Study on the Period of the Use of *Datong-li* in Korea

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Abstract

It has been generally known that *Datong-li* (a Chinese calendar in the Ming dynasty) was first introduced into Korea in the nineteenth reign of King *Gongmin* (1370) of the Goryeo dynasty and lasted to the third reign of King *Hyejong* (1652) of the Joseon dynasty. This understanding is based on the records of *Goryeo-sa* (History of the Goryeo dynasty) and of *Seoungwan-ji* (Official book of *Seoungwan*)/ *Jeungbo-munheon-bigo* (Explanatory Notes of Library Document). To verify the period of the use of *Datong-li* in Korea, we develop a Fortran code to calculate the calendar day by *Datong-li* and also investigate historical literatures and extant almanacs. As a result, we find the possibility that *Datong-li* had been in use since 1389 at least. However, we cannot confirm whether *Datong-li* was first enforced in 1370 or not. On the other hand, we confirm that *Datong-li* was used until 1653 and reintroduced during the period from 1667 to 1669. Also, we find that previous studies had some errors in the sexagenary cycle of the real first day of a month. We think that this study will contribute to understanding the calendrical history of the Joseon dynasty.

Keywords: calendrical methods (*Datong-li*, *Shoushi-li*, *Shixian-li*), astronomical almanac, period (Goryeo dynasty, Joseon dynasty)

1. Introduction

Datong-li is a calendrical method of the Ming dynasty in China (1368 ~ 1644) and there are two versions of ‘*Musin Datong-li*’ made by *Liu, Ji* on *Eulmi Dongji* in 1368¹⁾ and ‘*Datong-lifa-tonggui*’ made by *Yuan, Tong* in 1384 (Zhang 1971). Although there are slight differences between two calendars such as the fact that the epoch of the former is 1281 (*Sinsa* year) while that of the latter is 1384 (*Gapja* year), both are fundamentally the same calendrical methods based on *Shoushi-li* (Lee 1996). It is known that *Datong-li* began to be used in 1370, the 19th year of the reign of King *Gongmin* of the Goryeo dynasty (Jeon 1974, 1998, Lee 1996, Lee 1997b), based on the records of *Goryeo-sa* etc. On the contrary, Yu (1982) and Lee (1988) infer that *Datong-li* could not be adopted because the Goryeo dynasty was declining at that time.

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¹⁾According to our calendrical calculation by *Datong-li*, the sexagenary circle of the winter solstice of 1367 (23 November) not 1368, is *Eulmi*

According to *Sangwi-go* (Volume) of *Jeungbo-munheon-bigo* (Explanatory Notes of Literary Document) (King Sejong The Great Memorial Society 1978), the Joseon dynasty used *Datong-li* from the beginning of the dynasty. However, the calculation methods such as solar/lunar eclipses and five planets were not known. Hence, King Sejong ordered *In-Ji Jeong*, *Cho Jeong*, and *Heum-Ji Jeong* to study the methods, correct *Taiyang-tonggui*, *Taiyin-tonggui* and so forth, and compiled *Chiljeongsan-naepyeon* (Yu et al. 1973; hereafter Naepyeon). Currently, the oldest available edition of Naepyeon is the one compiled by *Sun-Ji Yi* and *Dam Kim* in 1444 (Lee & Kim 1444). The series of *tonggui* books such as *Datong-liri-tonggui*, *Taiyang-tonggui* and *Taiyin-tonggui* etc compiled by the same authors were also preserved in the *Gyujeonggak* library. According to the work of Lee (1988), these *tonggui* series became the basis of the compilation of Naepyeon. Naepyeon is basically the same line of calendrical method as *Datong-li* (therefore, *Shoushi-li*). Moreover, the titles of currently available astronomical almanacs at that time are written as *Datong-li* (see Kim 2002, Jeong 2008).

Shixian-li made by Adam Schall et al. became to be enforced in the *Ching* dynasty of China from 1645 (Lee 1985). In Joseon, the calendar became effective from the 4th year of the reign of King *Hyojong* (1653) after over ten years efforts of *Yuk Kim*, the head of the Bureau of Royal Astronomy and *Sang-Beom Kim*, a staff of the Bureau (King Sejong The Great Memorial Society 1978). Therefore, it is known that *Datong-li* was used until 1652, the 3rd year of the reign of King *Hyojong* (Lee 1997a, Yu 1999, Lee 2008). In recent, Jeon (2002, 2004) pointed out that *Shixian-li* was introduced in 1654, i.e., *Datong-li* was used until 1653, based on the records of *Joseon-Wangjo-Sillok* (Annals of Joseon dynasty; hereafter *Sillok*) (also see, Ahn et al. 2000).

As such, the introduction year or the period of the use of *Datong-li* completely depended on literary records without any verification through astronomical almanac or calendrical calculation. In this paper, we develop a computer program to calculate calendar days by *Datong-li* and investigate the period of use of *Datong-li* in Korea by the analysis of astronomical almanacs and records of old literatures. In section 2, the calculation of calendrical days by *Datong-li* was briefly explained and compared it with extant *Datong-li* almanacs. We discuss the introduction year and the period of the use of *Datong-li* in sections 3 and 4, respectively. The literary records related to *Datong-li* were verified in section 5. Finally, we summarize in section 6.

2. Calendrical day calculation by *Datong-li*

As mentioned earlier, *Shoushi-li*, *Datong-li* and Naepyeon are basically the same calendrical methods and differences between them are as shown in Table 1 (refer to Lee 1988). As shown in the table, Naepyeon is the same as *Datong-liri-tonggui* and *Musin Datong-li* except for *Xiaochang-fa*. We, therefore, refer to Naepyeon translated into Korean by Yu et al. (1973) in order to calculate calendrical days by *Datong-li*. There are two editions in Naepyeon: one is appended to the volume of *Sejong* in *Sillok* (hereafter *Sillok* edition) (King Sejong The Great Memorial Society 1990) and the other is compiled by Lee and Kim in 1444, printed with *Gabin* fonts and preserved in *Gyujeonggak* library (hereafter *Gyujeonggak* edition) nowadays. *Datong-ilri-tonggui* compiled by the same authors (hereinafter *tonggui* edition) are also preserved in *Gyujeonggak*. The former, *Sillok* edition, was translated into Korean by Yu et al. (1973). In the course of calculating calendrical days, we checked constant values presented in these three editions and found *Gyujeonggak* edition, in general, had relatively more errors than *Sillok* edition.

