

Size and Duration of Empires Growth-Decline Curves, 3000 to 600 B.C.

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Area changes of about 30 best known empires and states are compiled and tabulated. Superimposed and juxtaposed graphs (size versus time) help to visualize the relative size and location in time of these empires. Size-time integral, maximum stable size, adulthood date, and duration are defined operationally and are listed for 20 empires. A criterion is given for distinctness of successive empires. The size-time integral is a direct measure of an empire's impact on history insofar as that impact depends on sheer size and duration. The integral is largest for the Chinese Hsia-Shang, Egyptian New, Old, and Middle, Assyrian New, and Hittite empires. A world-wide territorial concentration index is tabulated. It increases during the period considered from 0.08 to 1.4% of the world dry land area.

The general objective of this study is to analyze recurring patterns in growth and decline of empire areas throughout history. The specific objective of this paper is to report and to analyze detailed data for the period ranging from 3000 to 600 B.C.

The motives for studying the area changes of empires were given in an earlier paper (Taagepera, 1978) which also reviewed previous work, defined various terms, and documented an increase in the size of the world's largest empires throughout history. Within this relatively steady increase three distinct phases could be distinguished on the basis of sudden size increases. The present paper deals in detail with the first of them. This phase started when the building of cities and occupational differentiation gave rise to the first recorded states or empires of more than 0.3 million km² and ended when improvements in power delegation ability rapidly raised the maximum empire size from 1.3 to 5 million km² around 700 to 500 B.C. Numerical data are tabulated for all empires and states, provided that

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information is available. An overview graph shows the relative sizes and positions in time of the various empires. Terms such as duration, maximum stable size, and size-time integral are defined and tabulated for all empires. Later papers will give similar data for later time periods and will extend the general systematics.

“Empire” designates here any relatively large sovereign political entity whose components are not sovereign, irrespective of this entity’s official designation or internal structure. During the period considered we will regard any organized entity of more than 25,000 km² as “large” compared to the predominant tribal organization of the time. Because of the paucity of historical information, we effectively include all entities on which there is sufficient information.

Empire size is defined as the dry land area it controls. For the sake of easy comparability, size will always be measured in megameters squared, abbreviated as “Mm².” Since 1 Mm = 1000 km, we have 1 Mm² = 10⁶ km² = 2.59 million mi².

In case of gradually increasing or decreasing control by an empire over a territory, our area count tries to use the earliest dates at which such trends become noticeable. In the case of vague spheres of influence and control of uninhabited deserts, average areas shown by historical atlases are accepted. In cases of feudal decentralization, the larger entity is still considered as a whole, if it tends to outlast its smaller quasi-independent components. For a longer discussion of these problems, see Taagepera (1978).

Empire areas are measured on maps in historical atlases or maps constructed on the basis of history texts and encyclopedias, using a planimeter or square-counting techniques (for details see Taagepera, 1968, 1978). Many history books report conquests of cities or provinces which do not show on their maps, either through neglect or because the location is unknown. The profusion of such contentless names should be avoided, or our ignorance of the location should be indicated.

Problems will arise regarding empire continuity and identity during temporary internal breakdowns and foreign conquests. What distinguishes a temporary breakdown from a complete one during which continuity is lost, although a new entity may eventually form within the same geographical theater? Our estimates of the duration of empires will depend in a crucial way on such questions of continuing identity. Further complexity is added when foreign conquerors gradually become acculturated. We will tackle such questions in the context of Egyptian data that will be considered next.

EGYPT: PROBLEMS OF EMPIRE CONTINUITY

Ancient Egypt was the first civilization to develop an empire extending beyond the vicinity of a particular city. Table 1 shows the data on this area

TABLE 1
Egypt

Date (B.C.)	Area (Mm ²) ^a	Reference ^b	Notes
3200	0.00	a,b	City culture starts.
3000	0.10 ± 0.05	a	Separate Upper and Lower Egypt formed.
	0.05 ± 0.03		
2900	0.10 ± 0.05	b	Unification starts.
	0.10 ± 0.05		
2850	0.25 ± 0.1	a,c	Old Empire: unification completed
2400	0.4 ± 0.1	d	Peak size: advance into Sinai, Nubia.
2300	0.25 ± 0.1	a,c	Feudalization. Independent South.
2200	0.08 ± 0.05	a	Largest fragment size estimated.
2050	0.15 ± 0.05	a	Middle Empire: unification starts.
1850	0.5 ± 0.1	a,e	Peak size: 2nd Cataract, Nubia, Sinai held.
1750	0.4 ± 0.15	a	Disturbances start.
1650–1570	0.00	a	Hykso conquest. First horse chariots.
1550	0.4 ± 0.15	a	New Empire: Hyksos expelled.
1500	0.65 ± 0.15	a,c,e	Palestine, 3rd Cataract held.
1450	1.0 ± 0.3	a,c,e	Peak size: 4th Cataract, Syria held.
1400	0.9 ± 0.3	a,d	Slow retreat from Asia starts.
1350	0.8 ± 0.3	a,d	Consolidation after disturbances.
1300	1.0 ± 0.3	a	Syria retaken. Reference (d): 0.4 Mm ² .
1275	0.9 ± 0.3	a,f	Syria divided with Hittites.
1150	0.65 ± 0.25	a,c	Asia, Nubia lost.
1000	0.4 ± 0.15	b	Delta independent.
900	0.15 ± 0.07	b	Largest fragment size estimated.
800	0.00	b	Gradual Ethiopian control.
715	0.5 ± 0.1	b	Late Period: consolidation under Ethiopian 25th Dynasty.
665	0.00	a,b	Assyrian conquest.
655	0.5 ± 0.1	a,b	Emancipation from Assyria.
550	0.65 ± 0.15	a,g	Last peak. Sea power.
525	0.00	a,c	Persian conquest.

