

## Research note: The administration of the iron industry in eleventh-century China

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### *Abstract*

Robert Hartwell's research in the early 1960's into the iron industry of Song China (960–1279) showed, using a variety of evidence, that the applications of iron expanded greatly in the early Song. He then calculated from tax data the annual iron production of China in the 11th century. This article argues that, while Hartwell's qualitative conclusions hold, his specific calculation of annual production is flawed: no reliable calculation is possible based on presently available sources.

### *Keywords*

China; Song period (960–1279); iron industry; industrial administration; statistical sources.

The iron industry of Northern Song China (960–1127) was studied in depth by the late Robert Hartwell in the early 1960's, and since then not much has been done on the subject in the West. In his unpublished Chicago dissertation (1963) Hartwell provided a variety of anecdotal sources which indicate that the use of iron – for weapons, implements, coins, structural members, bells, statues, and more – greatly increased at the beginning of the Song period.<sup>1</sup> Using statistical data preserved from official surveys

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<sup>1</sup>To Hartwell's evidence may now be added recent archaeological evidence on Song and Yuan ironworks; see Wagner 2001b.

of the mining industry in 1064–7 and 1078, he then calculated that iron production in China in the 11th century was 125,000 English tons (114,000 metric tonnes) per year. This work on the iron industry was part of Hartwell's documentation of a 'commercial revolution' in the Northern Song period, which remains an important part of our understanding of Chinese economic history (Hartwell 1962; 1966; 1967). In my own work, writing the volume on Ferrous Metallurgy for Joseph Needham's *Science and civilisation in China*, I have again and again been grateful to Hartwell for his both extensive and intensive study of the historical sources for the Song period.

Hartwell's precise calculation of production tonnage has been widely cited by economic historians, but is much less certain than his qualitative conclusions. It is based on statistical sources whose interpretation requires a detailed knowledge of the administrative system that produced them. I shall argue here that we do not today have this detailed knowledge, and that the system was much more complex than has been assumed. The order of magnitude of Hartwell's figure is plausible, but no reliable calculation is possible on the basis of presently available sources.

#### *The statistical sources*

Several Song texts give broad statistical overviews of the mining and smelting industry, including the iron industry, at particular times. Hartwell studied these closely, and concluded that they have their information from six official surveys carried out in the 10th and 11th centuries.<sup>2</sup> A seventh survey seems to have been carried out at some time

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<sup>2</sup>Hartwell 1963: 178, n. 6. The sources for the respective surveys are: (1–2) the years 997 and 1021: *Wenxian tongkao*, 18: 179b, lines 7–14; *Changbian*, 97: 2259. (3) 1049–53 (the Huangyou period): *Wenxian tongkao*, 18: 179c, lines 9–13; *Song shi*, 185: 4525, lines 1–3. (4) 1064–7 (the Zhiping period): *Wenxian tongkao*, 18: 179c, lines 14, 18; *Song shi*, 185: 4525, lines 4ff; *Song huiyao jigao*, *Shihuo*, 33: 27b; *Yu hai*, 180: 34a. (5)

in the 12th century.<sup>3</sup> These sources give the locations of industrial prefectures (*jian* 監), mining and smelting works (*chang* 場), and smelting tax offices (*yewu* 冶務). From two of the surveys some quantitative data are extant.

The *Song huiyao jigao* is a nineteenth-century collation of several ‘collections of important documents’ (*huiyao* 會要) originally compiled in the Song period.<sup>4</sup> Data given there on deliveries of iron to the government in various places are transcribed here in Table 1: these are the ‘Total mountain-and-marsh receipts’ (*fan shan-ze zhi ru* 凡山澤之入) of iron in 14 circuits for 1064–7, the ‘original quota’ (*yuan e* 元額) of iron in 28 prefectures, and the ‘receipts’ (*shou* 收) of iron in the same prefectures in 1078.

The geographical distribution of this last statistic is shown in the map of [Figure 1](#): iron-producing prefectures listed for 1078 are indicated by filled circles, and rings around these are proportional in area to the ‘receipts’ of 1078. (Prefectures without rings had ‘receipts’ which were too small to show in this way.)

It has sometimes been believed that these sources give total iron production (e.g. Tegengren 1923–4: 313), so that China produced about 3300 tonnes of iron in the year 1078, or 0.03 kg per capita. But this is clearly erroneous, for government receipts were only a part of total production. Some recent authors assume that the government received an in-kind tax of 20 per cent, so that the figure of 3300 tonnes should be multiplied by five to arrive at total production (e.g. Hua Shan 1982: 114).

*Wenxian tongkao*, 18: 180a, lines 7–8; (6) 1078: *Song huiyao jigao*, *Shihuo*, 33: 1a–6a, 7a–18b; *Wenxian tongkao*, 18: 180a, lines 14–19; *Song shi*, 185: 4526, lines 1–4.

<sup>3</sup>*Song huiyao jigao*, *Shihuo*, 33: 20b–23a.

<sup>4</sup>On the complex history of this book, and the problems involved in its use, see e.g. Wang Shumin 1981, pp. 225–30; Chen Gaohua & Chen Zhichao 1983, pp. 244–7; also Yamauchi Masahiro in Hervouet 1978, pp. 177–8.

Hartwell, in dealing with these data, makes two basic assumptions. First, all government receipts of iron represent an in-kind tax of 10 per cent. Second, the figures given in the *Song huiyao jigao* for 1064–7 and 1078 respectively are annual receipts from two different sectors of the iron industry. The former were from a ‘mountain-and-marsh tax’ on small-scale private works, the latter from an ‘annual monopoly receipt tax’ (*suike* 歲課) on large-scale works. Thus the two must be added together to obtain total annual government receipts, then multiplied by 10 to obtain a minimum figure for total annual production. To this must be added estimates of production by untaxed government works, production accidentally omitted in the *Song huiyao jigao*, and illegal production. He concludes that annual iron production around 1064–78 was 125,000 English tons (114,000 metric tonnes), or 1.2 kg per capita,<sup>5</sup> on its face much more credible than the lower figures which have been noted above. In this wonderfully exact form it has been admiringly cited by many Western economic historians, but it has been criticised by Chinese and Japanese historians. Before looking more closely at this controversy we shall look at some sources which tell something of the iron industry in particular places in the 11th century.<sup>6</sup>

### *Glimpses of the iron industry*

There is no source which gives an overall description of the administration of the iron industry in the Song period, but in the following a number of anecdotal sources will be considered which give glimpses of the industry as it could be seen at the local level. These do not give an impression of a monolithic administration which treated all

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<sup>5</sup>Hartwell 1963: 178–95; note also 1962: 154–5; 1966; 1967: 104–5. He takes the population in 1067 to be 95.76 million and one *jin* 斤 to be 596.82 grammes (1963: 35, 177).

<sup>6</sup>I have dealt with some aspects of the archaeology of the Song iron industry in Wagner 2000; 2001b.

localities alike. Rather, the government seems to have assured itself a supply of iron, and a share of the profits of the local producers, by *ad hoc* measures heavily influenced by local conditions and customary usages.

*Liguo Industrial Prefecture.* Parts of the Empire in which industrial production was important required a different sort of administration from agricultural regions, and administrative units called *jian* 監, usually translated ‘industrial prefecture’, were often established in these places.

