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THE PUBLIC GRANARY INSTITUTION OF THE CH'ING DYNASTY, 1644-1911

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The existence of dyanstic cycles during the long history of imperial China (221 B.C. - A.D. 1911) implies that for each dynasty a long prosperous period is to be followed by a declining period. During the prosperous period, various public institutions, such as civil service, education, and military, are gradually established as guided by certain ideology, only to witness their decline during the declining period. For the Ch'ing dynasty, in particular, there is a nearly unanimous agreement among historians that the turning point occurred around the year 1800, marking off the early prosperous phase (sheng-Ch'ing, 1683-1795) from the declining phase (wan-Ch'ing, 1796-1911).[1] In this paper, we want to study the construction and decline of public granary institution in the background of such a historical periodization of the Ch'ing dynasty.

The importance of the public granary institution is due primarily to the fact that in a premodern agrarian society, the most important cause of social insecurity is crop fluctuation. There are plenty of historical documentation of the frequency as well as severity of natural calamities (flood, drought, locust, etc.) throughout the history for which China has written records.[2] Indeed, the idea that public granary institution should be used to defend against crop fluctuations can be traced to the Han dynasty when the public granary (ch'ang-p'ing-ts'ang or ever-normal granary) was institutionalized in 54 B.C. Thereafter, it became a permanent Chinese institution of all later dynasties as

a variety of new public granary system were established.[3]

With all the experiments and experiences in previous dynasties, the founder of the Ch'ing dynasty readily recognized the importance of public granary system as a basic institutional design. An imperial order was decreed as early as in 1657 to the effect that "All provincial governors should repair or construct public granary." Later on, regulations specified details as to the amount of grain to be in stock and the rules according to which the grain should be "rotated" (usually over a three-year cycle) to compensate for seasonal and crop failure induced fluctuations. The imperial orders were earnestly implemented, developed, and strengthened during the prosperous phase. However, the institution began to decline from around 1815 coinciding with the beginning of dynastic decline.[4]

In analyzing the public granary system of the Ch'ing dynasty, we should emphasize not only its institutionalization and decline but also its operational consequences. The public granary system is used to defend against two types of fluctuations, i.e., seasonal and cyclical or crop failure induced, which are conceptually quite distinct. We shall first analyze principles governing these operational aspects from a theoretical standpoint (Sections I to III). The theoretical implication will be statistically implemented with data collected from the local gazetteers of Szechwan province which will be briefly discussed in Section IV and Appendix I. The idea is that the effectiveness of public granary system must be gauged mainly in terms of the severity of price fluctuations which the government seeks to prevent. This is, in turn, determined

by the quantity of food grain being stocked up in the warehouse. The construction and decline of public granary institution is reflected, in our study, by the time trends of quantity of stockpiled food grain as well as the grain price fluctuations. The analysis of this issue will be presented in the last section. The historical significance of our finding will be briefly summarized in conclusion.

Section I. Principles of Operation of Public Granary

The root cause of all major social security issues (or rather social insecurity) is traced to the divergence (i.e., non-coincidence) of production and consumption at each time point.[5] In a premodern agrarian society, the production and consumption can diverse either due to seasonal or to cyclical fluctuations. In general, the public granary system is used to improve the time utility of food grain (hereafter refers to as rice) so that the surplus food produced at times of abundance can be consumed at times of shortage. There are, however, major differences between the two types of fluctuations, which require different emphasis on the public granary supplementary to the private granary system. In principle, to defend against the seasonal fluctuations, the primary roles are played by the private granaries (e.g., that of the grain merchants and consuming households including the farmers themselves) and that public granary system operates only to compensate for the deficiency of the private system. In cyclical fluctuations, the opposite is true.

In this section, we shall first discuss the principles of

seasonal operation. Those governing cyclical operation will be discussed in Section II . The construction and decline of the public granary institution, which is a conceptually quite distinct long-term issue, will be discussed in Section III.

Natural Seasonal Price Fluctuation

In the upper deck of Figure 1, the 24 months of two consecutive years are indicated on the horizontal axis. Let us assume the annual total output of rice and consumption demand is 12 units as indicated by the height of the horizontal line aa'. The total output (ca = 12) appearing on the market during the month of August is assumed to be consumed during the next 12 months at a rate of d = 1 unit per month. Thus the straight line ab indicates the quantity of rice in storage (QRIS) which declines linearly to next August. (The vertical gap between ab and the horizontal line aa' is the cumulative value of consumption during the cycle.) Assuming constant rice output with no cyclical fluctuations, QRIS is indicated in Figure 2a by the curve $a_1b_1a_2b_2\ldots$ with constant periodicity (i.e., a 12-month cycle) as well as a constant amplitude of fluctuations (i.e., from 0 to 12 units).

Because of the divergence between the time of production (i.e., August) and consumption (i.e., evenly distributed through 12 months), the storage, interest, and transportation cost must be incurred to increase the time utility of rice. Thus the rational and natural monthly rice price increases from the first August to the next as indicated approximately by the straight line pq in the lower deck of Figure 1 (or $p_1q_1p_2q_2p_3q_3$ in Figure 2b) showing an

amplitude of fluctuation between a bottom price p_* and a ceiling price p^*, with a gap (p^*-p_*) which reflects the various cost elements. Such a natural fluctuation of rice price is absolutely essential to call forth the services rendered by the merchants.

In reality, the seasonal movement of prices is indicated in Figure 1 by the inverse u-shaped curve pmp' that reaches a maximum in March and declines steadily from March to the next August. (In Figure 2b, this is shown by the wave like curve $p_1m_1q_1p_2m_2q_2$...with the same amplitude of fluctuation between p_* and p^*). That seasonal price movement has a wave like pattern (pmp') rather than linear (pq) is due basically to speculation. In March when the rice merchants anticipate price decline in August (when new crop appears) will actually sell the rice more eagerly so that price will fall gradually after March.

Using the contemporary experience in Taiwan as an illustration, the average seasonal fluctuation of rice price during 1969-1974 is indicated by a solid curve in Figure 3. There is an 18.3% variation between p^* and p_*.[6]

Exaggerated Seasonal Price Fluctuation in a Speculative Market

Speculation, however, is a very tricky "psychological thing", witnessing the perpetual fluctuation of prices, traced to buyers' and sellers' speculation about the future, even in the highly organized stock market in a modern society. A slightly favorable or unfavorable expectation of the new crop may cause the merchants to withhold buying or selling, thus gives the seasonal price movement a more exaggerated amplitude of fluctuation as indicated

by the dotted curve uvu' in Figure 1. Thus in August, the rice price can be much lower than natural (gap pu) or in March much higher (gap vm).

That the seasonal price can move in an exaggerated fashion due to speculation has been well recognized in Chinese history. In fact, the most famous rural reform introduced in 1069 by Wang An-shih during the Northern Sung period (960-1127) dealt specifically with this issue under the so called ch'ing-miao-fa (green sprout system) to address to what was regarded as a serious social injustice to the farmers.[7] This issue is basically what is now regarded as a problem of short-term rural finance which is traced, on the one hand, to the seasonal pattern of agricultural production and to the storage management system on the other.

The Managerial System of Grain Stockpiling

The management of storage system, from the social point of view, is divided into public warehouse (ax) on the one hand and private storage (xc) on the other (see Figure 1). The latter is subdivided into storage by grain merchants (xy) and farmers for their own consumption (yc). For example, in August, QRIS = ax + xy + yc. Thus, the system is a mixed one involving public and private operations. Let us first describe the farmers' managerial system in respect to yc to concentrate on the equity issue mentioned above.

Because of their own consumption, the farmers exhaust their grain by March (as indicated by line yy') whereby they must borrow

money (which amounts to borrow rice in March) to be paid back by the new crop in August. With the rational seasonal fluctuation pattern (mp'), the farmers pay no more than the real rate of interest plus the storage cost.

Let us assume that the seasonal fluctuation of price is completely nature. It is obvious that the burden on the farmers has two natural components. On the one hand, they must pay a market interest rate (e.g., i = 3% per month). On the other hand, they must pay the storage and interest charge because the grain which they consume are already stored for six months between August and March. It can be shown, however, that the real interest rate in terms of rice (r), even when the seasonal fluctuation of price is completely normal, should be at least twice the market rate of interest (i). (See Appendix II, $r = 2i + j$.)

In other word, if market rate of interest is 3%, the farmers have to pay a 6% interest rate per month in terms of rice. This is completely equitable and natural. However, the farmers are easily penalized by an exaggerated cyclical price movement causing a wider price gap between p^* and p_*. For it is obvious that with more violent fluctuations of rice prices, the farmers' burden, measured in terms of the real rice interest rate would be much higher than twice the rate of interest mentioned earlier.

In Chinese history, this inequity to the farmers due to the exaggerated fluctuation of rice price was usually vaguely recognized as an issue involving usury and seasonal price fluctuation. Thus, during the Sung dynasty, the reform of Wang An-shih tried to incorporate a low interest rate loan policy to

help the farmers under the name of ch'ing-miao-ch'ien (green-sprout money). This regulation was attacked at the time mainly on the ground that the farmers were not able to pay back their loan. Underlying this argument is the fact that the real interest burden in terms of rice was too heavy.[8]

Purpose of Government Seasonal Operation

There are two purposes of government seasonal operation, a technical one and an equitable one. Both purposes are served simulteneously by the government managerial practices. Operation-wise, the government withholds the grain purchased in August (ax) for six months and gadually begin selling activity in March. (Thus, the portion of QRIS held by the government is indicated by the vertical shaded distance where the line xx' paralles to yy' and az in Figure 1.) The government will have to acquire the amount of ax again each August as the government granary becomes exhausted (see Figure 2c for the seasonal pattern, $g_1 f_1 d_1 g_2 f_2 d_2 \ldots$).

