.87	**1680s**	15.02	**1830s**	20.62
1390s	1.17	**1540s**	24.09	**1690s**	13.83	**1840s**	17.53
1400s	1.01	**1550s**	26.42	**1700s**	17.66	**1850s**	10.33
1410s	1.55	**1560s**	22.12	**1710s**	16.38	**1860s**	13.71
1420s	1.28	**1570s**	36.94	**1720s**	11.69	**1870s**	23.39
1430s	3.79	**1580s**	35.96	**1730s**	11.31	**1880s**	22.17
1440s	3.35	**1590s**	46.35	**1740s**	14.73	**1890s**	23.28
1450s	2.41	**1600s**	46.41	**1750s**	14.43	**1900s**	17.83
1460s	5.38	**1610s**	44.32	**1760s**	13.88		
1470s	5.78	**1620s**	32.85	**1770s**	13.74	**1933**	78.83
1480s	5.50	**1630s**	32.20	**1780s**	13.35		
1490s	8.81	**1640s**	12.67	**1790s**	16.36		
1500s	10.88	**1650s**	4.99	**1800s**	17.08		

6. Conclusion

It is unmistakable that Europe forged ahead of China after the introduction of the printing press in the 15th century and, after a long period of moving parallel with Chinese book production, forged further ahead in the 19th century. In this paper we explained this pattern using a simple demand and supply function.

We find that, contrary to China, 15th century Europe witnessed a strong reduction in that the same time there is e cost of printing. Hence, book prices fell relative to income and more books were sold. This changed for the 16th-18th century when book prices remained stable. Income did not change much in either China or Europe and neither was there an increased social demand for books. Hence, there was stability. The only exception is China in the 17th century when social demand for books fell, possibly as a result of the Ming-Qing transition. And even though in both Europe and China the social demand for books as well as their cost remained constant also in the 19th century, incomes in Europe grew much faster, hence stimulating an income effect which caused a further rise of book production in Europe in this century.

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