It happens that the poet Su Shi (Su Dongpo, 1036–1101) was for a time Governor of Xuzhou, where Liguo Industrial Prefecture was located. In a memorial written in 1078, on the administrative problems of the place, he includes an interesting description of the iron industry there:<sup>7</sup>

After being transferred to the governorship of Xuzhou I have inspected the topography of [the region’s] mountains and rivers, investigated what is esteemed by its customs, and studied it in written records. After all this I have realised that Xuzhou is a strategic point between North and South, on which the security of the circuits East of the Capital<sup>8</sup> depends.

. . . [The region is protected on three sides by rugged mountains. Four historical examples show the strategic importance of the prefecture, especially its administrative seat, the walled city of Pengcheng.]

About 70 *li* northeast of the prefectural city is Liguo Industrial Prefecture. From ancient times it has been the gathering place of Iron

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<sup>7</sup>*Xuzhou shang Huangdi shu* (Letter to the Emperor from Xuzhou), in *Dongpo wenji*, 571–80; cf. *Su Dongpo ji*, 14: 61–8; abridged version, 13: 50–58; Kong Fanli 1986: 758–63.

<sup>8</sup>Jingdong Xi lu and Jingdong Dong lu, roughly corresponding to modern Shandong.

Offices [*tieguan* 鐵官]<sup>9</sup> and merchants, and its people are prosperous. There are 36 smelters, each run by a wealthy and influential family with great myriads of cash in its coffers. They are a constant target for bandits, but the military guard is weak, and it is child's play [to rob them].

I have pondered this far into the night, filled with anxiety. I have had more than ten of the most powerful bandits put to death, [but still] when they enter the market in broad daylight the guards abandon their posts and flee.

This region produces fine iron, and the people are all excellent smiths. If some of the smelting households' money is distributed to call up [the local] hoodlums, then a mob could quickly be gathered, and weapons for several thousand men could be supplied in no time.

If [such a mob] were to follow the river and come south, it would arrive [in Pengcheng] in a matter of hours, and Xuzhou would be defenceless. Should the misfortune arise that the bandits had exceptional ability, . . . and they fulfilled their ambition by taking Xuzhou, then the fate of the region East of the Capital would be in doubt.

Recently the Fiscal Commission of Hebei<sup>10</sup> proposed that iron from Ligu Industrial Prefecture should not be permitted to enter Hebei, and the Court approved. . . . The Empire is one family, and the two smelting

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<sup>9</sup>There was an Iron Office here under the Han state monopoly; see Wagner 2001a: 90.

<sup>10</sup>The two circuits Hebei Xi lu and Hebei Dong lu, comprising the southern part of modern Hebei province, and located between the Liao empire to the north and the two circuits 'East of the Capital' (fn •• above) to the south. Deliveries of iron to the government in Hebei Xi lu were enormous, ca. 75 per cent of all deliveries in 1078. See Table 1, lines 18–21 and 53.

[regions] of the northeast both benefit the State; is it not narrow to take from the one to give to the other?

Since the time that iron stopped going north the smelting households have been in danger of bankruptcy, and many have come to me to complain. I propose therefore to call on the smelting households to be the defence of Ligu Industrial Prefecture.

There are 36 smelters, and each has several hundred persons who gather ore and chop [wood for] charcoal. They are for the most part poverty-stricken runaways, strong and fierce. I propose to require the smelting households to select and appoint ten men of ability and discipline from each smelter and register their names with the officials. These will be trained in the use of knives and spears. Each month the two offices<sup>11</sup> will assemble them at the administrative headquarters of Ligu Industrial Prefecture for inspection and drill. They will be excused from corvée duty, but any offences will be treated under the law pertaining to ‘malfeasance in official service’.

The smelting households have long been threatened by bandits. All the people know this, and they will be delighted to have each smelter send ten men for self-defence. If the officials also remove the recent prohibition, and again allow the iron to go north, then the smelting households will be satisfied and obedient. Treacherous elements will be terrified and will not dare to make plots.

With 36 ironworks, each with several hundred workers, this was indeed a major iron-producing region. Their unskilled workers are ‘poverty-stricken runaways, strong and fierce’, which is reminiscent of a description by Sang Hongyang, twelve centuries

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<sup>11</sup>*Liang ya* 兩衙, presumably the administrative offices of Xuzhou and Ligu.

before, of Han ironworkers, ‘common bandits’ who ‘abandoned the graves of their ancestors’ (Wagner 2001a: 26). Hired industrial labourers had no well-defined status in Chinese society.

*Wealthy ironmasters in Dengzhou.* At the tip of the Shandong peninsula was another major iron-producing region, comprising the two prefectures of Dengzhou and Laizhou. The statesman Bao Zheng (999–1062, later immortalised in the ‘Judge Bao’ detective stories) investigated conditions in Dengzhou in about 1046 and submitted a memorial which tells us something of the economics of iron production here:<sup>12</sup>

*Request for the removal of the names of certain iron-producing households in Dengzhou from the register.* Your servant begs to observe that he has previously set forth the condition of eighteen iron-smelting households in Dengzhou, including the Jiang and Lu families. I have stated that they are poor families without the means to smelt iron. Year after year they sell agricultural products and, ‘sitting on an empty nest’, purchase iron which they pay in to the government. I requested that, in accordance with the regulations, their names be removed from the register [of iron-producing households]. . . . I have twice made submissions on this subject, but have not yet received instructions.

My investigations show that in former times, in those areas which produced the largest quantities of iron products, many of the households which originally requested permission to smelt have used up their family fortunes, and have no iron to work with; but the officials will not accept that they are poor. Unassisted they have delivered their quotas of iron, and in so doing they have dissipated their assets. [The obligation] continues with their

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<sup>12</sup>*Bao Xiaosu zouyi*, 7: 22b–23b. Cf. Hartwell 1963: 157.



children and grandchildren, who cannot avoid it. This is very often the situation.

Though the potential profit is great, the rich fear future calamity, and are unwilling to establish [iron smelters]. For this reason the production of iron daily decreases, and for a long time there has been no entrepreneurial activity. I request that they [the rich] be required to be smelting households. But those who are truly bankrupt, and do not have the means to engage in industry, should be thoroughly investigated by an Imperial Commissioner; if no fraudulent practice is found, [the situation] should immediately be reported to the Tax Transport Bureau [of the circuit].

The prefectures and districts should as before be ordered to encourage all manner of persons, continually and in many ways, to establish ironworks, and not be permitted to delay or hinder them.

If this advice is followed, the [iron-smelting] households will be happy in their work and the supply of iron will increase. For the bringing of plenty to the people and enriching the state there is nothing better than this.

Implicit in this text is the assumption that iron production requires a large capital investment. It can be a means to great wealth, but can also lead to ruin. For unspecified reasons many of the wealthy families engaged in iron production have become bankrupt and therefore cannot produce iron. They are nevertheless required to continue delivering an assessed quota to the government, and they can do this only by buying iron on the open market.

The story should remind us that officials appointed to local posts were in a sense negotiators between the broad lines of Imperial policy and the endless variety of local conditions throughout the Empire. Our major sources see the administration from the viewpoint of the capital, and in collections of memorials like Bao Zheng's we see one side of the ongoing negotiations between central and local interests. We do not see the

other side, but we may imagine him simultaneously using whatever persuasive and coercive means were available to bring the local families to fulfil the requirements of the central government.