This is the so called rotating system mentioned earlier. For example, in 1689 an imperial order reads: "In Szechwan province, a third of the grain in storage is to be loaned to soldiers and citizens and to be paid back annually and cyclically. This is to be a permanent institution."[9] Apparently, the government decree meant that a stock-piling rice which is three times ax, or in Figure 2c the additional government storage is indicated by the distance of cs = 2ax. (In other words, the minimum amount of government grain which, reaches in the month of

July, is cs = 2ax.) Presumably, the extra grain (cs) not used for seasonal operation is a reserve for anti-cyclical fluctuations.

The rotation system is adopted primarily to prevent the deterioration of the quality of grain in storage. Under the three-year rotation system, no food grain should stay in the warehouse longer than three years.[10] Thus we see the seasonal operation is a technical matter complementary to the anti-cyclical fluctuation (i.e., to preserve the quality of rice for anti-cyclical operation). From the viewpoint of anti-seasonal operation, it is only a secondary consideration.

The basic and major purpose of anti-seasonal operation of public granary system is to bring the exaggerated price fluctuation back to the natural level. Again, using the contemporary experience as an illustration, the seasonal price fluctuation in Taiwan as shown by the dotted curve is only an 8% amplitude of fluctuation as compared with an 18% fluctuation of the solid curve (see Figure 3). This is due to the fact that in the period of 1963-1968, the government acquisitions of grain from the market accounted for a much higher percentage of output than in the period of 1969-1974.[11]

The above analysis shows that the seasonal operation is complementary to the cyclical operation in a technical sense (i.e., to preserve the quality of rice). The main purpose of seasonal operation is really on the equity ground. In what follows we shall show that the seasonal operation is in fact an easy by-product of the anti-cyclical operation.

Section II. Anti-Cyclical Operation

For the analysis of crop failure induced fluctuation, a basic assumption is that the long-run supply of rice output is adequate to feed an expanding population which occurred throughout the Ch'ing period. The fluctuations of rice crop throughout time is indicated by the crop fluctuation curve (i.e., curve I) in Figure 4 around a long-run trend curve (curve II) which reflects the demand for the rice with population expansion. The assumption means that the sum of areas ($B_1 + B_2 + B_3...$) representing the rice surplus in bumper crop years is approximately the same as the sum of areas ($D_1 + D_2 + D_3...$) representing the total rice deficiency in lean crop years. The civilization obviously cannot survive unless this assumption ($\Sigma B_i = \Sigma D_i$) is fulfilled in a closed agrarianism (i.e., a society without foreign trade).

Much of the principles discussed above with respect to seasonal fluctuation are applicable to crop failure induced fluctuation. Thus the function of public granary is to store up B_i to be released for consumption in order to make up for the deficiency of D_i and hence increases the time utility of rice crops. In this anti-cyclical operation, the government, to a certain extent, will have to deal with deficiency of the private storage system controlled by the speculated market. It is, however, important to recognize the difference between cyclical and seasonal fluctuations as they are crucially related to the evolution of public granary system during the Ch'ing dynasty.

As compare with seasonal fluctuation, the cyclical fluctuation

is characterized by three conspicuous characteristics: (i) uneven periodicity, (ii) uneven amplitude of fluctuation, and (iii) more severe amplitude of fluctuation. There is, moreover, a spatial dimension. A severe deficit (e.g., D_4 and D_8) described by historians as "consecutive severe droughts" (lien-nien-ta-han) implies severe crop failures for several consecutive years spreading over a wide geographic regions. On the contrary, a superb abundant bumper crops (e.g. B_2 and B_5) recorded as "consecutive bumper crops" (lien-sui-ta-shou) implies the opposite. The local gazetteers are full of such anecdotal descriptions.

The irregular periodicity and amplitude of cyclical fluctuations renders the predictions of future crops more difficult. For this reason, the role of anti-cyclical fluctuation as executed in the private market becomes more speculative. Moreover, the severity of amplitude of cyclical fluctuations implies that the storage capacity needed to address to this type of fluctuation is usually beyond the capacity of private granary. For all these reasons, while the major role for the management of the time utility of rice in respect to seasonal fluctuation is played by the merchants with the government playing only a subordinating role, the opposite is true for anti-cyclical fluctuations. For in the latter case, the government has to play the primary role while the merchants the subordinating one.

The basic principle governing the anti-cyclical operation centers in the quantity of rice in storage (QRIS). The quantity is not a major consideration for seasonal operation. In Figure 1, for example, the government seasonal operation as a fraction

of the total seasonal operation is measured by the ratio ax/ac (i.e., the government autumn buying as a fraction of the total output). The magnitude of this ratio is unimportant. Provided the government maintains an anti-cyclical stock (i.e., cs in Figure 1), a mere announcement of the government intention to stabilize seasonal price fluctuations is sufficient to forestall private speculations. The rational seasonal fluctuation pattern can be restored without actual buying and selling.[12] It is thus seen when the anti-cyclical stock is adequate, the anti-seasonal operation can come easily as a by-product.

The situation is entirely different for anti-cyclical fluctuation. Here the quantity (i.e, QRIS) is of crucial importance. A large quantity can defend against a more severe fluctuation while a small quantity cannot do. With a constant magnitude of QRIS (i.e., constant storage capacity), the anti-cyclical fluctuation capacity is shown by the pair of dotted curves III and IV in Figure 4. This capacity is adequate only to take care of less severe fluctuations (e.g., D_1, B_1, D_3, B_4) which fall within the range. For more severe fluctuations (e.g., B_2, B_3, D_4) that fall out of this range, the storage capacity becomes powerless.

When severe fluctuations beyond the storage capacity occur, the "adjustment mechanism" becomes painful during the bumper crop years. Rice price could drop to the bottom that is harmful to the farmers (ku-chien-shang-nung).[13] During a severe deficit year, the "adjustment mechanism" takes on two forms. On the one hand, there is regional adjustment through the shipment from

the public storage of bumper crop regions to the deficit neighbors. On the other hand, the adjustment may take on the most painful way of migration of refugees or even starvation. The only way to defend against a more severe fluctuation is to increase the storage capacity leading to a shift of the curves from III and IV to V and VI in Figure 4.

Section III. Construction and Decline of Public Granary Institution

From the above analysis, we see that the major principle governing rational design of public granary system is that the quantity (QRIS) is directed mainly at anti-cyclical fluctuations with anti-seasonal fluctuations come easily as a by-product. Furthermore, for anti-cyclical fluctuations, the basic principle is to expand the storage capacity through time so that the system can defend against increasingly more severe crop fluctuations.

Ideally, a rational institutional design of public granary is to increase the warehouse capacity and to build up an ever increasing stock of grain (QRIS). This is shown by the increasing the lower deck of curve AT in Figure 4 such that the shaded triangles (d_1, d_2, d_3...) represent the amount of increase of QRIS, that the government acquires from the market. The construction and decline of public granary system can be seen essentially from the long-run trend of the QRIS. During the prosperous period, we expect QRIS to increase (i.e., from point A to point T). During the declining phase, we expect QRIS to exhibit a long-run decreasing trend as shown by the curve TB, implying a successive decrease of QRIS (e_1, e_2, e_3...). Such decreases are probably a result of the

financial difficulties of local governments making it more difficult to budget expenditure to acquire additional rice stock as they did in the prosperous phase. There is a unanimous agreement among historians that the financial position of the Ch'ing government was much better during the prosperous than in the later period.[14]

The construction and decline of public granary system is manifested mainly in the severity of the cyclical pattern of price fluctuations which the system seeks to eliminate. During the prosperous phase, we expect the degree of price fluctuations becomes increasingly less severe through time. During the declining phase, we expect price fluctuations become increasingly more severe through time until the QRIS is exhausted and henceforth, the price fluctuations become the most severe.

On a closer examination, we should look at the rules according to which the incremental QRIS (d_1, d_2, d_3...) are acquired during the prosperous phase. Because of the fact that the anti-cyclical measures already in operation, the incremental acquisitions (d_i) are acquired mainly during the bumper crop years (B_1, B_2, B_3...). Possibly, during the deficit crop years (D_1, D_2, D_3...), the public granary does not release as much grain as it would have been, had there been adequate storage from the very beginning. During the declining phase, the government does not acquire as much grain during the bumper crop years (B_6, B_7, B_8...) and may release more grain during the deficit years (D_7, D_8...) as the public granary is gradually exhausted.

The implication of the above rules of acquisition on price fluctuations is shown in curves VIII and IX in Figure 4. The

solid curve VIII which represents the cyclical price fluctuations with the same periodicity as the crop fluctuation curve and with an amplitude of fluctuation in proportion with (but in the opposite direction) the crop fluctuation curve. The rules of acquisition is shown by the dotted curve IX whereby during the prosperous phase, in both bumper years and deficit years the prices are elevated. During the declining phase, the opposite is true; in both bumper years and deficit years, the market prices are depressed.[15]

Section VI. Statistical Data

For statistical implementation, we need data on the time path of QRIS as well as data on the time pattern of prices. In our study, we use data collected from various local gazetteers of Szechwan province including counties and prefectures as shown in Appendix I.[16] The study of Szechwan alone is meant to be an illustration for the evolution of granary system for the country as a whole for which data will be gradually organized.

Although we believe that we have collected all the relevant data from the local gazetteers of Szechwan for the entire period, the spottiness of historical data makes it necessary for us to make certain assumptions in respect to their interpretation. These assumptions as well as the data source and the computation procedures are given in details in appendix. The summary of these data are presented as time series in a diagrammtic form in the text to facilitate our discussion.