Because the translated book by Yu et al. (1973) also contains calculation examples referring to the books of *Jeongmyoyeon-gyeosik-garyung* (examples for the calculation of solar and lunar eclipses occurred in 1447) and *Gyeosik-chubobeob* (calculation method for the solar and lunar eclipses), we will not describe detailed processes of calendrical day calculation in this paper. In-

Table 1. Comparison between *Shoushi-li*, *Datong-li* and Naepyeon.

	<i>Shoushi-li</i>	<i>Datong-li</i>			Naepyeon
		<i>Musin</i> <i>Datong-li</i>	<i>Datong-lifa</i> <i>-tonggui</i>	<i>Datong-liri</i> <i>-tonggui</i>	
Epoch (year)	1281	1281	1384	1281	1281
<i>Xiaochang-fa</i> ^a	Adopted	Adopted (?)	Not adopted	Not adopted	Adopted
<i>Runying</i> ^b	201,850 min	202,050 min	182,070 min 18 s	202,050 min	202,050 min
<i>Qiyi</i> ^c	550,600 min	550,600 min	550,375 min	550,600 min	550,600 min
<i>Zhuanying</i> ^d	131,904 min	130,205 min	209,690 min	130,205 min	130,205 min
<i>Jiaoying</i> ^e	260,187 min 86 s	260,388 min	115,105 min 8s	260,388 min	260,388 min

^amethod adopting the variation of the length of tropical year

^blength from the winter solstice of the epoch year to the immediately previous new moon

^clength from the winter solstice of the epoch year to the midnight of the immediately previous *Gabja* day

^dlength from the winter solstice of the epoch year to the perigee of immediately previous month

^elength from the winter solstice of the epoch year to the immediately previous node.

stead, we will briefly mention on a few issues. First, the translated book is explaining that ‘according to *Gyeosik-chubobeob*, the difference between the lunar and solar movements (in unit of degree) should be divided in the process of obtaining the real first day from the mean first day of a month and this method is the same in *Datong-li*’. However, we found that when only the lunar movement was divided, the results were consistent with extant almanacs. Second, the method, adopting nowadays (refer to Korea Astronomy and Space Science Institute 2008) and mentioned in Naepyeon, was used in inserting a leap month. That is, we apply the intercalation method itself in the calculations of calendrical days differently with previous studies which were obtained the leap month information from historical documents. As a result, we find that all leap months were perfectly consistent with previously known leap months. Finally, when *Xiaochang-fa* was applied to calculate calendrical days, there were some disagreement on leap months. Thus, we do not use *Xiaochang-fa* in this study.

Table 2 is a list of *Datong-li* almanacs of the Joseon dynasty period used in this study. In the table, 1, 2 and 3 columns are year, content of the almanacs and reference, respectively. At present, the oldest almanac is *Gyeongjin* year (1580) which was designated as treasure no. 1319 and is currently stored in the National Folk Museum of Korea (Kim 2002). *Datong-li* almanacs are generally composed of a table of 24 seasonal subdivisions, a map showing the directions of evil spirits (hereafter, *Yeonshinbangwi-do*), the calendrical day data of each month covering two pages (one for the 1st day ~ 13th day and the other for the 14th day ~ 29th/30th day), and the producers. From the almanac after 1604, the tables of 24 seasonal subdivisions and of *Yeonshinbangwi-do* are also recorded covering two pages. In Table 2, the signs of *a* and *b* represent the former and the latter part between two pages, respectively (in this study, we will not consider *Yeonshinbangwi-do* and *Giyeon* [yearly] table). In the course of reviewing *Datong-li* almanacs, we found some parts of the almanac of 1601 in the almanac of 1604 compiled by Korea Mental Culture Research Institute (1994) (refer to Table 2). We also found some single pages of calendrical day from the archive of *Jangseogak* library: January *a* of 1595, yearly table of 1615, July *a*/August *a*/October *a* of 1618 and February *a* of 1621.

To verify calendrical calculations, we first compared our results with extant almanacs for the items of the dates and times of 24 seasonal subdivisions, sunrise and sunset times, the lengths of day and night times, the dates of the real first/last-quarter and so forth. All the data showed perfect

Table 2. A list of *Datong-li* almanacs of the Joseon dynasty period used in this study.

Year	Content	Reference
1580 ¹	table of 24 seasonal subdivisions, calendrical day data from Jan. to Dec., the producer	Kim (2002)
1594	table of 24 seasonal subdivisions, calendrical day data from Jan. to Apr. and from Jul. to Sep.	Korea Mental Culture Research Institute (1994)
1596	calendrical day data from Jan. to Aug. ² and from Sep. to Dec., the producer	
1597	table of 24 seasonal subdivisions, calendrical day data from Jan. to May, June <i>b</i> ³ and July	
1598	table of 24 seasonal subdivisions, calendrical day data from Jan. to Dec.	
1601	calendrical day data of Jan. <i>a</i> and Feb.	National Institute of Korean History ⁴
1604	table of 24 seasonal subdivisions, calendrical day data from Jan. <i>b</i> to Mar., May and Jun, the producer	
1605	table of 24 seasonal subdivisions <i>b</i> ³ , calendrical day data from Jan. <i>b</i> to Dec.	
1606	table of 24 seasonal subdivisions <i>b</i> , calendrical day data from Jan. to July, the producer	
1607	table of 24 seasonal subdivisions, the producer	Jeong (2008)
1607	table of 24 seasonal subdivisions, calendrical day data from Jan. to Dec., the producer	
1611	calendrical day data from Jan. to Dec., the producer	
1615	table of 24 seasonal subdivisions, calendrical day data from Jan. to Nov.	
1629	calendrical day data from Jan. to Dec., the producer	Lim & Kang (2005)
1602	calendrical day data from a leap Feb. to Mar.	
1637	table of 24 seasonal subdivisions	
1651	calendrical day data from Jan. to Dec., the producer	
1652	table of the 24 seasonal subdivisions, calendrical day data from Jan. to Dec., the producer	

¹The oldest extant almanac which is designated as treasure no. 1319.