How common was the situation which Bao Zheng describes? If it was at all common then the statistics given in Table 1 for deliveries of iron to the government have a very uncertain relation to actual production. It is interesting to note that there are numerous passages in Song sources concerning the closing of ironworks.<sup>13</sup> It is likely that each actual decision to reduce or eliminate a quota for deliveries of iron was preceded, as in this case, by years of investigation and negotiation, during which time quotas were met by open-market purchases.

*Corvée iron-production in Hancheng.* Among Bao Zheng's collected memorials, printed directly following the one quoted above, is another which likewise reports a lack of correspondence between name and reality in iron production. It concerns the district of Hancheng in the prefecture of Tongzhou, on the Yellow River on the extreme eastern side of the modern province of Shaanxi. The following translation is cryptic in parts because the writer assumes knowledge of an administration which is not understood today:<sup>14</sup>

*Request for the discontinuation of the system of iron-smelting households in Hancheng District in Tongzhou Prefecture.* Your servant has recently heard that the iron-smelting offices of Hancheng District in Tongzhou Prefecture consistently report on 700 households, among which 200 are well endowed with raw materials. [Among the 700] are always seen the household of the village head [*lizheng*] and all the powerful [households]. These are smelting

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<sup>13</sup>E.g. *Changbian*, 64: 1424; 67: 1511; *Song huiyao jigao*, *Shihuo*, 33: 3b–4a; *Wenxian tongkao*, 18: 179c, lines 7–9.

<sup>14</sup>*Bao Xiaosu zouyi*, 7: 23b–24b.

households in name only; for the past fifty years they have only nominally performed the various *corvée* duties at the prefecture and district level.

Among the smelting households, those of the first rank deliver each year to the smelting offices, counting all the various imposts together, no more than three strings of cash. Other than this they have no expenses.

Furthermore the iron goods received by the government amount to only 100,000 *jin* [ca. 60 tonnes], while its outlay for charcoal<sup>15</sup> and the wages of craftsmen amounts to more than 300 strings. Supervision of the *corvée* requires one government employee.

My investigations have also shown that the households of this district all consider service with the smelting tax offices to be the most onerous *corvée*; when the *corvée* is frequent they await orders and do not volunteer.

If the above-mentioned quantity of iron were spread out according to rank among the households of the entire district, so that all were required to supply iron to the government, then the annual [requirement per household] would be only between 10 and 20–30 *jin*. Further, in this place iron is sold at a price of 24–25 cash per *jin*. Each household, in supplying iron to the government, would expend annually between 300 and 500 cash.

Although the government has long forbidden [private] smelting, there are many in the population who sell [iron] privately. If the common people were permitted to smelt freely, then the price of iron would certainly fall. . . .

We may perhaps surmise from this that the 200 true iron-smelting households in Hancheng operated on a kind of ‘putting-out’ system: the government provided charcoal and the services of skilled ‘craftsmen’, while the designated households

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<sup>15</sup>On the ambiguous term *tan* 炭 see Hartwell 1963: 89–90, fn. 2. It is possible, but not likely, that it refers here to mineral coal rather than charcoal.

provided semi-skilled and unskilled labour, delivering a set quota of iron to the government. The iron-smelting households found this work onerous, and presumably produced no more than their quota. Private smelting was illegal, but iron was available on the market – was this produced in Hancheng, or imported from other districts?

The situation is confused by the fact that for wealthy families there were advantages to being registered as iron-smelting households. They seem to have been excused from most other obligations, and thus some 500 families could avoid taxes and *corvée* duties, fulfilling their quotas by buying iron on the market.

The industrial structure described here is very different from that in Xuzhou or Dengzhou seen above. In those prefectures the ironmasters were wealthy industrialists, supplying their own capital and expertise and employing hundreds of workers. Here in Hancheng production seems to have been tightly supervised by the government, which supplied both capital and expertise.

If 60 tonnes per year was the quota to be delivered by 700 households, production per household was very small compared with other regions.<sup>16</sup> It seems very likely that we are dealing here with a low-capital labour-intensive iron-production technology. While the ironmasters of Xuzhou and Dengzhou presumably operated large blast furnaces like those of 19th-century Sichuan, iron may have been produced in Hancheng in small blast furnaces like those of Dabieshan or by the crucible process of Shanxi (see Wagner 1997; 2001b).

Bao Zheng's plea for a change in the iron-production quota system in Hancheng was in time accepted, and in 1055 an order was sent to the Fiscal Commissioner of Shaanxi circuit that iron smelters in Tongzhou be allowed to 'purchase for transfer'

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<sup>16</sup>The figure would still be small if 60 tonnes was 10 per cent of the production of 200 households, as Hartwell (1963: 183 fn. 4) appears to assume.

(*chengmai* 承買).<sup>17</sup> Tongzhou is not listed as having an iron quota in the *Song huiyao jigao* in either 1064–7 or 1078 (Table 1, rows 46–8).

In 1083 the Fiscal Commission of Shaanxi Circuit reported that in Hancheng district, ‘the veins of iron ore in the mountains are deep and thick; a mint [*qianjian* 錢監] can be established there.’<sup>18</sup> It also proposed that several existing mints further to the west, in modern Gansu, be closed. These measures were presumably part of a general tightening of security against the Xi Xia threat, moving iron production away from the border region.

The report of 1083 mentions only potential production in Hancheng, and gives no information on actual current production.<sup>19</sup> Probably production here was quite low until this move brought renewed development, with a new injection of both capital and technological expertise, and perhaps a new technology as well. It made a great difference to iron production in Hancheng, as the report of an official investigation three decades later indicates.

In 1112 an official named Jiang Yi 蔣彝 (1074–1122) was vested with special powers and sent to reorganise the mining industry of Shaanxi.<sup>20</sup> His report of 1114 appears to indicate that two ‘mining and smelting works’ (undoubtedly ironworks) in Hancheng have annual quotas of 600,000 *jin*, or about 360 tonnes, each.<sup>21</sup> Thus these

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<sup>17</sup>*Changbian*, 181: 4382.

<sup>18</sup>*Changbian*, 338: 8137; cf. Hartwell 1963: 183, fn. 4.

<sup>19</sup>I have not been able to find a modern study of mineral resources in Hancheng, but Nyström (1912, e.g. pp. 35–6, 61–2) reports important deposits of both iron ore and coal immediately across the Yellow River in Shanxi.

<sup>20</sup>See his epitaph-biography in *Beishan xiaoji*, 30 (pp. 7b–11a): 8b.

<sup>21</sup>Quotations from the report are found in several Song texts. The *Song huiyao jigao* quotes it as stating that the ironworks have annual quotas of six million *jin*; this is not credible, for it suggests that each of the two had a quota greater than the *total* of all

two works each delivered a quota which was six times the earlier quota for the entire district. They were now having difficulty delivering their quotas, but an underlying assumption in the memorial is that the quotas had earlier been realistic. No doubt the two works had been established, and their quotas set, as a result of the proposal of 1083.

*Production statistics*

Hartwell calculated on the basis of the statistics reproduced here in Table 1 that annual iron production in the Song empire in the 11th century was, at a minimum, 114,000 tonnes. The premises on which he based this calculation were put in doubt by Yoshida Mitsukuni in an important article published in 1966;<sup>22</sup> Hartwell responded in a long footnote in a 1967 article (Hartwell 1967: 104–6), but he did not answer Yoshida’s crucial argument: In the same sources *copper* is treated in exactly the same way as iron, but if the same method is applied, the result is that annual copper production in Song China in the 11th century was an unbelievable 210,000 tonnes per year (cf. Hartwell 1963: 31). To this would presumably be added an estimate of untaxed production and

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ironworks quotas in Song China only 36 years before, in 1078 (Table 1, rows 53–4). Hartwell (1963: 183, fn. 4) silently corrects six million (*liubaiwan*) to 600,000 (*liushiwan*), and this seems to be the best guess we can make as to the original figure.