Section V. Empirical Verification

In order to verify the thesis for the construction and decline of granary institution, the statistical data on the ever-normal granary is used here as a major reference. With the vertical axis indicated on the right the total public granary stock (TPGS) is indicated by a solid curve in Figure 5.[17] It is seen that TPGS increases consistently and monotonously from a negligible magnitude from 1680 to a peak value around 1812, thereafter it declines consistently. This pattern demonstrates conclusively that we can divide the Ch'ing dynasty into two periods: a stock increasing phase (SIP, 1680-1815) which approximately coincides with the prosperous phase and a stock decreasing phase (SDP, 1815-1911) coinciding the declining phase.

The stock decreasing phase is again subdivided into two phases: a stock reducing phase (SRP, 1815-1850) and a stock exhausting phase (SEP, 1850 onward). The demaraction of these phases partially reflects the historical event of the Taiping Rebellion which urshered in a phase of severe fiscal difficulties so that the government expenditures were shifted drastically to other more urgent needs. This is reflected in curve I in Figure 5 by the drastic decline of the total stock of grain between 1850 and 1860.[18]

The time pattern for the whole province that we have seen can be verified by patterns of individual administrative districts in Szechwan. In Figure 6, the time pattern of the QRIS for ten individual counties are depicted. A visual impression convinces

us that they demonstrate the same pattern as the curve for the whole province. Thus in the stock increasing phase, all local governments seem to have make an uniform effort in the granary construction process while all of them fell the pressure and contribute to the decline of the granary institution during the declining phase.

In Figure 7, the time path of rice prices for these periods are shown. Notice that these prices are plotted on a logarithmic scale on the vertical axis. This means that throughout these periods, the fluctuations of rice price are much more violent than what a visual impression would have conveyed. Also notice that the very nature of the local gazetteers tended to record not the regular market price as a modern price index will require. Instead, they tended to record major events (e.g., prices at times of major calamities or major bumper crop years) with certain "journalistic" values.

Thus, the time path of Figure 7 really shows the extreme variation of rice prices. The amplitude of fluctuation is indeed very violent according to a modern standard. For example, in terms of copper cash, the prices varied from a low value of 400 cash to a high value of 5,000 cash in the ten-year period of 1860-1870. This means that the prices can vary more than 10 times! Most modern countries will regard this as extremely unlikely and intolerable. The violent price fluctuation for the historical period can be more clearly seen with the contemporary experience. For example, in Taiwan during the past 25 years (i.e., a much longer period, 1953-1977), the fluctuation of rice prices between a high price

in 1975 (11.01 NT Yuan per kg.) and a low price in 1954 (1.89 NT Yuan per kg.) was only 5.8 times.[19]

In our analysis, the violence of price fluctuation for the Ch'ing period should be examined from the viewpoint of adequacy of the size of QRIS. The data for the year 1812 (i.e., the date when the maximum value was achieved in curve I of Figure 5) is very complete. In that year, the total amount of rice stockpiled in the ever-normal granaries in Szechwan was 3,118,004 shih and that in the community granaries was 1,563,006 shih. Altogether, there were 4,681,010 shih of rice stock piled in Szechwan, while the total number of household (hu) was 5,050,482. The average amounts to .9268 shih per household (see Table 1 in Appendix I). Since there were, on the average, 4.8 adults per household, the per adult person grain storage was only .1931 shih, or about 25 catties (assuming 1 shih = 130 catties). Assuming that annual consumption of grain per person was 400 catties, the storage of rice in Szechwan at times of maximum was no more than 6.25% of the annual consumption.[20] Thus, even in the peak year of 1812, the public granary which was the main instrument for defending against cyclical fluctuations was apparently inadequate.

Again, using contemporay standard as a guide to measure the historical experience, we know that the rice stored in public warehouse in Taiwan for the last twenty years could usually take care of consumption for two months.[21] In comparison with the case of Szechwan in the Ch'ing dynasty, even at the peak storage capacity in 1812, the storage capacity would only take care of the consumption of adult population for 23 days, and of course, even fewer days, if the demand of non-adult population is added. In other words,

the modern capacity to defend against cyclical fluctuation is at least three times that of the maximum capacity achieved in the Ch'ing period. It is no wonder that the historical grain storage capacity did not has the power to elimate the very violent price fluctuations.

As far as the severity of price fluctuation is concerned, we naturally expect that prices fluctuate most severely during the stock exhausting phase after 1850. For the two earlier periods, we expect the prices flutuate slightly less during the stock reducing phase than during the stock increasing phase. This is due to the fact that in the latter phase, rice must be acquired from the market by the government on a net basis, while during the former phase, rice is gradually released. For the three periods, the coefficient of variation (i.e., standard deviation/mean) are respectively .43, .40, and .64 which support our predictions. (see Table 3 in Appendix I).

Again, using contemporary standard as a yardstick, if we compute the coefficient of variation of the rice prices in Taiwan during 1953-1973, before the price rose very drastically in 1974, the value is .30, which is lower than our ovservations in Szechwan during the Ch'ing period. However, taking the whole period of 1953-1977 into consideration, the value is .54. This comparison suggests that the prices recorded in the local gazetteers are not at all unbelievable.

Taking into consideration of the rules of anti-cyclical operation discussed in the earlier section, we expect that during the stock increasing phase (1750-1815), the government defends more vigerously against price decline during the bumper crop

years and defends the price increases during the lean crop years less vigerously. The opposite is true during the stock decreasing phase. This idea is shown by the long run price trend ABCD in Figure 7 such that the shaded areas below the price trend are smaller than those above the price trend during the stock increasing phase. The opposite is true during the stock decreasing phase.[22]

Conclusion

We have shown that the construction and decline of the public granary system coincides with that of the prosperous and declining phases of the Ch'ing dynasty. This institutional evolution is reflected in turn by the effectiveness on the elimination of price fluctuations which the public granary institution aims to prevent.

The founder of the Ch'ing dynasty did have the vision to strengthen the economy's capacity to achieve social security by increasing the grain in storage through time. However, after 150 years (1660-1810) of consistent efforts, they have not been able to build up a sizable public granary stock to eliminate severe price fluctuations. In the absence of wars and other exogenous historical events in the nineteenth century, the size of public granary stock would have kept on increasing. There are records in earlier periods when the public granary had accumulated a very sizable stock.[23]

The fate of the Ch'ing dynasty can probably be assessed with this historical hindsight on public granary capacity.

Appendix I. Data Source

1. Data of Quantity of Rice in Storage

The quantities of rice in storage in the ch'ang-p'ing-ts'ang and she-ts'ang for the year 1812 are listed in Table 1 showing the total amount of the whole province and the subtotal of each prefecture (fu) and independent department (chih-li-chou). Each of these administrative units contains a number of counties (hsien) for which the original statistics are available. The statistics shown in Table 1 are the aggregates of the counties. Also listed in Table 1 are the number of households in each administrative unit. Moreover, the average number of rice in storage per county and per household are computed and listed in Table 1. It should be noted that the figures of the population as recorded with those of household in the Szechwan t'ung-chih (1816 ed.), are probably related to adults only, for statement given in this local gazetteer reads: "...there are nan (males) of how many ting (adult) and fu (adult females) of how many kuo (mouth)." With this assumption, the average number of adults per household is computed as mentioned in the text.

Table 1. Quantity of Rice in Storage in Szechwan, 1812

unit: shih

Place	Ch'ang-p'ing-ts'ang	She-ts'ang	Total Quantity	Average per hsien*	No. of Household	Average per Household
Szechwan	3,118,004	1,563,006	4,681,010	33,920 (138)	5,050,482	.9268
Ch'eng-tu	657,993	456,686	1,114,679	69,667 (16)	1,167,343	.9549
Ch'ung-ch'ing	452,498	124,957	577,455	41,246 (14)	690,163	.8367
Pao-ning	87,057	4,746	91,803	10,200 (9)	212,037	.4330
Shung-ch'ing	130,905	33,676	164,581	20,572 (8)	243,878	.6748
Hsu-chou	230,378	79,534	309,912	23,839 (13)	390,021	.7946
K'ui-chou	132,570	16,069	148,639	24,773 (6)	186,304	.7978
Lung-an	40,158+	28,558	68.716	17,179 (4)	91,757	.7489
Ning-yuan	103,340+	27,654	130,994	26,199 (5)	145,497	.9003
Ya-chou	61,176+	42,810	103,986	14,855 (7)	116,724	.8909
Chia-ting	296,944	155,102	452,046	56,505 (8)	302,527	1.4942
T'ung-ch'uan	126,600	50,861	177,461	22,183 (8)	311,370	.5699
Sui-ting	54,710	39.840	94.550	18,910 (5)	185,404	.5099
Mei-chou	108,310	33,933	142,243	35,560 (4)	106,504	1.3356
Ch'iung-chou	41,000	108,670	149,670	49,890 (3)	88,209	1.6968
Lu-chou	163,000	37,761	200,761	50,190 (4)	148,470	1.3522
Tzu-chou	186,070	108,747	249,817	68,963 (5)	141,257	2.0871
Mien-chou	72,480	166,467	238,947	39,824 (6)	156,707	1.5248
Chung-chou	78,480	9,224	87,704	21,926 (4)	130,661	.6712
Yu-yang	45,548	14,443	59,991	14,997 (4)	117,544	.5104
Mao-chou	10,837+	1,654	12,491	6,245 (2)	9,565	.3157
Hsu-yung	33,750	14,805	48,555	24,277 (2)	52,176	.9306
T'ai-p'ing-t'ing	4,200	5,112	9,312	9,312 (1)	26,364	.3532

* The number of hsien is in parenthesis.