²There was a leap August in this year, but this part is missing in the almanac.

³*a, b* refers to the former part and the latter part, respectively, in the tables consisted of two pages.

⁴<http://www.history.go.kr>

consistency except for the sunrise time on August 28, 1607: *Myojeong* 1 and 2 *Ke* according to almanac and our calculation, respectively. This difference seems a typo in the almanac of 1607. Next, we compared our results with previous studies (Han 1987, 2001, Ahn, et al. 2009a) for day names as the sexagenary cycle (hereafter *Iljin*) of the real first day in each month and found generally matched well. However, there were differences in several days as shown in Table 3. In particular, *Iljin* of the real first day of February 1530 is *Sinyu* and *Imsul* according to *Sillok* and our calculation, respectively. In the case of the real first day of September 1597, *Iljin* is *Muja* in the volume of King *Seonjo* while it is *Gichuk* according to our calculation, the revised volume of King *Seonjo*, almanac of the year and *Baekjungryeok*²⁾. In addition, *Iljin* of the real first day of September 1602 is *Gyeongsin* in the volume of King *Seonjo*, while it is *Gimi* according to our calculation and *Baekjungryeok*. Lastly *Iljin* of the real first days of September and October of 1652 are *Gisa* and *Gihae*, respectively, according to our calculation and the almanac of the year. While Ahn et al. (2009a) identified the

²⁾An almanac contains brief calendrical data for long periods. This book is preserved in *Gyujanggak* (no. 7275) and the names of the producer and the year of production are unknown.

Table 3. Comparison of our calculations by *Datong-li* with a previous study for Iljin of the first day in each month.

Year	Month	Iljin of the first day in each month		
		Ahn et al. (2009a)	this study	Remark
1397	March	<i>Gabin</i>	<i>Gyechuk</i>	
1399	May	<i>Gyeongoh</i>	<i>Sinmi</i>	
1430	April	<i>Gyeongoh</i>	<i>Sinmi</i>	
1440	December	<i>Gyeongoh</i>	<i>Gisa</i>	
1444	December	<i>Byeongoh</i>	<i>Eulsa</i>	
1530	February	<i>Sinyu</i>	<i>Imsul</i>	Sillok: <i>Sinyu</i>
1597	September	<i>Muja</i>	<i>Gichuk</i>	Sillok (volume of King <i>Seonjo</i>): <i>Muja</i> Sillok (revised volume of King <i>Seonjo</i>), <i>Baekjungryeok</i> ¹ , almanac: <i>Gichuk</i>
1602	September	<i>Gyeongsin</i>	<i>Gimi</i>	Sillok: <i>Gyeongsin</i> <i>Baekjungryeok</i> ¹ : <i>Gimi</i>
1652	September	<i>Gyeongoh</i>	<i>Gisa</i>	almanac: <i>Gisa</i> :
1652	October	<i>Gyeongja</i>	<i>Gihae</i>	almanac: <i>Gihae</i>

¹no. 7275 in *Gyuganggak* catalog.

days as *Gyeongoh* and *Gyeongja*. For your information, Han (1997) pointed out that Iljin of the real first days of December 1437, December 1499, February 1548 and September 1592 in Sillok are obvious errors and thus attention should be paid when quoting Iljin from Sillok's records.

3. Introduction year of *Datong-li*

The argument that *Datong-li* was introduced in the 19th year of the reign of King *Gongmin* (1370) is based on the records of *Goryeo-sa* and *Jeungbo-munheon-bigo*. The records of *Goryeo-sa* on the 19th year of the reign of King *Gongmin* are as follows.

- On *Gabin* day, the emperor of *Ming* sent an envoy to deliver his letter relating to an investiture King went out to the outside of the castle to meet the envoy on arrival accompanying with officials. The letter read, “*Jeon Wang*, the king of *Goryeo*, has been Now, I am sending an envoy with a seal to install you as the king of the *Goryeo* dynasty I am also sending a *Datong-li* almanac and 10 rolls of embroidered silk carpet, you take them!”
- *Jun-Deuk Seong* came back from the *Ming* country. The emperor sent an autograph letter stamped with the imperial seal and the letter read, Now, I am sending a king's official uniform, musical instruments, your retainers' uniforms and the *Datong-li* almanac of the 3rd year of *Hongwu* [author's note: 1370], you take them!”.

According to *Sangwi-go* of *Jeungbo-munheon-bigo* (King *Sejong* The Great Memorial Society 1978),

- When *Jun-Deuk Seong*, an envoy of our country, was coming back from *Ming* in the 19th year of the reign on King *Gongmin*, the emperor of *Ming* granted a *Datong-li* almanac. [*Gyobing-go* read, “The emperor sent an envoy to deliver a royal order and then granted a *Datong-li* almanac.”]
- In the 19th year of the reign of King *Gongmin*, the emperor granted a *Datong-li* almanac and *Jun-Deuk* brought it

- In the 19th year of the reign of King *Gongmin*, the emperor of *Ming* sent an envoy and allowed to follow the traditional manners and customs. Then the emperor granted a *Datong-li* almanac and embroidered silk carpets

However, it will be correct to interpret the above records as indicating that just the *Datong-li* almanac of 1370 was received from the *Ming* dynasty rather than indicating that *Datong-li* was used from the 19th year of the reign of King *Gongmin*. The grounds of this interpretation include, first, the fact that *Datong-li* began to be enforced since 1368 in the *Ming* dynasty (Lee 1985). Thus it is too early, two years later, for the Goryeo dynasty to use the calendrical method even if the method is similar to *Shoushi-li*. Second, *Shoushi-li* began to be used in the Goryeo dynasty since the reign of King *Chungseon* (1308-1313), about 20 years later, from the record that a newly made *Shoushi-li* almanac was received from the *Yuan* dynasty in the 7th year of the reign of King *Chungryeol* (1281). Finally, Iljin of the real first day of August 1378 is *Gyeongja* in the calculation by *Datong-li*, but, it is *Sinchuk* in the calculation by *Shoushi-li*. According to previous studies (e.g. Yang et al. 1999, Ahn et al. 2001, 2009b), Iljin of the day is *Sinchuk* in Korea, China and Japan. We, therefore, think that it is difficult to conclude that *Datong-li* was used from the 19th year of the reign of King *Gongmin*, solely based on the record that a *Datong-li* almanac was ‘granted/taken’. Instead, we think that it is more reasonable to consider that a *Datong-li* almanac was received in 1370 like the case of receiving a *Shoushi-li* almanac in 1281. Probably, those records might have been specially made because a new calendar, *Shoushi-li*, was made in 1281 and *Datong-minli* by *Musin Datong-li*, the almanac of the 3rd year of *Hongwu* (1370), was published in China.