The *Song huiyao jigao* is notorious for the number of banal copying errors it contains (see e.g. Chen Gaohua & Chen Zhichao 1983: 246–7). A good example is seen in overlapping quotations of another part of Jiang Yi’s memorial: in one a number is given as 700, in the other as 800, and other obvious copying errors are apparent as well.

*Song huiyao jigao*: *Zhiguan*, 43: 135a; *Shihuo*, 34: 16a; *Xingfa*, 4: 35a. See also *Song shi*, 185: 4528; *Wenxian tongkao*, 18: 180b. Hartwell (1963: 183, fn. 4) has a somewhat different interpretation from the one given here.

<sup>22</sup>Yoshida Mitsukuni 1966: 517–23; repr. 1972: 364–70.

illegal production, bringing it up to more than twice the iron production in the same period. This result would make nonsense of the many contemporary sources that speak of a great shortage of copper which led to the use of iron coins.

This one consideration indicates that there is some flaw in Hartwell's reasoning. The question is so important, and Hartwell's results so widely accepted, that it will be necessary to look in detail at the relevant sources and the discussions which have arisen around them.

*The sources.* Official surveys of the mining industry appear to have been compiled in 997, 1021, 1049–53, 1064–7, 1074, 1078, and 1127–62. Information from these is found in a number of Song texts, but the most inclusive is the *Song huiyao jigao*, which only became generally available in 1935.<sup>23</sup> It gives a geographic breakdown of the quantitative data for government receipts of mining products. The extant edition of this book contains a frightening number of copying errors;<sup>24</sup> but comparison of the national totals with the actual totals of the figures given for circuits and prefectures (see Table 1, rows 53 and 54) indicates that copying errors in this part of the text are unlikely to be severe, for the totals are very close to being correct. Further, the same precise figures for the national totals (not for the individual circuits and prefectures) can be found in other Song texts.<sup>25</sup>

The structure of the relevant part of the section on 'Mining and smelting' (*keng-ye* 坑冶) of the *Song huiyao jigao* is as follows:<sup>26</sup>

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<sup>23</sup>See fn. •• above.

<sup>24</sup>See fn. •• above.

<sup>25</sup>*Song shi*, 185: 4526, line 2; *Wenxian tongkao*, 18: 180a, line 16; *Yu hai*, 180: 34a.

<sup>26</sup>*Song huiyao jigao*, *Shihuo*, 33: 1a–28a.

**1.** Survey of mining and smelting works, probably compiled in 1078. For each mining product, a list of prefectures with notes giving a variety of information, especially the dates when production units were opened or closed. The latest date in this part is 1077.

Gold, p. 1b.

Silver, pp. 1b–3a.

Copper, pp. 3a–3b.

Iron, pp. 3b–4a.

Lead, pp. 4a–4b.

Tin, pp. 4b–5a.

Mercury and cinnabar, p. 5a.

**2.** Government quotas and receipts of mining products in 1078. The figures given are ‘original quota’ and ‘received in 1078’, totals and by prefecture.

Gold, pp. 7a–7b.

Silver, 7b–11a.

Copper, pp. 11a–12b.

Iron, pp. 12b–14a (see Table 1, A).

Lead, pp. 14a–16b.

Tin, pp. 16b–17b.

Mercury and cinnabar, pp. 17b–18b.

**3.** Brief survey giving the number of mining and smelting works opened and closed in each circuit in the period 1127–62, sometimes with quantitative data, especially on iron and copper production related to the making of copper by precipitation.

Gold, p. 18b.

Silver, pp. 18b–19a.

Copper, pp. 19a–20b.

Iron, pp. 20b–23a.

Lead, pp. 23a–25a.

Tin, pp. 25a–26a.



4–8 are probably for the period 1064–7:<sup>27</sup>

4. Data on tax paid in silver in four circuits; presumably a mining tax, but this is not made explicit. P. 27a.

5. ‘Mountain and marsh receipts’, totals and by circuit.

Gold, p. 27a.

Silver, pp. 27a–27b.

Copper, p. 27b.

Iron, p. 27b (see Table 1, B)

Lead, p. 27b.

Tin, pp. 27b–28a.

Cinnabar, p. 28a.

Mercury, p. 28a.

6. ‘Total poll tax received’, totals and by circuit. Cf. no. 8 below.

Gold, p. 28a.

Silver, pp. 28a–28b.

7. ‘Tribute presented by the circuits’, totals and by circuit.

Gold, p. 28b.

Silver, pp. 28b–29a.

8. ‘Land tax received’, totals and by circuit. Cf. no. 6 above.

Gold, p. 29a.

Silver, pp. 29a–29b.

Mercury, p. 29b.

The fact that the different sections are not arranged in chronological order is not likely to be relevant, given the chaotic state in which the *Song huiyao jigao* has reached us.

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<sup>27</sup> Parts 4–8 (pp. 27a–29b) were copied into the *Song huiyao jigao* from the now-lost *Guochao huiyao* 國朝會要 (see p. 29b), which concerns the period 960–1077 (Wang Shumin 1981: 225). Hartwell (1963: 178) notes that these parts use circuit names only established in 1059, and that the only survey in the period 1059–77 (ignoring the one in 1074, see fn. •• above) was that of 1064–7.

The sections which are important here are nos. 2 and 5, which give quantitative data for 1078 and 1064–7 respectively; see Table 1. As already noted, Hartwell makes two assumptions: that the two sets of data are for in-kind taxes on two different sectors of the mining and smelting industry, and that the tax in each case was 10 per cent. The first assumption can be dealt with briefly, while the second will require a lengthy discussion.

*Assumption 1: The two sectors.* From a naïve viewpoint the most natural assumption would be that each of the two sets of figures covers the entire iron industry of Song China, in different years. Among other things, their totals are approximately equal (Table 1, row 53), and before the geographical breakdown in the *Song huiyao jigao* became available in 1935 no great difference could be seen. It was Hartwell who pointed out that the geographical distributions of the figures are quite different, as the reader can see in Table 1, comparing columns B and A3. As Hartwell argued, it is unreasonable to suppose that the geographic distribution of iron production could have changed so much in such a short time, from 1064–7 to 1078 (Hartwell 1963: 178–9, 183–4; 1967: 104–6). He therefore suggested that the figures are for two different sectors of the industry: those for 1064–7 representing a tax on small-scale private ironworks and those for 1078 representing a tax on some (but not all) large-scale government-sponsored ironworks.

One possible explanation for the difference is surely the one Hartwell proposes, but he does not actually cite any evidence that in the Song period a clear distinction was made between precisely two sectors of the industry. The sources cited above suggest instead that production and taxation arrangements were made largely on an *ad hoc* basis from locality to locality.

Other explanations are possible. In particular, it should be noted that it is only an assumption (Assumption 2, to be discussed below) that the two sets of figures are closely related to production at all. They are labelled ‘quotas’ or ‘receipts’, and the

geographical distribution of taxation, or of the government's consumption of iron, could have changed greatly even in this short period. Bao Zheng's memorials (in 1046 and sometime before 1055) suggest that quotas often did not reflect actual current production, with quota deliveries being purchased on the open market from production elsewhere. The many closures of ironworks listed in the sources<sup>28</sup> indicate that local officials like Bao Zheng often attempted to have the quotas changed to reflect more faithfully the actual situation, and his experience suggests that they had difficulty being heard.