^a Areas are expressed in megameters squared (Mm²).

^b References listed; a, Kinder and Hilgemann (1964); b, Otava (1970); c, Encyclopaedia Britannica (1968); d, Leonhardt (1951); e, Stier *et al.* (1963); f, Engel (1953); g, Roolvink (1957); h, Hammond (1968); i, Muir (1961); j, Gustafson (1974); and k, Puhvel (1964).

variation from the creation of the first known states up to Egypt's final loss of political identity in 525 B.C. Historical maps are the preferred data source, with intervening gaps filled out using narrative history. For 1300 B.C., however, a period of reconsolidation according to all narrative sources, the map in Leonhardt (1951) shows a decreased area. Such discordant map measurements are ignored in the main list but are shown in the notes part of Table 1.

During early and disturbed periods information on area is very vague. The degree of control over desert areas remains a permanent problem. We

may only presume that consolidation of central power in the Nile valley also makes wider stretches of wasteland subject to control, at least in the sense of denying control to anybody else. Isolated campaigns present further problems: The royal chroniclers may present their king's expeditions as durable conquests while actual control may fade as soon as the campaign ends.

Such uncertainties are expressed in Table 1 by wide error margins. The value of $1.0 \pm 0.3 \text{ Mm}^2$ for 1450 B.C. means that the area could be as high as 1.3 Mm^2 if one chose to include liberal amounts of desert areas and one-campaign conquests; it could also be as low as 0.7 Mm^2 if one chose to include well-controlled areas only. Note that subsequent choices must be consistent: One cannot pick the lowest allowed value for 1450 B.C. and the highest allowed value for 1400 B.C.

The recording of error margins may be disturbing to the nonscientific reader, who might prefer that the author either presented his best average guess as absolute certainty or else admitted that control of area is an "intangible" that cannot be measured. But the truth is inbetween certainty and ignorance. In scientific measurement indication of possible error range is almost as important as that of the mean value. Rather than being ashamed of a wide error margin, I have tried, on the contrary, to keep it sufficiently wide so that no informed estimate should fall outside this margin.

There are more serious problems with identifying distinct empires within Egyptian history. Traditionally Old, Middle, and New Empires are distinguished along with a Late Period, implying that the interlude periods between them were severe enough to disrupt a continuous identity. There are, however, also breakdown periods within the duration of the Empires thus distinguished. We need operational quantitative rules to reflect the intuition of historians. The main consideration might be the relative duration of breakdown compared to previous undisturbed empire duration. A 50-year breakdown may be negligible in face of a previous 1000-year duration, whereas a 5-year breakdown may change the identity of an empire which has lasted only for one ruler's lifetime. We will rather arbitrarily consider an empire defunct when breakdown endures for more than 30% of the empire's previous duration. This is still imprecise because duration has not been defined operationally. An unambiguous criterion will be given toward the end of this paper.

Further identity problems arise from gradual assimilation of foreign rulers. The Hykso invasion clearly represented a discontinuity that completed the decay of the Middle Empire. But the Hyksos gradually adopted the Egyptian culture. Should the start of the New Empire be counted from the time Hyksos were expelled, or should the Hykso period already be counted as the beginning of the New Empire? In other words, did Ahmose carry out a war of national liberation in 1570 B.C., or did he merely evict a