To verify the introduction time of *Datong-li* in the Goryeo dynasty, we first examined the records of the dates of 24 seasonal subdivisions presented in *Goryeo-sa*. After the reign of King *Chungseon*, there were only two records: one is that the *Gihae* day of November 1345 was *Daehan* (Sever Cold) and another is that the *Gyeongin* day of November 1389 was *Dongji* (Winter Solstice). First, *Daehan* is a seasonal subdivision belonging to December and there was no *Gihae* day in December 1345. Sillok also has the record that prisoners with minor crime were released because it was *Daehan* (a record on December 4 of the 29th year of the reign of King *Sukjong*). This day was January 10, 1704 (in Gregorian calendar) and was not *Daehan*. Therefore, all of these records about *Daehan* should be translated as ‘severe cold’ not as a seasonal subdivision. In the case of 1389, *Dongji* was the *Gyeongin* day of November according to our calculation by *Datong-li*. This result, of course, is the same in the calculation by *Shoushi-li*. In conclusion, we think that it is difficult to conclude that *Datong-li* was used from the 19th year of the reign of King *Gongmin*. If *Datong-li* was really accepted in the Goryeo dynasty, on the other hand, it might have begun to be used since 1389 at least.

4. Period of the use of *Datong-li*

4.1 Verification using Iljin of 24 seasonal subdivisions recorded in Sillok/Ilgi

To verify until when the Joseon court used *Datong-li*, we, first, examined the records regarding seasonal subdivisions from Sillok as did from *Goryeo-sa*. Except for records with obscurity in interpreting, a total of 160 Iljin of seasonal subdivisions ranging from 1392 to 1654 are recorded in Sillok³⁾ and *Seungjeongwon-ilgi* (Diary of the Royal Secretariat; hereafter Ilgi⁴⁾). There was one record of each *Ipchun*, *Cheoseo*, *Ipdong* and *Soseol*, two records of *Daeseol* and 153 records of

³⁾<http://silok.history.go.kr>

⁴⁾<http://sjw.history.go.kr>

Table 4. Comparison of our calculations by *Datong-li* with the records of Sillok/Iljin for 24 seasonal subdivisions.

Year	Seasonal subdivision	Month	Date and Iljin			
			record from Sillok/Iljin		our calculation	
1445	<i>Dongji</i>	November	13th	<i>Gabsin</i>	15th	<i>Gabsin</i>
1447	<i>Dongji</i>	November	5th	<i>Gaboh</i>	6th	<i>Gaboh</i>
1468	<i>Dongji</i>	November	29th	<i>Eulyu</i>	28th	<i>Gabsin</i>
1479	<i>Daeseol</i>	November	28th	<i>Giyu</i>	15th	<i>Jeongmyo</i>
1621	<i>Dongji</i>	November	11th	<i>Musin</i>	9th	<i>Byeongoh</i>
1654	<i>Dongji</i>	November	>13th	-	13th	<i>Gihae</i>

Figure 1. The first pages of the almanacs of *Imjin* year (1652), *Gyesa* year (1653) and *Gaboh* year (1654).

Dongji, the largest in numbers. Of the records of *Dongji*, the records performed the ritual at *Dongji* were the most frequent. We compared the 160 Iljin with our calculations by *Datong-li* and found a good agreement in general including *Dongji* Iljin of 1653. However, we found six records showing disagreement and listed in Table 4. First, the records of 1445 and 1447 are the cases which Iljin are same but dates are different because of incorrect estimate of the dates of the real first day in the website of Sillok. While, the record of November 30, 1479 is translated as, “The 28th of this month is *Daeseol*, thus” and the record of November 11, 1621 as, “This day was *Dongji* and an earthquake occurred, and thus” in Sillok. However, these should be translated as “A heavy snow came on the 28th of this month, and thus” and “An earthquake continued for a long time

on this day, and” respectively. The record of November 29, 1468 reads, “Since it was *Dongji*, *Euijeong-bu* (State Council) and six departments dedicated inner and outer materials of clothes, and”. Considering this record, we cannot explain the cause for the inconsistency at this moment. Finally, from the record of November 13, 1654 (*Gihae* day) reading “Since *Dongji* already came close”, we can infer that *Dongji* was later than the 13th. According to the almanac of 1654, however, *Dongji* of this year was November 13.

4.2. Verification by the comparison with extant almanacs

A direct way to investigate the period of the use of *Datong-li* in the Joseon dynasty is to check the almanacs used at that time. To this end, we obtained *Datong-li* almanacs of the 1650s among Yoon, Jeung’s Family collection from a private owner and examined them. Figure 1 shows the first pages of the almanacs of 1652, 1653 and 1654. As can be seen in the figure, however, the first page showing the name of the calendrical method and 24 seasonal subdivisions was tore off in most almanacs. In the case of the almanac of 1652, the part relating to the reign name of the *Ching* dynasty was erased. According to the work of Jeon (2002), the Family of Yoon-Seok Hwang (a linguist in the middle of the Joseon dynasty) also had been used almanacs after cutting out the first page until in the later of 1760s. Therefore, the date, Iljin and time of 12 seasons⁵⁾ were compared with the results of calendrical calculations.