It is important to note as well that precisely in the period between the dates of the two sets of figures was the period of the reforms of Wang Anshi, which influenced most aspects of the economic life of the time.<sup>29</sup> We do not know how the 'New Policies' specifically affected mining and smelting, but the whole taxation system was reorganised, and one of the specific motivations of this reorganisation was that out-of-date quotas gave merchants too much economic power.<sup>30</sup> It is therefore not an untenable hypothesis that both sets of figures represent total government receipts of iron, without any division into separate sectors. The set for 1064–7 might for example reflect quotas established a century before, at the beginning of the dynasty, while the set

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<sup>28</sup>See fn. •• above.

<sup>29</sup>On the reforms of Wang Anshi see e.g. Kuhn 1987: 204–9; Williamson 1935; Liu 1959; Smith 1991, esp. pp. 111–18; Qi Xia 1987–8: 410–22.

<sup>30</sup>In order to supply its needs, the Song court relied on an inadequate and inflexible command structure to siphon off goods and services from a complex and bustling market economy. This provided well-capitalised merchants enormous opportunities to profit from the gap between "plan" – typically represented by outmoded quotas – and reality' (Smith 1991: 114). Cf. Wang Anshi's *Qi zhizhi sansi tiaoli* 乞制置三司條例 (Request for the reorganisation of the State Finance Commission), in *Linchuan wenji*, 70: 7a–8a, esp. p. 7b.

for 1078 might reflect quotas which had been revised on the basis of a new investigation of actual iron production in the different localities.

*Assumption 2: The 10 per cent tax.* On the rate of the tax Hartwell cites a classic article by Katō Shigeru.<sup>31</sup> Katō's article is about gold and silver, and says very little about iron, but on the cited pages he quotes from a 10th-century geographical compendium a passage concerning Shangrao district (modern Shangrao, Jiangxi):

‘Iron Mountain’ [Tieshan 鐵山], also called Dingxi Mountain 丁溪山, is located 70 *li* southeast of the district seat. Earlier the common people were permitted to mine here, with the government receiving one-tenth. Later it was incorporated into Yongping Industrial Prefecture, but now it is closed.<sup>32</sup>

This appears to be the only statement in any Song source which suggests a fixed in-kind tax rate on iron production. It refers to one particular place, and to the past not the present.<sup>33</sup> The passage is in the *Taiping huanyu ji*, which was compiled in the period 976–83, and the ‘earlier’ period referred to is surely before the establishment of the Song in 960.

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<sup>31</sup>‘. . . the rate of both the mountain-and-marsh iron tax and the “monopoly receipt tax” was 10 per cent . . .’. Hartwell 1963: 183, citing Hino Kaisaburō 1934: 115 and Katō Shigeru 1926: 527–8. But Hino merely cites Katō.

<sup>32</sup>*Taiping huanyu ji*, 107: 14b. Katō's quotation does not include the last sentence.

<sup>33</sup>Nor does it explicitly state that what was mined at Iron Mountain was actually iron. According to the *Song huiyao jigao* (*Shihuo*, 33: 2a, 4a, 8b, 11b), iron, silver, and copper were all at various times mined here.

Katō goes on to quote another passage on a nearby place, where lead was mined and a tax of 10 per cent was paid.<sup>34</sup> He concludes: ‘Judging from these two passages, production of iron, lead, copper, and the like was probably taxed at a rate of one-tenth.’ This is in distinction to a tax on gold and silver mining, which he argues was 20 per cent.

In one publication Hartwell also notes an apparent concrete example of a tax of 10 per cent on iron production. ‘In 1084, for example, officials expected to obtain 2,340 tons [2,127 metric tonnes] of iron from the mines and smelters of Xuzhou for the purpose of casting iron cash. The 1078 *sui-k’o* 歲課 figures indicate the receipt of only 206 tons [see Table 1: 308,000 *jin*, 185 metric tonnes], or a little short of ten percent . . . Other instances could be cited.’<sup>35</sup> Yoshida counters this example with an analogous one, a memorial of 1116:

The Fiscal Commissioner [*caosi*] of Guang[-nan] Dong [circuit] reported: ‘In this circuit there are 92 iron mining and smelting sites, with an annual quota [*sui-e* 歲額] of 2,890,000 *jin* [ca. 1700 tonnes]. Besides the precipitation of copper there is no other use for it.’<sup>36</sup>

Comparing this production with the figure for the circuit in 1078 (see Table 1), 31,344 *jin* (ca. 19 tonnes), would indicate, writes Yoshida, a tax of only around 1 per cent; and thus that the whole situation is much more complex than Hartwell assumes.

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<sup>34</sup>*Taiping huanyu ji*, 107: 20b.

<sup>35</sup> Hartwell 1962: 155, n. 12. He cites *Xu Zizhi tongjian changbian*, ch. 97, pp. 20a–21b (*Changbian*, 97: 2258–63, in the edition used here), but there must be a typographical error in Hartwell’s article, for on the pages cited there is no mention of the date 1084, and only one, irrelevant, mention of Xuzhou.

<sup>36</sup>*Song shi*, 185: 4528; Yoshida Mitsukuni 1966; repr. 1972: 364, 366.

Yoshida's argument is not very strong as it stands, for it is not impossible that iron production in this southern circuit could have increased tenfold between 1078 and 1116, especially considering the new demand for cheap iron brought by the introduction of the precipitation process in copper production (see Golas 1999: 370–86). However, the data given in the *Song huiyao jigao* for some time in the period 1127–62 (part 3 in the above outline) include annual quota receipts of iron from six districts in Guangnan Dong Circuit, and these add up to 123,220 *jin* (74 tonnes),<sup>37</sup> which suggests that this source reports a tax of ca. 4 per cent of production. But a further complication is that the same source reports the quantities of iron used in copper precipitation in the same places, and these add up to 31,548 *jin* (19 tonnes), or about a quarter of tax receipts. It is difficult to see how this can be reconciled with the statement in 1116 that there was no other use for iron than the precipitation of copper. And a final complication is that the three sources which are relevant here, those referring to 1078, 1116, and 1127–62, all refer to the numbers they give as 'quotas' (e 額), obviously not all using the word with the same meaning.

...

It appears, then, that no evidence is known of a general in-kind tax of 10 per cent on iron production at any time in the Song period. There does seem to have been some sort of in-kind tax in some places, but it is not known whether this was a fixed percentage of production, or varied from place to place according to local conditions. Bao Zheng's memorials from Dengzhou and Hancheng, quoted above, suggest that the latter is more likely. Note in particular that Bao Zheng refers to 'quotas' rather than 'taxes'.

What do the figures reported in Table 1 for 1064–7 and 1078 represent? Recall that quotations from the original surveys are found in several sources, with the *Song huiyao jigao* reporting the figures broken down geographically and the rest giving only

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<sup>37</sup>*Song huiyao jigao*, *Shihuo*, 33: 21b, lines 3–6; p. 23a, lines 2–6.

the totals. The different sources describe the totals differently. Those for 1078 are given as follows:

‘Total iron mining and smelting quota 5,482,770 *jin*; total receipts, first year of Yuanfeng, 5,501,097 *jin*.’