\+ Part of these amounts are not rice, but they are converted to rice according to the rates regulated by the Board of Revenue. See Hu-pu tse-li (regulations of the Board of Revenue, 1865), 17:20.

Source: The quantity of storage in ch'ang-p'ing-ts'ang, see Hu-pu tse-li, 18:24-25; The quantity of storage in ch'ang-p'ing-ts'ang and she-ts'ang can also be found in Szechwan t'ung-chih (The gazetteer of Szechwan province, 1816), 72:11-19. We have compared the records in most local gazetteers of individual county and found that 95 hsien had the same figure as mentioned in the two sources indicated above. The number of households see Szechwan t'ung-chih, 65:1-37.

2. Data of Changes of Rice in Storage

From all the local gazetteers in Szechwan, we have selected 34 counties for which data aoubt the changes of rice stockpiled in the ch'ang-p'ing-ts'ang through time are available.* The annual growth rate is first computed with the exponential formular for each individual county at the time points when data are available. Then, the average of the growth rate at each time point is computed. The results of these computations are shown in Table 2. Also shown in Table 2 are the estimated total quantity of rice in storage at each time point. These numbers are obtained by using the actual total amount of rice in storage in 1812 (shown in Table 1) as a reference and extrapolating with the growth rate at each time point forward and backward. These estimated amounts do not mean to represent the real magnitudes but rather to show a trend of change.

In addition to the ch'ang-p'ing-ts'ang, there were other public granaries, such as she-ts'ang, i-ts'ang and after 1880, chi-ku-ts'ang (literally, grain stockpiling granary), established in rural area. However, the statistics available for these lesser establishments are all the more spotty. It may not be worthwhile to try to piece them together for an overall observation.

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*In addition to the local gazetteers of ten counties indicated in Figure 6, other 24 counties are as follows: (HC denoted for hisen-chih or the gazetteer of county, CC for chou-chih or the gazetteer of department, and FC for fu-chih or the gazetteer of prefecture).

Chin-t'ang HC (1844), 8:10-12; (1867), 8:1; (1921), 3:10-11.

Nan-ch'uan HC (1931), 4:16-18.

Pi-shan HC (1865), 2:34-43.

Ting-yuan HC (1843), 3:38; (1875), 2:3-4.

Chao-hua HC (1821), 19:2; (1864), 19:1-3.

Yun-yang HC (1827), 11:2-3; (1854), 3:2-3; (1935), 19:1-4.

Wan HC (1827), 11:3; (1866), 9:8-9.

Hui-li CC (1870), 9:1-2.

Chia-chiang HC (1813), 3:5-6; (1935), 3:11.

Wei-yuan HC (1775), 3:36; (1877), 2:5-6.

San-t'ai HC (1814), 2:56; T'ung-ch'uan FC (1786), 9:33-34.

She-hung HC (1819), 6:11; (1884), 5:8-11; T'ung-ch'uan FC (1897), 11:8.

Chung-chiang HC (1899), 3:7-10.

Sui-ning HC (1878), 1:86; T'ung-ch'uan FC (1786), 9:35-36.

Mei CC (1799), 6:19; Mei-shan HC (1923), 3:9-10.

Ch'ing-sheng HC (1877), 8:43-45.

Ch'iung CC (1818), 8:5-7.

Tzu-yang HC (1860), 6:10.

Jen-shou HC (1803), 1:45-46; (1837), 2:21-23; (1866), 3:35-37.

Ching-yen HC (1900), 5:11-14.

Lo-chiang HC (1802), 1:3; (1865), 7:6-7.

An HC (1812:1864), 8:1-4.

Chung CC (1826), 4:17-19.

Hsiu-shan HC (1891), 4:5-6.

Table 2. The annual growth rate of rise in storage and the estimated quantity in storage in Szechwan

year	annual growth rate	quantity in storage unit: shih
1690	.12	22,089
1700	.036	73,338
1710	.019	105,117
1720	.051	127,112
1730	.083	211,675
1740	.039	485,426
1750	.017	716,957
1760	.019	849,809
1770	.016	1,027,626
1780	.014	1,205,925
1790	.034	1,387,138
1800	.032	1,948,836
1810	.031	2,683,707
1815		3,118,004
1820	-.018	2,849,649
1830	-.030	2,111,091
1840	-.042	1,387,103
1850	-.054	808,345
1860	-.110	269,083
1870	-.028	203,370
1880	-.006	191,527
1890	-.023	152,175
1900	-.011	136,324

3. Data of the Prices of Rice

From about 60 local gazetteers of counties and prefectures in Szechwan, we have collected data of the prices of rice throughout the Ch'ing period. It should be noted, however, these price quotations are mostly related to bumrer crop years and deficit crop years. The extent to which these prices prevailed cannot be easily ascertained as there is, in most years, only one entry available. When there are more than one entry in one year, the average value is taken. Another problem is the measurement unit. The local gazetteers usually used the term "tou-mi" before a quotation of price. The word tou should be understood as the measurement instrument of capacity rather than as 0.1 shih, otherwise, the prices of rice in Szechwan would be very high. Table 3 shows these prices in the three periods with the average value(p), the standard deviation(s), and the coefficient of variation(V) computed for each period.

The prices shown in Table 3 are quoted in terms of copper cash. In terms of silver, the prices in the third period (1850 onward) can be deflated to some extent for we know that during this period, the ratio of cash to silver was usually more than 1200 cash to 1 tael. From various local gazetteers, we have collected spotty data related to the cash/silver ratio throughout the Ch'ing period. Suffice it here to mention particularly that a rather complete series during the period 1830-1924 can be found in Chien-wei HC (1937), 11:28-29. Two other series of the period 1875-1925 can be found in Ho-chiang HC (1929), 2:27 and in Nan-hsi HC (1937), 2:33.

Table 3. Prices of Rice in Szechwan

(1) Price Increasing Phase, 1750-1815

Year	Price in Cash per shih	Source of Data
1751	525	Chao-hua HC (1864), 19:1.
1760	1,000	Lu-CC (1882), 12:67
1778	1,600	Yung-ch'ang HC (1883), 19:1; She-hung HC (1819), 17:3; T'ung-ch'uan FC (1786), 11:51; Chiang-an HC (1812), 6:71.
1779	1,500	Hsu-chou FC (1895), 23:10; Hung-ya HC (1813), 16:2; Chung CC (1826), 4:44.
1783	300	Ching-yen HC (1900), 42:8.
1786	1,450	Tien-chiang HC (1828), 6:37.
1788	400	Ya-an HC (1928), chuan 10.
1799	1,000	Hsu-chou FC (1895), 23:11.
1800	1,000	Lu CC (1882), 12:67.
1801	900	Chiang-an HC (1812), 6:71; Tien-chiang HC (1828), 6:37.
1804	1,000	Chung-chiang HC (1839), 7:16.
1805	1,000	Jen-shou HC (1837), 5:30.
1810	300	Ho-chiang HC (1813), 52:18.
1812	1,500	Chung CC (1826), 4:44.
1814	1,000	Feng-chieh HC (1893), 11:1.

$p = 965$

$s = 41.8$

$V = .43$

Table 3 (continued)

(2) Price Decreasing Phase, 1815-1850

Year	Price in Cash per *shih*	Source of Data
1819	500	*She-hung HC* (1819), 6:11.
1823	350	*Lu CC* (1882), 12:65.
1824	1,000	*Hsu-chou FC* (1895), 23:11.
1825	1,000	*T'ung-chuan FC* (1897), 11:9.
1832	1,000	*Hsu-chou FC* (1895), 23:11.
1838	1,000	*Chung-chiang HC* (1839), 7:19; *Jen-shou HC* (1866), 9:34.
1840	1,100	*Ho CC* (1876), 2:6.
1843	800	*Ch'ung-ch'ing FC* (1843), 3:43.
1844	650	*Ch'eng-k'ou t'ing-chih* (1844), 6:14.
1845	320	*Lu CC* (1882), 12:65; *Ho CC* (1876), 2:6.
1849	1,500	*Hsiu-shan HC* (1891), 3:13.

$p = 838$

$s = 33.8$

$V = .40$

(3) Price Increasing Phase, 1850-1890

Year	Price in Cash per shih	Source of Data
1855	1,100	Hsu-chou FC (1895), 23:12.
1860	1,200	P'eng HC (1878), 4:41.
1861	400	Ho-chiang HC (1871), 52:18.
1863	4,000	Feng-hsi HC (1899), 4:22.
1864	2,000	Lu CC (1882), 12:66; She-hung HC (1819), 17:3; Tzu CC (1876), 30:5; Ho-chiang HC (1871), 52:18.
1865	1,500	Tzu CC (1876), 30:8.
1866	1,000	Tan-ling HC (1892), 10:29.
1869	5,000	Hsiu-shan HC (1891), 3:24.
1871	1,850	Ho CC (1876), 2:6; Lo-chih HC (1883), 3:1.
1872	2,300	Lo-chih HC (1883), 3:1;
1875	3,100	Nan-hsi HC (1937), 2:36.
1879	500	Ya-an HC (1928), Chuan 10.
1880	3,200	Nan-hsi HC (1937), 2:36;
1881	500	P'ei CC (1928), 24:6.
1883	4,000	Hsiu-shan HC (1891), 3:25.
1884	750	She-hung HC (1884), 5:8.
1885	4,000	Nan-hsi HC (1937), 2:36..
1886	2,000	P'ei CC (1928), 24:6; Nan-hsi HC (1937), 6:3; Tan-ling HC (1892), 10:29.
1890	2,000	Yung HC (1929), 7:16; Kuang-an CC (1907), 13:6; Nan-hsi HC (1937), 2:36.