Table 5 shows the results of comparison between the calendrical calculation and the almanacs of 1653 and 1654. As shown in the table, whereas the almanac of 1653 shows exact agreement with the calculations for the date, Iljin and time in all 12 seasons, that of 1654 does for date and Iljin in several seasons. Meanwhile, the almanac shows completely difference in the time of 12 seasons. From this fact, we can know that *Datong-li* was used until the 4th year of the reign of King Hyojong (i.e. 1653) in the Joseon dynasty.

5. Verification of records related to *Datong-li*

5.1 Records regarding the reintroduction of *Datong-li*

In Sillok, a discussion and order of a king about the reuse of *Datong-li* are recorded on a leap July 13, 1661 (the 2nd year of the reign of King Hyeonjong) and on December 11, 1666 (5 years later), respectively. Also, the record of August 8, 1671 (the 12th year of the reign of King Hyeonjong) reads,

The birthday of the prince is August 15 of *Sinchuk* year (1661). However, the calendar system was changed into *Datong-li* in *Jeongmi* year (1667) so the leap month of *Sinchuk* year is not July but October⁶⁾. Given this fact, August should become September and thus the birthday of the prince was determined to be September through discussion with ministers. However, since *Shixian-li* began to be used again in *Gyeongsul* year (1670), the birthday of the prince should be changed back to August

From above record, we can infer that *Datong-li* was used from 1667 (*Jeongmi* year) to 1669 and *Shixian-li* began to be used again from 1670 (*Gyeongsul* year). To verify this record, the date, Iljin

⁵⁾In the almanacs of the Joseon dynasty, the date, Iljin and time of 12 seasons (not 12 subdivisions) corresponding to the relevant month are recorded in the beginning part of each month except for a leap month (refer to Lee 2005).

⁶⁾*Shixian-li* was used in 1661 and the leap month was July. However, according to calendrical calculations by *Datong-li*, the year of 1661 becomes to have a leap month in October.

Table 5. Comparison of our calculations by *Datong-li* with the almanacs for date, Iljin and time of 12 seasons.