鐵坑冶祖額總計…斤元豐元年收總計…斤<sup>38</sup>

‘First year of Yuanfeng: In this year, in the mines and smelters of the circuits: gold, total . . . ; iron 5,501,097 *jin*; . . . ’

元豐元年是歲諸路坑冶金總計…鐵…斤<sup>39</sup>

‘In the first year of Yuanfeng, the mines and smelters: gold, total receipts . . . ; iron 5,501,097 *jin*; . . . ’

元豐元年諸院冶金總收…鐵…斤<sup>40</sup>

Hartwell refers consistently to the figures for 1078 as ‘annual monopoly receipt tax (*sui-k’o*)’ (Hartwell 1962: 154, fn. 12; 1963: 178, 179; 1966: 32, fn. 9; 1967: 105). In fact the sources never use the phrase *suike* 歲課 for these figures; as can be seen, they call them ‘total receipts’ of ‘quotas’ (*zu’e . . . shou zongji*); ‘totals’ (*zongji*); or ‘total receipts’ (*zongshou*).

...

Such phrases as ‘quota’ and ‘total receipts’ sound as if they include more than the tax; they might for example be the total of all deliveries to the government, or perhaps all obligatory deliveries. This would explain the discrepancy between the figures for iron and copper: the government took for its own purposes (largely coinage) nearly all the

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<sup>38</sup>*Song huiyao jigao, Shihuo*, 33: 14a.

<sup>39</sup>*Wenxian tongkao*, 18: 180a, lines 14–19.

<sup>40</sup>*Song shi*, 185: 4526.

copper produced, but only some fraction of iron production. The figures given in two sources for annual monopoly receipts (*suike*) of silver and gold in 997 and 1021 explicitly include both taxes and compulsory sales to the government under the ‘harmonious purchase’ (*hemai* 和買, *heshi* 和市) scheme, and the phrasing of the statement suggests (less certainly) that the figures given for other metals, including iron, for these years includes both of these posts.<sup>41</sup>

Katō argues that the figures for silver and gold for 1078 probably include the harmonious purchase deliveries, and that this is also a possibility for 1064–7 (Katō 1926: 536–7). An example of the way in which these deliveries could vary is seen in a notice for 1086 concerning silver production in Guozhou (modern Lingbao, Henan). The in-kind tax was 20 per cent and the compulsory harmonious purchase 80 per cent of production; this was ordered changed to its ‘original value’, 40 per cent.<sup>42</sup>

There does not seem to be any definite evidence that the harmonious purchase scheme ever included iron, but we do have evidence from a later time of compulsory sales of iron to the government. For Fuzhou (modern Fuzhou, Fujian) at some time in the 12th century we have a list of mining and smelting works and their required deliveries.<sup>43</sup> The requirements varied considerably between different works within this one prefecture, but several paid a 20 per cent tax and in addition were required to sell

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<sup>41</sup>‘However, in [the figures for] gold and silver, besides the mining and smelting poll tax and harmonious purchases, receipts of *keli*, *zhena*, and *hushi* are all included’ 然金銀除坑冶丁稅和市外，課利折納互市所得皆在焉。

*Changbian*, 97: 2263; same text, *Wenxian tongkao*, 18: 179b. On the harmonious purchase scheme and its many changes in the course of the Northern Song period see e.g. Qi Xia 1987–8: 419–22; Zhao Baoyu 1981.

<sup>42</sup>*Changbian*, 389: 9075; Katō 1926: 527.

<sup>43</sup>*San shan zhi*, 14: 7749–51. Note that there are numerous copying errors in this text, for example several obvious substitutions of *qian* 千 for *jin* 斤.



the rest of their production to the government, while others delivered a fixed quota to the government. Still others paid a tax in money rather than in kind.

### *Conclusion*

Hartwell's two assumptions have been examined here, and neither seems to have much justification. A more likely assumption is that the figures given in the *Song huiyao jigao* for 'total receipts' of iron in 1078, totalling 3300 tonnes, represent a rough approximation for the government's total consumption of iron in this year. How this relates to total production is not at all clear.

For the Han period I have suggested elsewhere that iron production might have been on the order of 0.1 kg per capita per year (Wagner 2001a: 73). Since, as Hartwell has shown, the uses of iron had broadened greatly between the Han and the Song one might well be justified in supposing an increase in production by an order of magnitude in the intervening thousand years. Therefore his suggestion, 114,000 metric tonnes, amounting to about 1.2 kg of iron per capita per year, is quite plausible, but there appears to be no direct quantitative evidence for it.

### *Acknowledgements*

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As an experiment I placed an earlier version of the article on the World Wide Web and asked for comments and advice from three Internet discussion lists. The response was quite heartening, and I especially wish to thank Peter K. Bol, Charles Curwen, Peter J. Golas, Christian de Pee, and Gideon Shelach for useful comments. As always, errors, misunderstandings, and infelicities of expression are mine alone.

*Figure caption*

Figure 1. Map showing locations of prefectures mentioned in Table 1. Modern province names and boundaries are also shown. Prefectures listed for 1078 are indicated by filled circles, and rings around these are proportional in area to the ‘receipts’ of 1078. Receipts from prefectures without rings were too small to be shown in this way.

*Abbreviations*

- Bao Xiaosu zouyi* Bao Zheng 包拯, 999–10. *Bao Xiaosu zouyi* 包孝肅奏議 (Memorials of Bao Zheng).
- Yueya Tang congshu sanbian* 粵雅堂叢書三編, 1853, facs. repr. Taipei: Zhongwen Chubanshe, 1965.
- Beishan xiaoji* Cheng Ju 程俱, 1078–1144. *Beishan xiaoji* 北山小集 (Prose from the Northern Mountain). *Sibu congkan* 四部叢刊 edition.
- Changbian* Li Dao 李燾, 1115–1184. *Xu Zizhi tongjian changbian* 續資治通鑑長編 (Collected data for a continuation of the *Comprehensive mirror for aid in government*, 1183). Typeset ed., Beijing: Zhonghua Shuju, 1979 ff.
- Dongpo wenji* Su Shi 蘇軾, 1036–1101. *Jingjin Dongpo wenji shiliüe* 經進東坡文集事略. (Essays of Su Shi, annotated by Lang Ye 郎曄, fl. 1229). Typeset ed. Beijing: Xinhua Shuju, 1957.
- Linchuan wenji* Wang Anshi 王安石, 1021–86. *Linchuan xiansheng wenji* 臨川先生文集 (Collected works of Wang Anshi). *Sibu congkan* edition.

- San shan zhi* Liang Kejia 梁克家, 1128–87, and Chen Fuliang 陳傅良, 1137–1203. *San shan zhi* 三山志 (Monograph on the Three Mountains, i.e. Fuzhou). Facs. repr. of Ming ed., *Song Yuan difangzhi congshu* 宋元地方志叢書, Taipei: Zhongguo Dizhi Yanjiuhui, 1978, vol. 12, pp. 7623–8100.
- Song huiyao jigao* Xu Song 徐松, 1781–1848. *Song huiyao jigao* 宋會要輯稿 (Draft collection of fragments of ‘Collected documents of the Song dynasty’). Remaining fragments of several *huiyao* of the Song dynasty, ed. and publ. by Chen Yuan a.o., 1935; facs. repr., 8 vols., Beijing: Zhonghua Shuju, 1957.
- Song shi* Tuo Tuo 脫脫, 1313–55. *Song shi* 宋史 (Standard history of the Song dynasty). Typeset ed., 40 vols., Beijing: Zhonghua Shuju, 1985.
- Su Dongpo ji* Su Shi 蘇軾, 1036–1101. *Su Dongpo ji* 蘇東坡集 (Collected works of Su Shi). Typeset ed., *Guoxue jiben congshu jianbian* 國學基本叢書簡編, 6 vols., Shanghai: Shangwu Yinshuguan, 1930.
- Taiping huanyu ji* Yue Shi 樂史, 930–1007. *Taiping huanyu ji* 太平寰宇記 (Universal geography of the Taiping period, 976–83). *Siku quanshu* 四庫全書 ed., Shanghai: Shanghai Guji Chubanshe, 1987, vols. 469–70.