$p = 2,126$

$s = 135.3$

$V = .64$

Appendix II

In this appendix, we want to prove that the real interest rate in terms of rice (r) is twice that of the market interest rate (i). Let x be the amount of rice that the farmers borrow in March and p^* the price of rice. Then, in terms of money, the amount to be paid back in August at the market interest rate (i) is $p^* x e^{i6}$. If, in August, the farmers sell y units of rice at price p_* to pay back what they borrowed last March, we have

1) $\quad p_* y = p^* x e^{i6}$.

However, in terms of rice, the same process of borrowing and returning can be stated as

2) $\quad x e^{r6} = y$.

From equations (1) and (2), we know

3a) $\quad e^{r6} = (p^*/p_*)\, e^{i6}$, or

b) $\quad r = (1/6)\ln(p^*/p_*) + i$

Thus, the rice rate of interest (r) is the sum of the market rate of interest (i) and a term which increases with p^*/p_*.

In order to determine p^*/p_*, the storage cost to the grain merchants is again computed as the market rate of interest. If the merchants incur monthly storage charge, the cost per month may be written as (i + j). Thus, the ceiling and bottom prices are determined by

4a) $\quad p^* = p_* e^{(i + j)6}$, implying

b) $\quad (1/6)\ln(p^*/p_*) = i + j$.

Substituting in 3b), we have

5) $\quad r = 2i + j$.

Thus, the rice rate of interest is at least 2i even when there is completely no storage cost which is our assumption in the text.

Notes

[1]For a discussion of periodization of Chinese history, see Lien-sheng Yang, "Toward a Study of Dynastic Configurations in Chinese History," in Studies in Chinese Institutional History (Cambridge, Mass., 1961), pp. 1-17.

[2]See, Yao Shan-yu, "The Chronological and Seasonal Distribution of Floods and Droughts in Chinese History, 206 B.C.-A.D. 1911," Harvard Journal of Asiatic Studies 6(1942), 273-312; "The Geographical Distribution of Floods and Droughts in Chinese History, 206 B.C.-A.D. 1911," Far Eastern Quartery 2.4 (1943), 357-378; "Flood and Drought Data in the T'u-shu chi-ch'eng and the Ch'ing shih-kao," Harvard Journal of Asiatic Studies 8 (1944), 214-226.

[3]In addition to the ch'ang-p'ing-ts'ang of the Han dynasty, the i-ts'ang (charity granary) was added in the Sui dynasty; the Kuang-hui-ts'ang (extensive benevolent granary) was added in Sung Dynasty; the yu-pei-ts'ang (preparatory granary) and the she-ts'ang (community granary) were added in the Ming dynasty. See Han-shu (The History of Han Dynasty), 24A:19; Sui-shu (The History of Sui Dynasty), 24:15; Sung-shih (The History of Sung Dynasty), 176:14-17; Ming-shih (The History of Ming Dynasty), 79:11-13. The edition of these dynastic histories is the reprint edition by I-wen Bookstore, Taipei.

[4]See, for example, Szechwan t'ung-chih (1816 ed.) 72:6-11 for the establishment and regulation of granary in Szechwan. For a discussion of granary as a famine contral institution duning

the ch'ing dynasty, see Kung-chuan Hsiao, Rural China: Imperial Control in the Nineteenth Century (Seattle, 1960), ch. 5.

[5]The major social security issue in the U. S. centered in child and senior citizen welfare and unemployment, relative to which the institutions of "social security" and "unemployment compensation" are designed. The first issue is obviously traced to the longivity of human life and the non-coincidence of the productive period (e.g., ages 20-68) and the periods when an individual becomes a "dependent population" (i.e., below age 20 and above age 68). Unemployment, according to modern theory, is caused by the instability of investment which is the currently produced capital goods that leads to the expansion of the capacity of consumer goods output in the future, again a divergence between current production and future consumption.

[6]Notice that in Taiwan, the p_* prevails in the month of September while the p^* in the month of Feburary. These months will have shifted earlier for a lunar calendar. In the sub-tropical climate of Taiwan, there are two crops of rice which ripe in July and October respectively. For these reasons, the selection of August and March in our diagram is mainly a theoretical simplification. For an analysis of the months in which the peak and bottom prices prevailed during the Ch'ing period, see Chuan Han-sheng, "Ch'ing Yung-cheng nine-chien ti mi-chia (Rice prices during the Yung-cheng reign (1723-1735)," in Chung-kuo ching-chi-shih lun-ts'ung (Studies on Chinese Economic History; Hong Kong, 1972), pp. 534-535.

[7]For a brief discussion of this measure see, Lien-sheng Yang, Money and Credit in China (Cambridge, Mass., 1952), pp. 96-97. For Wang An-shih's reform see James T. C. Liu, Reform in Sung China (Cambridge, Mass., 1957).

[8]Under the ch'ing-miao regulation, the interest charged for the most part of China was 20 per cent and for Ho-pei area 30 per cent. This meant that if the period of loan was six months, the compound interest rate per month was .04 for Ho-pei and .03 for the rest of China. Then, the completely equitable rice interest rate to the farmers were .08 and .06 respectively. Taking the rate of .08 as an example, if the farmers barrowed 1 bushel of rice in March, they were expected to pay $(1.08)^6 = 1.58$ bushel in August. Although there were loud protest against Wang An-shih on account of this alarming high rate of interest, the protest was, in fact, groundless as this rice rate of interest was completely unavoidable in view of the capital shortage and high commercial interest rate (e.g., 20% for six months loan).

[9]Szechwan t'ung-chih (1816), 72:6.

[10]In our interview with officials of Taiwan Provincial Food Bureau, we are told that even with the modern scientific princibles of ventilation and dehumidification, the rice in storage must be rotated every two years. In a less humid climate area than Taiwan, a rotation based on three-year cycle is very reasonable. Cf. Hu-pu tse-li, 16:12-13, for the regulation of rotation cycle in various provinces.

[11]For an analysis of government storage of rice in Taiwan see Huang Teng-chung, "Taiwan ku-chia ch'ang-ch'i pien-tung chih feng-hsi yen-chiu (An analsysis of secular trend of rice price in Taiwan)," Paper present at the meeting of Association of Agricultural Economics (Taipei, January 1978), pp. 16-20.

[12]This is comparable to the stability of foreign exchange rate ensured by the very announcement of the central bank that stands ready to buy and sell at a constant rate. This announcement has the effect of forestalling speculation provided the central bank has adequate reserve of foreign exchange stock, comparable to our anti-cyclical rice stock. The rotation of rice through seasonal operation mentioned earlier is for the purpose of preserving the quality of rice in storage and has little to do with anti-cyclical price fluctuations.

[13]This phenomenon was recognized by Chinese people as early as in the period of Warring States, see Nancy Lee Swann, Food and Money in Ancient China (Princeton, 1950), p. 139.

[14]See, for example, Ts'ui-jung Liu and John C. H. Fei, "An Analysis of the Land Tax Burden in China, 1650-1865," Journal of Economic History, 37.2 (June 1977), 378.

[15]The observation here has statistical significance when empirical data are used to implement the theory. This is due to the fact that the observable data on rice prices are mainly indicated by the dotted curve, while the solid curve cannot be observed, i.e., it exists only ideally.

[16]Szechwan is selected as our case of study under two considerations: (i) this province was a major rice production area and (ii) of all local gazetteers throughout China that we have investigated, the local gazetteers of Szechwan contained the most complete data on the subject of granary system.

[17]As explained in appendix, curve I in Figure 5 is built up from curve II which is, in turn, obtained as an average value for all the districts from which data are available. Curve II shows the growth rate of grain in storage. Note that in the SIP, the growth rate has a decreasing trend while in the SDP, the growth rate curve is u-shaped. This kind of pattern is entirely to be expected as the growth rate should show a declining trend because the stock value increases. Similarily, the u-shaped pattern in the SDP is to be expected. Hence, the time pattern of stock of grain as illustrated in curve I portrays a reasonable picture for Szechwan province.

[18]Many local gazetteers reported difficulties in refurnishing the granary stock on account of military need and government financial difficulties during 1850-1860. See, for example, Hsu-hsiu Hsin-fan hsien-chih (1873 ed.), 4:16; Chien-chou hsu-chih (1897 ed), A:80; Chiang-chin hsien-chih (1875 ed.), 4:9-10.

[19]Huang Teng-chung, "Taiwan ku-chia," Table 1 (3) for annual average price of rice in Taiwan.

[20]See Dwight Perkins, Agricultural Development in China, 1368-1968 (Chicago, 1969), pp. 14-15 for the argument of the minimum level of grain consumption.

[21]The annual time trend of storage capacity in Taiwan is a state secret. We are informed by the officials of the Taiwan Provincial Food Bureau that the storage capacity can take care for the consumption for two months. This two-month capacity is also a target in Japan.

[22]Thus ideally, our thesis can be verified or refuted if the long-run price trend data is available. Unfortunately, we do not have the price index of Szechwan during the entire period. Chuan Han-sheng has constructed some price index series averaging out seasonal fluctuation for the lower Yangtze area in the eighteenth century and for Szechwan in the late nineteenth century, see Chung-kuo ching-chi-shih lun-ts'ung, pp. 475-566; 767-776. The long-run price trends are determined by monetary factors associated with international trade and silver import and export. The curve ABCD in Figure 6 reflects only the pattern of long-run price trend for the country as a whole as compiled by Yeh-chien Wang, see "The Secular Trend of Prices during the Ch'ing Period," Journal of the Institute of Chinese Studies of the Chinese University of Hong Kong, 5.2 (1972), 362. That trend price declines during the SRP and increases during the other two phases is a mere historical coincidence from the viewpoint of our analysis.