Year	Season	Month	Almanac			Calendrical calculation by <i>Datong-li</i>		
			Day	Iljin	Time	Day	Iljin	Time
1653	<i>Ipchun</i>	Jan.	7	<i>Gihae</i>	<i>Haejeong 0 Ke</i>	7	<i>Gihae</i>	<i>Haejeong 0 Ke</i>
	<i>Wusu</i>	Jan.	23	<i>Gyeongin</i>		23	<i>Gyeongin</i>	<i>Incho 1 Ke</i>
	<i>Gyeongchip</i>	Feb.	8	<i>Eulsa</i>	<i>Jinjeong 2 Ke</i>	8	<i>Eulsa</i>	<i>Jinjeong 2 Ke</i>
	<i>Chunbun</i>	Feb.	23	<i>Gyeongsin</i>		23	<i>Gyeongsin</i>	<i>Micho 3 Ke</i>
	<i>Cheongmyeong</i>	Mar.	9	<i>Eulhae</i>	<i>Sulcho 0 Ke</i>	9	<i>Eulhae</i>	<i>Sulcho 0 Ke</i>
	<i>Gokwu</i>	Mar.	25	<i>Sinmyo</i>		25	<i>Sinmyo</i>	<i>Jajeong 1 Ke</i>
	<i>Ipha</i>	Apr.	11	<i>Byeongoh</i>	<i>Myocho 2 Ke</i>	11	<i>Byeongoh</i>	<i>Myocho 2 Ke</i>
	<i>Soman</i>	Apr.	26	<i>Sinyu</i>		26	<i>Sinyu</i>	<i>Sajeong 3 Ke</i>
	<i>Mangjong</i>	May	11	<i>Byeongja</i>	<i>Sinjeong 0 Ke</i>	11	<i>Byeongja</i>	<i>Sinjeong 0 Ke</i>
	<i>Haji</i>	May	26	<i>Sinmyo</i>		26	<i>Sinmyo</i>	<i>Haecho 1 Ke</i>
	<i>Soseo</i>	Jun	13	<i>Jeongmi</i>	<i>Chukjeong 2 Ke</i>	13	<i>Jeongmi</i>	<i>Chukjeong 2 Ke</i>
	<i>Daeseo</i>	Jun	28	<i>Imsul</i>		28	<i>Imsul</i>	<i>Jincho 3 Ke</i>
	<i>Ipchu</i>	Jul.	14	<i>Jeongchuk</i>	<i>Micho 0 Ke</i>	14	<i>Jeongchuk</i>	<i>Micho 0 Ke</i>
	<i>Cheoseo</i>	Jul.	29	<i>Imjin</i>		29	<i>Imjin</i>	<i>Yujeong 1 Ke</i>
	<i>Baekro</i>	Jul.*	14	<i>Jeongmi</i>	<i>Jacho 2 Ke</i>	14	<i>Jeongmi</i>	<i>Jacho 2 Ke</i>
	<i>Chubun</i>	Aug.	1	<i>Gyehae</i>		1	<i>Gyehae</i>	<i>Injeong 3 Ke</i>
	<i>Hanro</i>	Aug.	16	<i>Muin</i>	<i>Sajeong 0 Ke</i>	16	<i>Muin</i>	<i>Sajeong 0 Ke</i>
	<i>Sanggang</i>	Sep.	1	<i>Gyesa</i>		1	<i>Gyesa</i>	<i>Sincho 1 Ke</i>
	<i>Ipdong</i>	Sep.	16	<i>Musin</i>	<i>Suljeong 2 Ke</i>	16	<i>Musin</i>	<i>Suljeong 2 Ke</i>
	<i>Soseol</i>	Oct.	2	<i>Gabja</i>		2	<i>Gabja</i>	<i>Chukcho 3 Ke</i>
	<i>Daeseol</i>	Oct.	17	<i>Gimyo</i>	<i>Jincho 0 Ke</i>	17	<i>Gimyo</i>	<i>Jincho 0 Ke</i>
	<i>Dongji</i>	Nov.	2	<i>Gaboh</i>		2	<i>Gaboh</i>	<i>Ojeong 1 Ke</i>
	<i>Sohan</i>	Nov.	17	<i>Giyu</i>	<i>Yucho 2 Ke</i>	17	<i>Giyu</i>	<i>Yucho 2 Ke</i>
	<i>Daehan</i>	Dec.	2	<i>Gabja</i>		2	<i>Gabja</i>	<i>Haejeong 3 Ke</i>
	<i>Ipchun</i>	Dec.	18	<i>Gyeongjin</i>	<i>Injeong 0 Ke</i>	18	<i>Gyeongjin</i>	<i>Injeong 0 Ke</i>
1654	<i>Wusu</i>	Jan.	2	<i>Gyesa</i>		4	<i>Eulmi</i>	<i>Sacho 1 Ke</i>
	<i>Gyeongchip</i>	Jan.	17	<i>Musin</i>	<i>Micho 3 Ke</i>	19	<i>Gyeongsul</i>	<i>Mijeong 2 Ke</i>
	<i>Chunbun</i>	Feb.	2	<i>Gyehae</i>		4	<i>Eulchuk</i>	<i>Sulcho 3 Ke</i>
	<i>Cheongmyeong</i>	Feb.	17	<i>Muin</i>	<i>Haecho 1 Ke</i>	20	<i>Sinsa</i>	<i>Jajeong 4 Ke</i>
	<i>Gokwu</i>	Mar.	4	<i>Gaboh</i>		6	<i>Byeongsin</i>	<i>Myojeong 1 Ke</i>
	<i>Ipha</i>	Mar.	19	<i>Giyu</i>	<i>Yucho 3 Ke</i>	21	<i>Sinhae</i>	<i>Ocho 2 Ke</i>
	<i>Soman</i>	Apr.	6	<i>Eulchuk</i>		7	<i>Byeongin</i>	<i>Sinjeong 3 Ke</i>
	<i>Mangjong</i>	Apr.	22	<i>Sinsa</i>	<i>Chukcho 1 Ke</i>	22	<i>Sinsa</i>	<i>Haecho 4 Ke</i>
	<i>Haji</i>	May	7	<i>Byeongsin</i>		8	<i>Jeongyu</i>	<i>Incho 0 Ke</i>
	<i>Soseo</i>	May	23	<i>Imja</i>	<i>Micho 3 Ke</i>	23	<i>Imja</i>	<i>Jinjeong 1 Ke</i>
	<i>Daeseo</i>	Jun	10	<i>Mujin</i>		9	<i>Jeongmyo</i>	<i>Micho 2 Ke</i>
	<i>Ipchu</i>	Jun	26	<i>Gabsin</i>	<i>Jajeong 1 Ke</i>	24	<i>Imoh</i>	<i>Yujeong 3 Ke</i>
	<i>Cheoseo</i>	Jul.	12	<i>Gihae</i>		11	<i>Musul</i>	<i>Jajeong 0 Ke</i>
	<i>Baekro</i>	Jul.	28	<i>Eulmyo</i>	<i>Chukjeong 0 Ke</i>	26	<i>Gyechuk</i>	<i>Myocho 1 Ke</i>
	<i>Chubun</i>	Aug.	13	<i>Gyeongoh</i>		11	<i>Mujin</i>	<i>Sajeong 2 Ke</i>
	<i>Hanro</i>	Aug.	28	<i>Eulyu</i>	<i>Sincho 1 Ke</i>	26	<i>Gyemi</i>	<i>Sincho 3 Ke</i>
	<i>Sanggang</i>	Sep.	14	<i>Gyeongja</i>		12	<i>Musul</i>	<i>Haecho 0 Ke</i>
	<i>Ipdong</i>	Sep.	29	<i>Eulmyo</i>	<i>Sincho 0 Ke</i>	28	<i>Gabin</i>	<i>Chukjeong 1 Ke</i>
	<i>Soseol</i>	Oct.	14	<i>Gyeongoh</i>		13	<i>Gisa</i>	<i>Jincho 2 Ke</i>
	<i>Daeseol</i>	Oct.	29	<i>Eulyu</i>	<i>Injeong 3 Ke</i>	28	<i>Gabsin</i>	<i>Ojeong 3 Ke</i>
	<i>Dongji</i>	Nov.	13	<i>Gihae</i>		13	<i>Gihae</i>	<i>Yujeong 0 Ke</i>
	<i>Sohan</i>	Nov.	28	<i>Gabin</i>	<i>Micho 2 Ke</i>	28	<i>Gabin</i>	<i>Jacho 1 Ke</i>
	<i>Daehan</i>	Dec.	13	<i>Gisa</i>		14	<i>Gyeongoh</i>	<i>Injeong 2 Ke</i>
	<i>Ipchun</i>	Dec.	28	<i>Gabsin</i>	<i>Jajeong 2 Ke</i>	29	<i>Eulyu</i>	<i>Sacho 3 Ke</i>

* symbol means a leap month

大正四年歲次丁未曆											
正月大	二月小	三月大	四月大	閏四月小	五月大	六月小	七月大	八月小	九月大	十月小	十一月大
子丙	丑丁	寅戊	卯己	辰庚	巳辛	午壬	未癸	申甲	酉乙	戌丙	亥丁
初一日	初二日	初三日	初四日	初五日	初六日	初七日	初八日	初九日	初十日	初十一日	初十二日
刻立春正月節	刻驚蟄二月節	刻清明三月節	刻立夏四月節	刻芒種五月節	刻夏至五月中	刻大暑六月中	刻處暑七月中	刻立秋八月中	刻白露八月節	刻寒露九月節	刻立冬十月節
初一日	初二日	初三日	初四日	初五日	初六日	初七日	初八日	初九日	初十日	初十一日	初十二日
刻雨水正月節	刻春分二月節	刻穀雨三月節	刻小滿四月節	刻小暑六月節	刻立秋七月節	刻處暑七月中	刻白露八月節	刻寒露九月節	刻立冬十月節	刻大雪十月節	刻小寒十一月節
初一日	初二日	初三日	初四日	初五日	初六日	初七日	初八日	初九日	初十日	初十一日	初十二日
刻大寒十一月節	刻小寒十一月節	刻立春正月節	刻雨水正月節	刻春分二月節	刻穀雨三月節	刻小滿四月節	刻小暑六月節	刻立秋七月節	刻處暑七月中	刻白露八月節	刻寒露九月節
初一日	初二日	初三日	初四日	初五日	初六日	初七日	初八日	初九日	初十日	初十一日	初十二日
刻大寒十一月節	刻小寒十一月節	刻立春正月節	刻雨水正月節	刻春分二月節	刻穀雨三月節	刻小滿四月節	刻小暑六月節	刻立秋七月節	刻處暑七月中	刻白露八月節	刻寒露九月節
初一日	初二日	初三日	初四日	初五日	初六日	初七日	初八日	初九日	初十日	初十一日	初十二日