- Wenxian tongkao* Ma Duanlin 馬端臨, 1254–1325. *Wenxian tongkao* 文獻通考 (General investigation on important writings). Shi tong 十通, no. 7. 2 vols., Shanghai: Shangwu Yinshuguan, 1936.
- Yu hai* Wang Yinglin 王應麟, 1223–96. *Yu hai* 玉海 (Sea of jade, an encyclopedia). Facs. repr. of early ed., Taipei: Hualian Chubanshe, 1967.

### References

- Chen Gaohua & Chen Zhichao (a.o.). 1983. *Zhongguo gudai shi shiliaoxue* (The sources of pre-modern Chinese history). Beijing: Beijing Chubanshe.
- Golas, Peter. 1999. Joseph Needham, *Science and civilisation in China*. Vol. 5: *Chemistry and chemical technology*. Part 13: *Mining*. Cambridge: Cambridge University Press.
- Hartwell, Robert. 1962. ‘A revolution in the iron and coal industries in the Northern Sung.’ *Journal of Asian Studies* 21.2: 153–62.
- 1963. *Iron and early industrialism in eleventh-century China*. Ph.D. dissertation, University of Chicago.
- 1966. ‘Markets, technology, and the structure of enterprise in the development of the eleventh-century Chinese iron and steel industry.’ *Journal of Economic History* 26.1: 29–58.
- 1967. ‘A cycle of economic change in imperial China: Coal and iron in northeast China, 750–1350.’ *Journal of the Economic and Social History of the Orient*, 10: 102–59.
- Hervouet, Yves. 1978. *A Sung bibliography (Bibliographie des Sung)*. Hong Kong: Chinese University Press.

- Hino Kaisaburō. 1934. ‘Hoku Sō jidai ni okeru dō, tetsu no sanshutsu gaku ni tsuite’ (On the production quotas of copper and iron in the Northern Song period). *Tōyō gaku* (Oriental studies), 22.1: 100–159.
- . 1935. ‘Hoku Sō jidai ni okeru dō tetsu sen no chūsō gaku ni tsuite’ (The quotas for casting copper and iron coins in the Northern Song period). *Shigaku zasshi* 46.1: 46–105.
- Hua Shan. 1982. *Song shi lunji* (Essays on Song history). Ji’nan: Qi–Lu Shushe.
- Katō Shigeru. 1926. *Tō–Sō jidai ni okeru kin, gin no kenkyū* (Researches on the precious metals in the T’ang and Sung dynasties, centred on their monetary function). Tōyō Bunko ronsō, 6/1–2. Tōkyō: Tōyō Bunko.
- Kong Fanli, ed. 1986. *Su Shi wenji* (Collected works of Su Shi, 1036–1101). Beijing: Zhonghua Shuju.
- Kuhn, Dieter. 1987. *Die Song-Dynastie (960 bis 1279): Eine neue Gesellschaft im Spiegel ihrer Kultur*. Weinheim: Acta Humaniora, VCH.
- Liu, James T. C. 1959. *Reform in Sung China: Wang An-shih (1021–1086) and his New Policies*. Harvard East Asian studies, no. 3. Cambridge, Mass.: Harvard University Press.
- Nyström, Erik. T. 1912. *The coal and mineral resources of Shansi province, China, analytically examined*. Stockholm: Norstedt.
- Qi Xia. 1987–8. *Song dai jingji shi* (The economic history of the Song period). 2 vols. Zhongguo gudai jingji shi duandai yanjiu, no. 5. Shanghai: Shanghai Renmin Chubanshe.
- Smith, Paul J. 1991. *Taxing Heaven’s storehouse: Horses, bureaucrats, and the destruction of the Sichuan tea industry, 1074–1224*. Harvard–Yenching Institute monograph series, 32. Cambridge, Mass. & London: Council on East Asian Studies, Harvard University.

- Tegengren, F. R. 1923–24. *The iron ores and iron industry of China: Including a summary of the iron situation of the circum-Pacific region*. Memoirs of the Geological Survey of China, series A, no. 2. Peking: Geological Survey of China, Ministry of Agriculture and Commerce. Part I 1921–23, part II 1923–24. English text with abridged Chinese translation by Xie Jiarong.
- Wagner, Donald B. 1997. *The traditional Chinese iron industry and its modern fate*. Richmond, Surrey: Curzon Press.
- 2000 ‘Chinese monumental iron castings.’ *Journal of East Asian archaeology* 2.3/4: 199-224.
- 2001a. *The state and the iron industry in Han China*. Copenhagen: Nordic Institute of Asian Studies.
- [2001b]. ‘Blast furnaces in Song–Yuan China.’ Forthcoming in *Journal of East Asian Science, Technology, and Medicine*.
- Wang Shumin. 1981. *Shibu yaoji jieti* (Annotated bibliography of historical sources). Beijing: Zhonghua Shuju.
- Williamson, H. R. 1935. *Wang An Shih: A Chinese statesman and educationalist of the Sung Dynasty*. 2 vols. Probsthain’s Oriental series, 21. London: Arthur Probsthain.
- Yoshida Mitsukuni. 1966. ‘Sōdai no tetsu ni tsuite’ (On iron in the Song period), *Tōyō shi kenkyū* 24.4: 508–24 with Eng. abstract pp. 5–6. Repr. Yoshida 1972, pp. 353–71.
- 1972. *Chūgoku kagaku gijutsu shi ronshū* (Essays on the history of science and technology in China). Tōkyō: Nihon Hōsō Shuppan Kyōkai.
- Zhao Baoyu. 1981. ‘Song-dai “hemai” qiyuan kaolüe’ (The origin of the ‘harmonious purchase’ system of the Song period). *Tianjin Shiyuan xuebao* (Journal of Tianjin Normal University), 1981.2: 60–63.

**Table 1.** Statistics given in *Song huiyao jigao*, *Shihuo* section (SHY:SH), concerning iron mines and smelters in the Song period.

**A1:** Iron quota for 1078, believed to be the average of receipts in 1075, 1076 and 1077 (Hino 1934, pp. 109–10, 145–6; Hartwell 1963, pp. 178–9, fn. 6).

**A2:** Actual receipts in 1078.

**B:** ‘Total Mountain-and-marsh receipts’ (*fan shan-ze zhi ru*) related to iron. Hartwell (1963, pp. 178–9 fn. 6) argues that these figures refer to the period 1064–7.