[23]For example, at the reign of the Wen Emperor of Sui (581-604), the total quantity of grain in stock was so large as it was said that it could provide for the need of fifty years. See Ch'ien

Mu, Kuo-shih-ta-kang (An outline of Chinese history; first ed., 1940, Taipei ed., 1966), p. 274. For such a huge stock, it is mathematically impossible to rotate the grain over a three-year cycle. This technical difficulty alone is sufficient to induce the government to use the grain before the quality deteriorates. This is perhaps a major reason that led to the various social overhead construction projects (digging canal, constructing palace etc.) legendarily launched by Emperor Yang of the Sui dynasty.

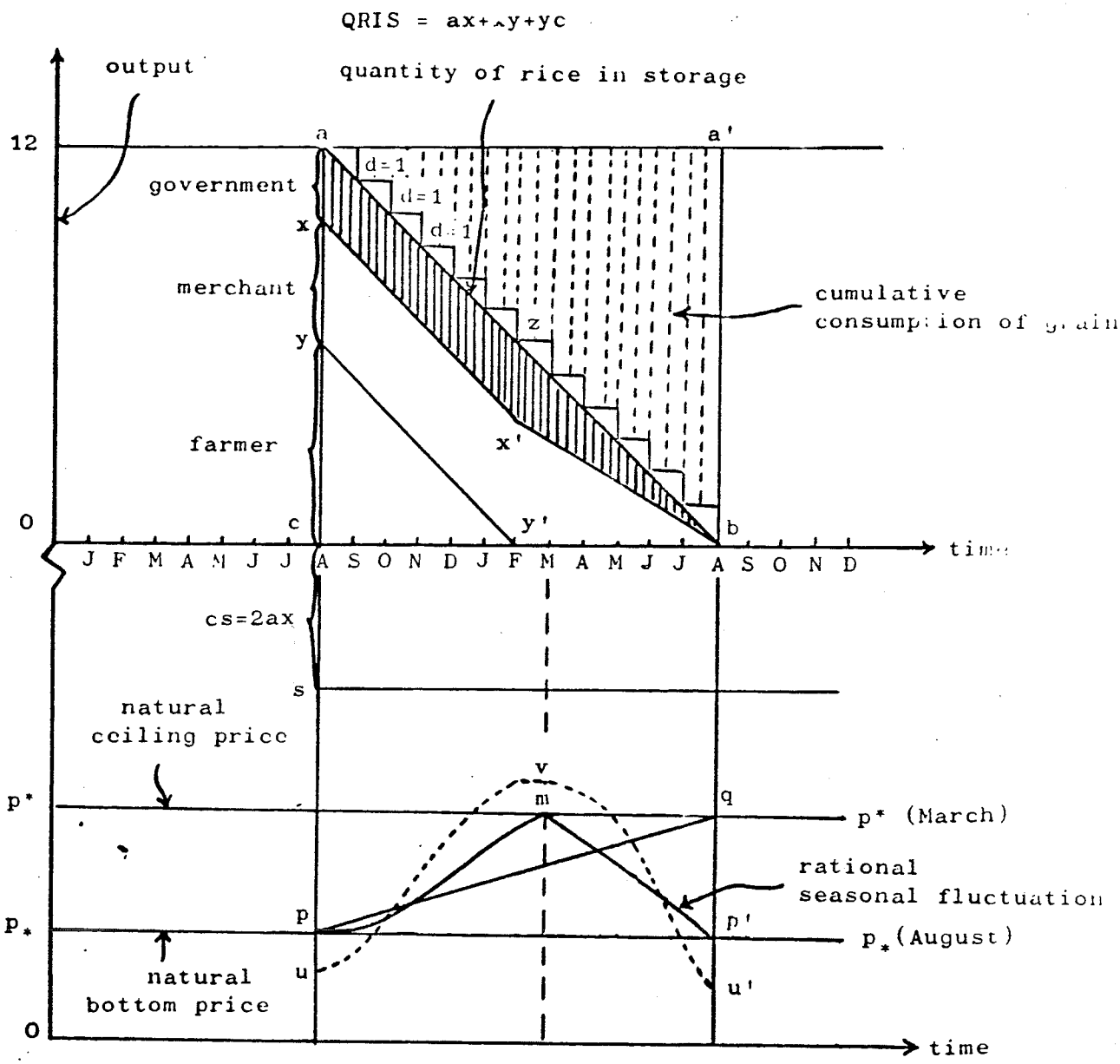

Figure 1. Natural Seasonal Fluctuation

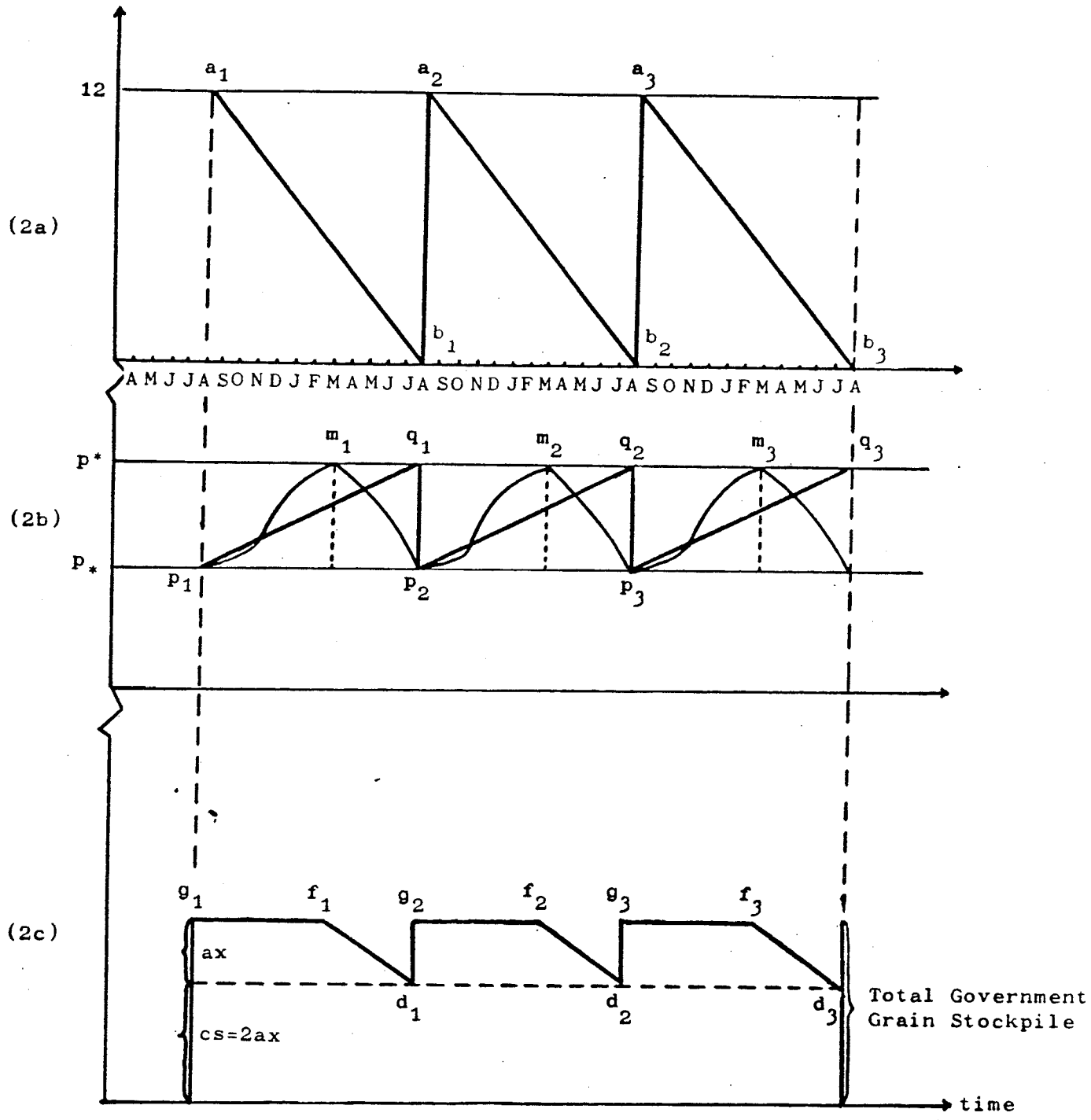

Figure 2. Fluctuations with Constant Periodicity and Amplitude

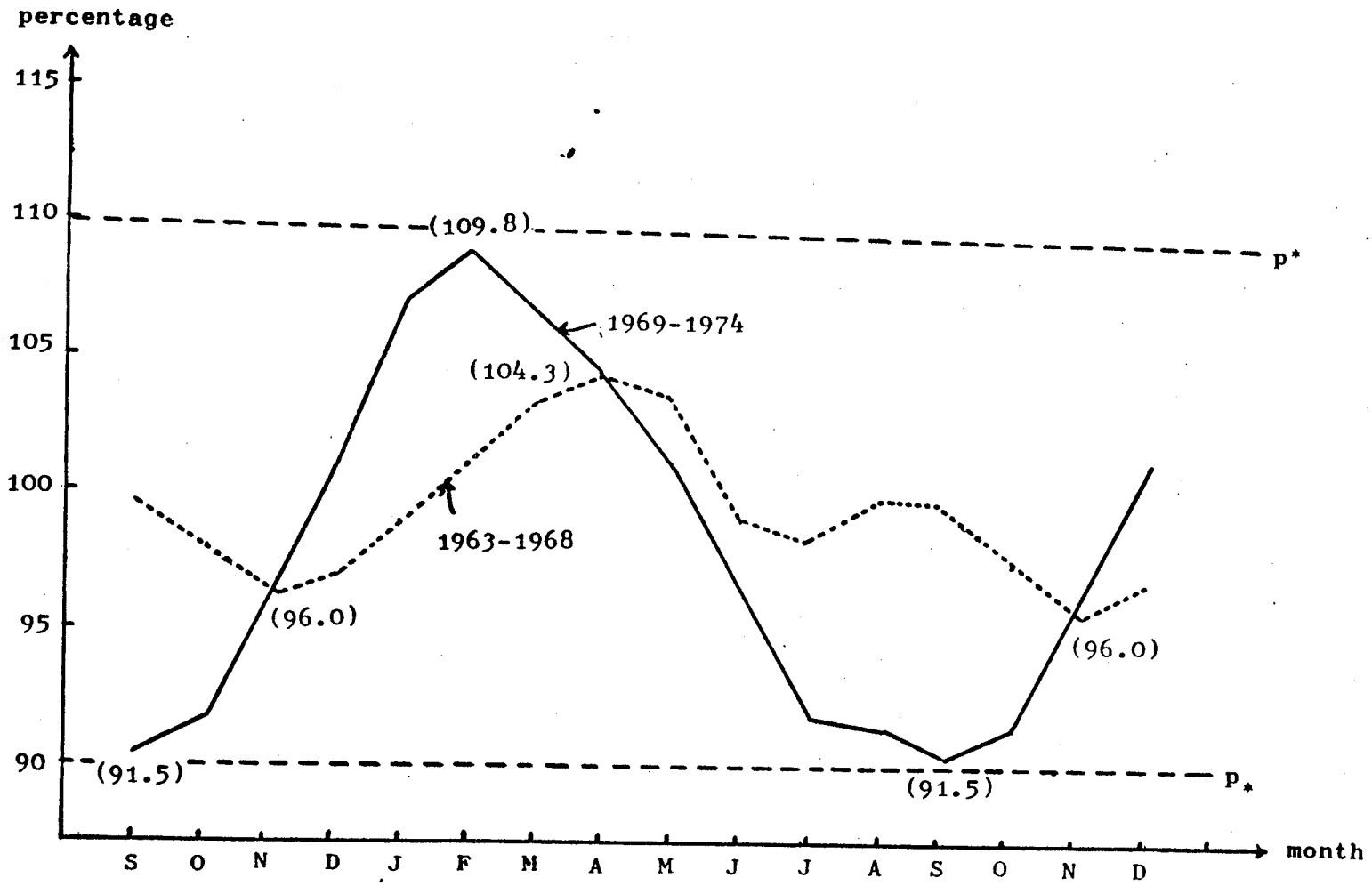

Figure 3. Seasonal Price Movement of Rice in Taiwan

Source: Original diagram provided by Mr. Huang Teng-chung, Statistics Office Chief of Taiwan Provincial Food Bureau.

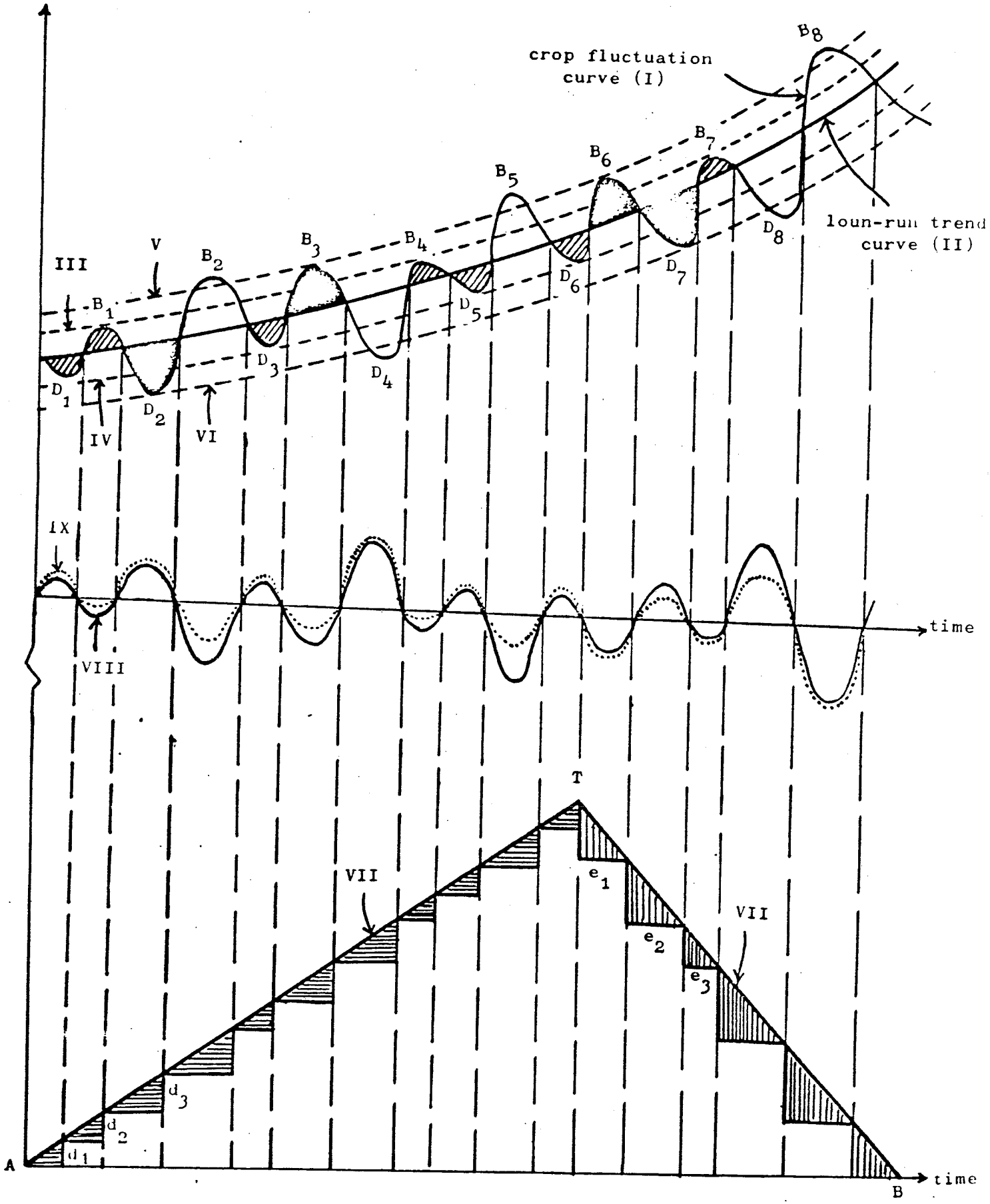

Figure 4. Cyclical Fluctuations

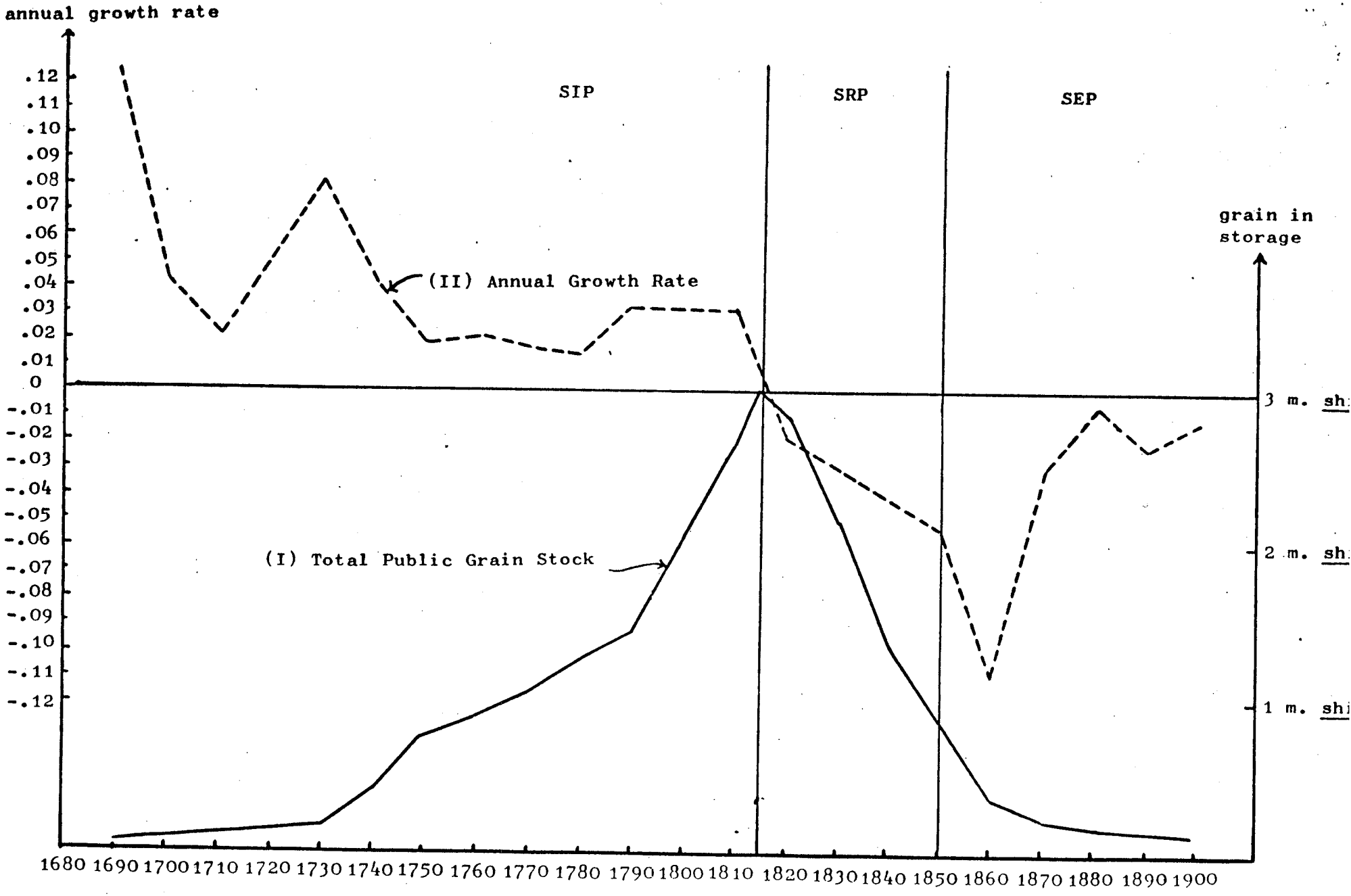

Figure 5. Changes of Quantity of Rice in Storage in Szechwan

Source: See Appendix I, Table 2.