Figure 2. The almanac of 1667 where the dates and times of 24 seasonal subdivisions were corrected.

and time of 12 seasons in the almanac of the years of 1667, 1668 and 1669 were compared with the results of the calculations by *Datong-li* as the same manner mentioned in section 4.2. Whereas the almanacs of 1668 and 1669 were completely consistent with the calculations by *Datong-li*, that of 1667 showed differences.

This means that *Shixian-li* was used in 1667 and *Datong-li* did only in 1668 and 1669. In other word, our result suggests that *Datong-li* began to be used again in 1668 not 1667. However, we can clear the mystery from both the record of King Hyeonjong regarding the discussion about the reason why the almanac of 1667 brought from the *Ching* country was different from previous ones and the table of 24 seasonal subdivisions of the almanac of 1667. According to the record of December 10, 1666, the *Ching* court decided to abolish *Shixian-li* and use *Datong-li* again from 1667. In Joseon, however, the almanac by the old calendrical method (author's note: *Shixian-li*) had been already distributed in time so the government tried to urgently print the almanac by new calendrical method (author's note: *Datong-li*) and redistribute. But since the time was not enough, the king ordered to

Figure 3. Comparison between Iljin of the leap December 1669 and that of January 1670.

print and distribute a simple almanac. In the almanac of 1667, we found that the table of 24 seasonal subdivisions was corrected (see Figure 2) and confirmed that corrected dates and times were those by *Datong-li*. Therefore, it is inferred that the almanac we obtained is the one which was already distributed, that is, the almanac by *Shixian-li* and the dates and times of 24 seasonal subdivisions were corrected on the base of the simple almanac by *Datong-li*. Another interesting fact is that there is a leap December in the almanac of 1669 (the leap December also becomes to exist in our calculation of calendrical days by *Datong-li*). According to the study of Jeon (2002), the *Ching* court informed the Joseon court that there would be no leap month in December 1669 and instead, there would be a leap month in February next year due to the reuse of *Shixian-li* from 1671. The almanac of 1670 was also already distributed in Joseon. This time the government just announced that there would be no leap month (record of April 11 1680, the 10th year of the reign of King *Hyeongjong*). This fact is also can be verified from the fact that Iljin of January 1670 is the same as that of a leap December 1666 in almanacs of both years (refer to Figure 3).

5.2 Records regarding the use of sunrise and sunset time of the Joseon dynasty

When obtaining the days of real first/last-quarter or real full-moon, one day is to be set back in *Datong-li* or *Naepyeon* if the time is before the sunrise time of the day. Examples of this rule also appear in the record of *Sillok*. According to the record of April 18, 1457 (the 3rd year of the reign of King *Sejo*),

In discussing the differences between *Tang*'s and Joseon's almanacs with a vice director of *Seoun-gwan* The determination of a real full-moon day differs from place to place due to the different time of sunrise/sunset in each place. In determining a real full-moon day of August, *Tang*'s court set back one day because the real full-moon time is before the sunrise in *Tang*'s country, while our court did not set back

because its time is after sunrise in our country. As such, the ways to determine the real full-moon day are not the same. Please determine the real full-moon day as the 16th based on our almanac and announce it to the public. The king follows the vice director's request.

Based on the calculation by *Datong-li*, the summer solstice of 1457 is May 22 and the real full-moon time of August is 2,428.05 min on the 16th day. This day is 83 days after the summer solstice and the sunrise time is 2,412.09 min according to the sunrise/sunset time presented in Naepyeon (i.e. sunrise/sunset time in Joseon). That is, the real full-moon time at that time is 15.96 min (2.29 min in the modern time) later than the sunrise time. Hence, the real full-moon day is the 16th without setting back to one day. To check whether this rule was also applied to other years or not, we examined the cases when the time of a real first/last-quarter or full-moon was before the sunrise time in the year of 1580. Of 10 cases, we found that all dates were determined by setting back one day in the almanac of the year. We also examined *Datong-li* almanac of 1637 published in the *Ming* country but preserved in *Gyujanggak*⁷⁾. Based on the result, the dates, Iljin and times of 24 seasonal subdivisions showed perfect match with our calendrical calculation. However, the length of a day/night showed maximum 2 *Ke* differences. In particular, the first-quarter time of February is 2629.6425 min on the 8th (73 days after *Dongji* of 1636 [November 25]) and the sunrise time of the day is 2,631.86 min by Naepyeon, and thus the first-quarter day should become the 7th by setting back one day. But, the almanac of *Ming* is writing as the 8th day.

6. Summary

In this paper, the period of the use of *Datong-li* in Korea was studied. To this end, a program to calculate calendrical days by *Datong-li* was developed first and then compared our calculations with extant almanacs and previous studies to verify the program. As a result, we found that the dates, Iljin and times of 24 seasonal subdivisions, Iljin of real first days in months, the lengths of the months, leap months, and so forth show match well in general. On the other hand, in comparison of Iljin of a real first day in each month with previous studies, a total of 10 cases showed differences. Among them, three cases could be checked with extant almanac and all were consistent with the results of our calculation.

With regards to the introduction year of *Datong-li*, we analyzed the records relating to Iljin of 24 seasonal subdivisions from *Goryeo-sa* and compared them with our calendrical calculations. However, it was difficult to conclude whether *Datong-li* was actually used in Korea from the 19th year of the reign of King *Gongmin* or not. Nonetheless, we confirm that *Datong-li* might have been used from about 1389 at least if it was actually used. On the other hand, we verified that *Datong-li* was used until 1653 and again used for three years from 1667 to 1669 in Joseon. In addition, we found that there was a leap December in 1669, but it was not used because *Shixian-li* became to be used again from the next year. Finally, we also verified that the records of *Sillok* indicating that if the time of the first/last-quarter or the full moon is before sunrise time, the day is determined by setting one day back.