Quantities of iron are given in *jin* 斤, ca. 0.6 kg.

|   | Circuit          | Approximate location of circuit | Place in circuit | A. Iron quota, 1078 SHY:SH 33.12b–14a |           |              |                             | B. Mountain and marsh receipts, 1064–7: Iron, SHY:SH 33: 27b |          |
|---|------------------|---------------------------------|------------------|---------------------------------------|-----------|--------------|-----------------------------|--|----------|
|   |                  |                                 |                  | Page & line no.                       | A1. Quota | A2. Receipts | A3. Total of A2 for circuit | Page & line no.  | Receipts |
| 1 | Chengdu fu lu    | W Si-chuan                      |                  |                                       |           |              | —                           | 27b.11   | 76,611   |
| 2 |                  |                                 | Yazhou           | 13b.6                                 | —         | —            |                             |  |          |
| 3 | Fujian lu        | Fujian                          |                  |                                       |           |              | 32,652                      | 27b.10   | 69,224   |
| 4 |                  |                                 | Jianzhou         | 13b.9                                 | 500       | 3,400        |                             |  |          |
| 5 |                  |                                 | Nanjianzhou      | 13b.10                                | 15,179    | 13,350       |                             |  |          |
| 6 |                  |                                 | Quanzhou         | 14a.1                                 | —         | —            |                             |  |          |
| 7 |                  |                                 | Shaowu jun       | 14a.2                                 | 6,902     | 6,902        |                             |  |          |
| 8 |                  |                                 | Tingzhou         | 13b.11                                | 9,000     | 9,000        |                             |  |          |
| 9 | Guangnan Dong lu | Guangdong                       |                  |                                       |           |              | 52,831                      | 27b.11   | 31,344   |

|    |                     |                             |                 |        |           |           |           |       |           |
|----|---------------------|-----------------------------|-----------------|--------|-----------|-----------|-----------|-------|-----------|
| 10 |                     |                             | Duanzhou        | 14a.1  | 1,404     | 1,410     |           |       |           |
| 11 |                     |                             | Guangzhou       | 14a.3  | —         | —         |           |       |           |
| 12 |                     |                             | Huizhou         | 14a.4  | 6,128     | 6,128     |           |       |           |
| 13 |                     |                             | Nan'enzhou      | 14a.7  | —         | —         |           |       |           |
| 14 |                     |                             | Shaozhou        | 14a.4  | 1,500     | 1,800     |           |       |           |
| 15 |                     |                             | Yingzhou        | 14a.6  | 43,493    | 43,493    |           |       |           |
| 16 | Guangnan<br>Xi lu   | Guangxi +<br>Hainan         |                 |        |           |           | 860       |       |           |
| 17 |                     |                             | Rongzhou        | 14a.8  | 500       | 860       |           |       |           |
| 18 | Hebei Xi<br>lu      | SW Hebei                    |                 |        |           |           | 4,144,202 | 27b.8 | 1,067,232 |
| 19 |                     |                             | Cizhou          | 13a.1  | 1,814,261 | 1,971,001 |           |       |           |
| 20 |                     |                             | Xiangzhou       | 12b.11 | —         | —         |           |       |           |
| 21 |                     |                             | Xingzhou        | 13a.3  | 1,716,413 | 2,173,201 |           |       |           |
| 22 | Hedong lu           | S Shanxi                    |                 |        |           |           | 258,384   | 27b.8 | 64,786    |
| 23 |                     |                             | Jinzhou         | 13a.9  | 569,776   | 30,098    |           |       |           |
| 24 |                     |                             | Weisheng<br>jun | 13a.11 | 158,506   | 228,286   |           |       |           |
| 25 | Jiangnan<br>Dong lu | SE Anhui<br>+ NE<br>Jiangxi |                 |        |           |           | 3,133     | 27b.9 | 21,769    |
| 26 |                     |                             | Xinzhou         | 13b.1  | 3,133     | 3,133     |           |       |           |
| 27 | Jiangnan<br>Xi lu   | Jiangxi                     |                 |        |           |           | 100,808   | 27b.9 | 1,741,809 |
| 28 |                     |                             | Qianzhou        | 13b.1  | —         | —         |           |       |           |
| 29 |                     |                             | Xingguo<br>jun  | 13b.3  | 88,888    | 59,215    |           |       |           |
| 30 |                     |                             | Yuanzhou        | 13b.2  | 41,593    | 41,593    |           |       |           |
| 31 | Jingdong<br>Dong lu | E Shan-<br>dong             |                 |        |           |           | 8,065     | 27b.6 | 472,999   |



|    |                               |                        |                      |        |         |         |         |        |           |
|----|-------------------------------|------------------------|----------------------|--------|---------|---------|---------|--------|-----------|
| 32 |                               |                        | Dengzhou             | 12b.6  | 2,655   | 3,775   |         |        |           |
| 33 |                               |                        | Laizhou              | 12b.7  | 4,800   | 4,290   |         |        |           |
| 34 |                               |                        | Yanzhou              | 12b.9  | 396,000 | 242,000 |         |        |           |
| 35 | Jingdong<br>Xi lu             | W Shan-<br>dong        |                      |        |         |         | 308,000 | 27b.6  | 197,400   |
| 36 |                               |                        | Xuzhou<br>Liguo jian | 12b.8  | 300,000 | 308,000 |         |        |           |
| 37 | Jinghu<br>Nan lu              | S Hunan                |                      |        |         |         | 504     | 27b.10 | 312,724   |
| 38 |                               |                        | Daozhou              | 13b.5  | 504     | 504     |         |        |           |
| 39 | Jingxi<br>Nan lu              | N Hubei +<br>S Shaanxi |                      |        |         |         | 84,410  |        | —         |
| 40 |                               |                        | Dengzhou             | 12b.10 | 69,360  | 84,410  |         |        |           |
| 41 | Lizhou lu                     | NE<br>Sichuan          |                      |        |         |         | —       | 27b.12 | 203,965   |
| 42 |                               |                        | Xingzhou             | 13b.9  | —       | —       |         |        |           |
| 43 | Qinfeng lu                    | E Gansu                |                      |        |         |         | 85,068  | 27b.7  | 137,557   |
| 44 |                               |                        | Fengxiang<br>fu      | 13a.7  | 40,560  | 48,248  |         |        |           |
| 45 |                               |                        | Fengzhou             | 13a.8  | 36,820  | 36,820  |         |        |           |
| 46 | Shaanxi<br>Yongxing<br>jun lu | S Shaanxi              |                      |        |         |         | 168,850 | 27b.6  | 1,256,663 |
| 47 |                               |                        | Guozhou              | 13a.5  | 139,050 | 155,850 |         |        |           |
| 48 |                               |                        | Shanzhou             | 13a.6  | 13,000  | 13,000  |         |        |           |
| 49 | Zizhou lu<br>梓州<br>路          | C Sichuan              |                      |        |         |         | 7,549   | 27b.12 | 5,771     |
| 50 |                               |                        | Rongzhou             | 13b.7  | 300     | 295     |         |        |           |
| 51 |                               |                        | Zizhou<br>梓州         | 13b.6  | —       | —       |         |        |           |
| 52 |                               |                        | Zizhou<br>資州         | 13b.8  | 6,706   | 7,254   |         |        |           |

|    |                           |  |  |       |           |           |  |       |           |
|----|---------------------------|--|--|-------|-----------|-----------|--|-------|-----------|
| 53 | Total according to source |  |  | 14a.9 | 5,482,770 | 5,501,097 |  | 27b.5 | 5,659,646 |
| 54 | Actual sum                |  |  |       | 5,489,835 | 5,500,526 |  |       | 5,659,854 |
| 55 | Equivalent in tonnes      |  |  |       | 3,293     | 3,300     |  |       | 3,396     |