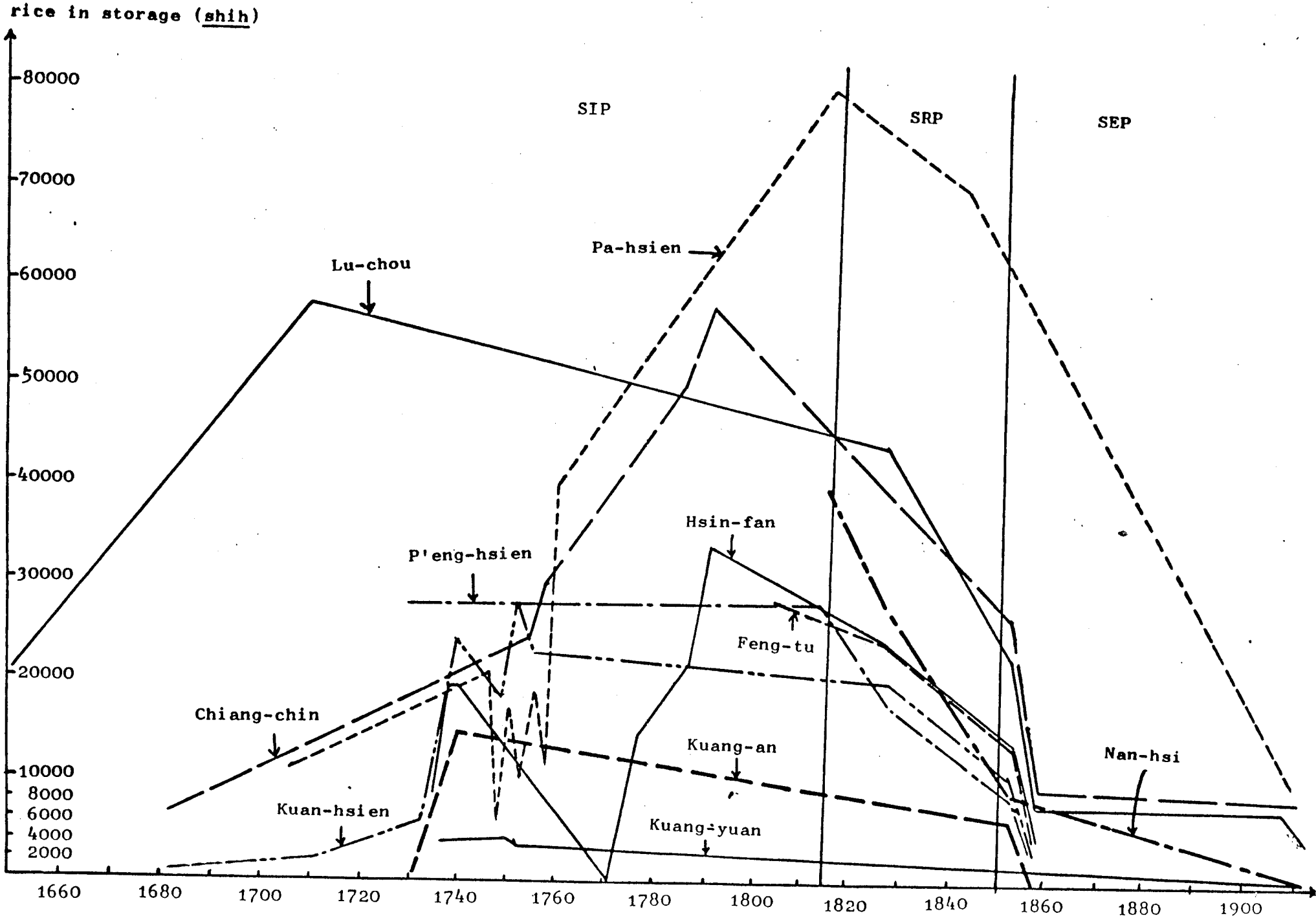

Figure 6. Quantity of Rice in Storage in Ten Counties in Szechwan

Figure 6 (continued)

Source: (the number in parenthesis is the year of edition)

Hsin-an HC (1873), 4:15-16

Kuan HC (1786), 6:1-4; (1894), 2:9-10.

P'eng HC (1878), 4:38-39.

Pa HC (1760), 3:33-36; (1939), 4B:39-40.

Chiang-chin HC (1875), 4:9-13.

Kuang-yuan HC (1757),5:41; (1940), 13:106-107.

Huang-an CC (1907), 17:2-4.

Nan-hsi HC (1874), 3:1-3; (1937), 2:28-29.

Lu HC (1938), 3:10-11.

Feng-tu HC (1826), 4:17-19; (1893), 2:30-31.

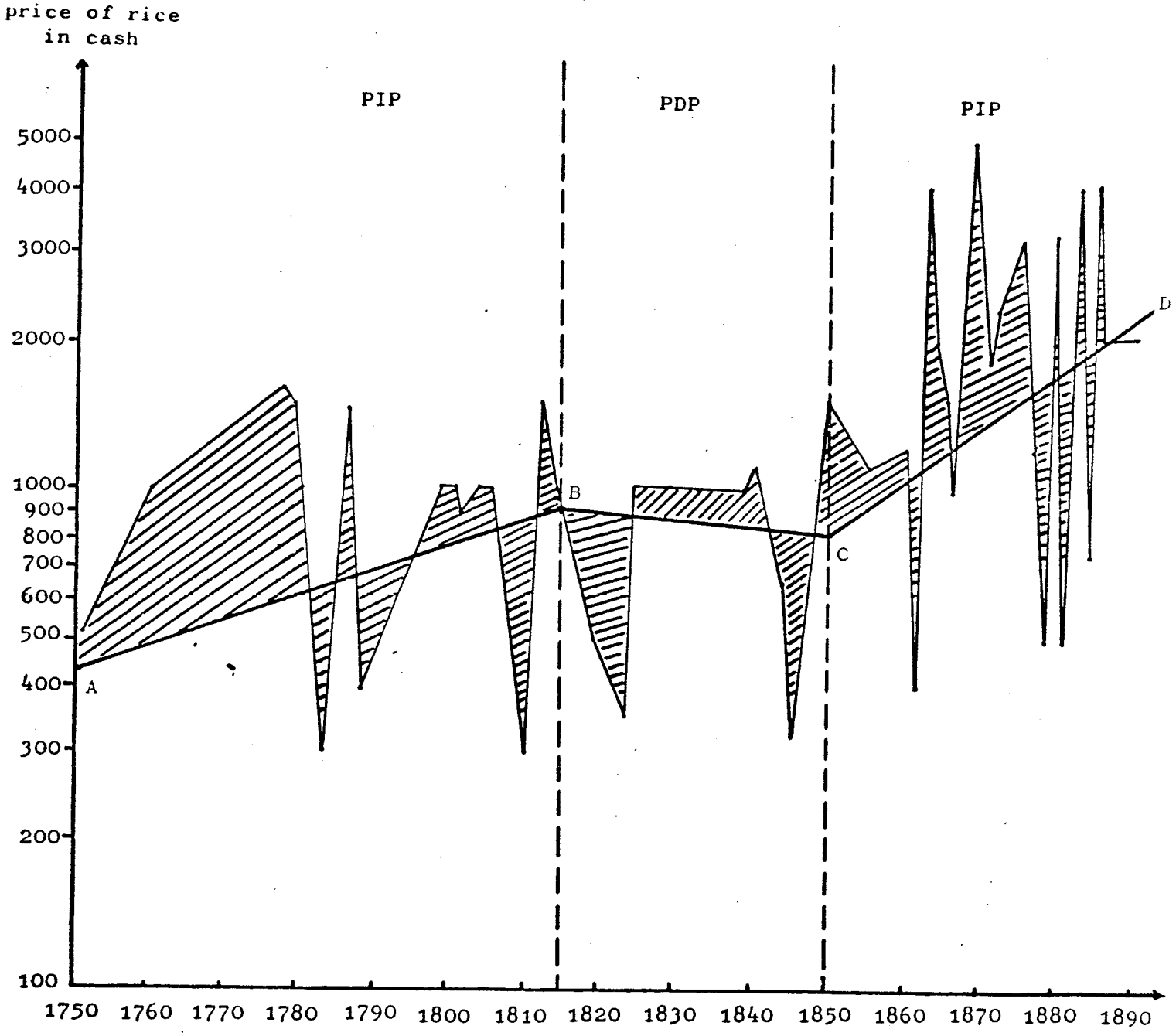

Figure 7. Fluctuations of Rice Prices in Szechwan

Source: See Appendix I, Table 3.