In conclusion, we think that this study will be very helpful to the studies on calendrical methods of the Joseon dynasty, particular studies on Iljin of real first days in months and the dates of 24 seasonal subdivisions during the period of the early Joseon dyansty.

⁷⁾<http://kyujanggak.snu.ac.kr>

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Appendix

Baekjungryeok 百中曆 *Baekro* 白露 *Byeongin* 丙寅 *Byeongja* 丙子 *Byeongoh* 丙午 *Byeongsin* 丙申

Cheongmyeong 清明 *Cheoseo* 處暑 *Chiljeongsan-naepyeon* 七政算內篇 *Ching* 清 [*Cho Jeong*] *Jeong, Cho* 鄭招 *Chubun* 秋分 *Chukcho* 丑初 *Chukjeong* 丑正 *Chunbun* 春分 *Chungryeol* 忠烈 *Chungseon* 忠宣

Daehan 大寒 *Daeseo* 大暑 *Daeseol* 大雪 [*Dam Kim*] *Kim, Dam* 金淡 *Datong-li* 大統曆 *Datong-lifa-tonggui* 大統曆法通軌 *Datong-liri-tonggui* 大統曆日通軌 *Datong-minli* 大統民曆 *Dongji* 冬至

Euijeong-bu 議政府 *Eulchuk* 乙丑 *Eulhae* 乙亥 *Eulmi* 乙未 *Eulmyo* 乙卯 *Eulsa* 乙巳 *Eulyu* 乙酉

Jacho 子初 *Jajeong* 子正 *Jangseogak* 藏書閣 [*Jeon Wang*] *Wang, Jeon* 王○ *Jeongchuk* 丁丑 *Jeongmi* 丁未 *Jeongmyo* 丁卯 *Jeongmyoyeon-gyosik-garyeong* 丁卯年交食假令 *Jeongyu* 丁酉 *Jeungbo-munheon-bigo* 增補文獻備考 *Jiaoying* 交應 *Jincho* 辰初 *Jinjeong* 辰正 *Joseon-Wangjo-Sillok* 朝鮮王朝實錄 *Jun-Deuk* 准得 [*Jun-Deuk Seong*] *Seong, Jun-Deuk* 成准得

Gabin 甲寅 *Gabja* 甲子 *Gaboh* 甲午 *Gabsin* 甲申 *Gichuk* 己丑 *Gihae* 己亥 *Gimi* 己未 *Gimyo* 己卯 *Gisa* 己巳 *Giyeon* 紀年 *Giyu* 己酉 *Gokwu* 穀雨 *Gongmin* 恭愍 *Goryeo-sa* 高麗史 *Gyechuk* 癸丑 *Gyehae* 癸亥 *Gyemi* 癸未 *Gyeongchip* 驚蟄 *Gyeongin* 庚寅 *Gyeongja* 庚子 *Gyeongjin* 庚辰 *Gyeongoh* 庚午 *Gyeongsin* 庚申 *Gyeongsul* 庚戌 *Gyesa* 癸巳 *Gyosik-chubobeob* 交食推步法 *Gyobing-go* 交聘考 *Gyujanggak* 奎章閣

Haecho 亥初 *Hajeong* 亥正 *Haji* 夏至 *Hanro* 寒露 [*Heum-Ji Jeong*] *Jeong, Heum-Ji* 鄭欽之 *Hongwu* 洪武 *Hyojong* 孝宗

Imja 壬子 *Imjin* 壬寅 *Imoh* 壬午 *Imsul* 壬戌 *Incho* 寅初 *Injeong* 寅正 [*In-Ji Jeong*] *Jeong, In-Ji* 鄭麟趾 *Ipchu* 立秋 *Ipchun* 立春 *Ipdong* 立冬 *Ipha* 立夏

Ke 刻 *Liu, Ji* 劉基

Mangjong 芒種 *Micho* 未初 *Mijeong* 未正 *Ming* 明 *Muin* 戊寅 *Musin* 戊申 *Musin Datong-li* 戊申 大統曆 *Muja* 戊子 *Mujin* 戊辰 *Musul* 戊戌 *Myocho* 卯初 *Myojeong* 卯正

Ocho 午初 *Ojeong* 午正 *Qiyong* 氣應 *Runying* 閏應

Sacho 巳初 *Sang-Beom Kim* 金尚范 *Sangwi-go* 象緯考 *Sajeong* 巳正 *Sanggang* 霜降 *Sejo* 世祖 *Sejong* 世宗 *Sejongjangheon-Daewang-Sillok* 世宗莊憲大王實錄 *Seonjo* 宣祖 *Seoungwan* 書雲觀 *Seoungwan-ji* 書雲觀志 *Seungjeongwon-ilgi* 承政院日記 *Shoushi-li* 授時曆 *Shixian-li* 時憲曆 *Sincho* 申初 *Sinchuk* 辛丑 *Sinhae* 辛亥 *Sinjeong* 申正 *Sinmi* 辛未 *Sinmyo* 辛卯 *Sinsa* 辛巳 *Sinyu* 辛酉 *Sohan* 小寒 *Soman* 小滿 *Soseo* 小暑 *Soseol* 小雪 *Sukjong* 肅宗 *Sulcho* 戌初 *Suljeong* 戌正 [*Sun-Ji Lee*] *Lee, Sun-Ji* 李純之

Tang 唐 *Taiyang-tonggui* 太陽通軌 *Taiyin-tonggui* 太陰通軌 *tonggui* 通軌

Wusu 雨水 *Xiaochang-fa* 消長法 *Yeonshinbangwi-do* 年神方位圖 *Yoon, Jeung* 尹拯 [*Yoon-Seok Hwang*] *Hwang, Yoon-Seok* 黃胤錫 *Yuan* 元 *Yuan, Tong* 元統 [*Yuk Kim*] *Kim, Yuk* 金堉 *Yucho* 酉初 *Yujeong* 酉正 *Zhuanying* 轉應