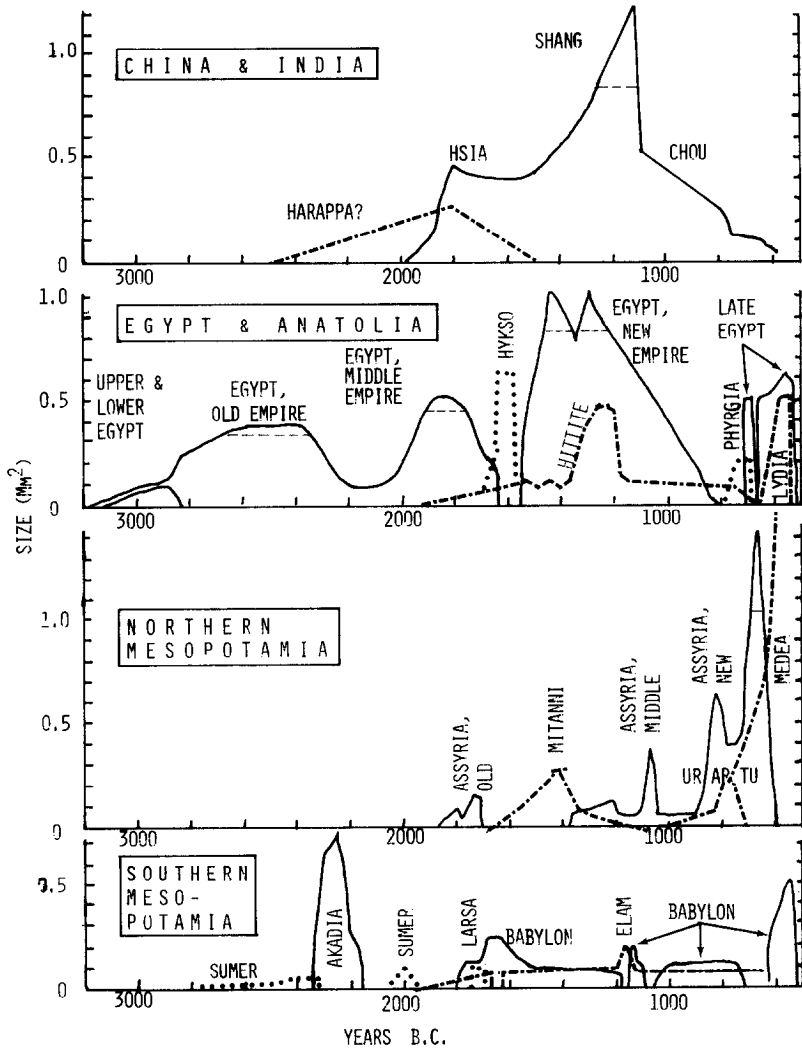


FIG. 1. Growth–decline curves of empires 3000 to 500 B.C. The data are taken from Tables 1 to 5. The horizontal dashed lines across peaks indicate stable maximum size as defined in text.

dynasty and start a new one? Those questions may be considered sophistry, and I would gladly bypass them, if the numerical value of the duration of Egyptian empires did not depend on the answer: If the Hyksos were considered quickly assimilated, then the Middle and New Empires might be considered as a single empire of record duration. In Table 1 the Hykso period is considered as establishing a break in the continuity of the

Egyptian empire, because some of the Hykso power base still seems to have remained outside Egypt, in Syria–Palestine. Similarly, the Ethiopian control prior to 715 B.C. is counted as non-Egyptian because it apparently was exerted from the outside. The ethnically Ethiopian 25th Dynasty is counted as Egyptian, however, because in spite of origin these rulers did not seem to control any areas outside the traditional Egypt.

Despite foreign raids into Egypt and Egyptian raids into neighboring areas, the control over a given region tended to be rather stable over relatively long time periods. However, in Mesopotamia, the region that we will consider next, some huge empires rose and fell in a matter of years.

Figure 1 shows the areas of Egyptian and of all other empires plotted versus time. For the sake of clarity four different plots are made, but all have the same time and size scales. All sizes and durations in Fig. 1 are thus directly comparable to each other.

MESOPOTAMIA

City culture started in Mesopotamia at least as early as in Egypt, but the political pattern was different. In Egypt the main objective of loyalty was the country or, more precisely, the Nile valley which demanded cooperation for irrigation. The cities existed for the convenience of the countryside and its rulers, and were often abandoned in favor of new sites. Political infighting involved factions, dynasties, and leaders but rarely cities as such. In Mesopotamia, however, the city was the prime object of loyalty (Franfort, 1951). For a long time states remained small areas around cities. Later conquests of larger areas were usually of brief duration. The tables were often turned, with the dominant city–region of yesterday becoming the dominated one today, and vice versa. The special problem with Mesopotamian data is that empires rise and fall so rapidly that it is hard to keep track of all of them and not to assign the same area to different empires simultaneously. Historical atlases attempting to show the predominant pattern of a period are in a quandry because no pattern really prevails; this sometimes results in showing two entities on the same map both at their maximum size, one of which waned a century before the other one expanded. Conquests often amounted to military expeditions during which cities were besieged, taken, and destroyed, without any subsequent machinery of administrative control beyond tributes paid as long as the impact of terror lasted.

The curves illustrated in Fig. 1 show the difference between Egypt and Mesopotamia: The broad massive peaks of Egyptian empires contrast with the sharp narrow needles of the Mesopotamian empires.

Table 2 records the data for the empires whose core areas were located

TABLE 2
Southern Mesopotamia

Date (B.C.)	Entity	Area (Mm ²)	Reference ^a	Notes
3200	Sumer	0.00	a	City culture starts.
2800		0.01 ?	a	Early city dynasties start: Kish.
2500		0.03 ?	a	Kish, Ur, Lagash city states.
2400		0.05 ± 0.03	a	Lagash holds all Sumer.
2330		0.00	a	Conquest by Akadia.
2350	Akadia	0.03 ?	a	Rule of Sargon I starts.
2300		0.65 ± 0.15	a	Mesopotamia held.
2250		0.8 ± 0.15	a,d,e	Advance into Arabia, Zagros.
2200		0.25 ± 0.15	a	Decline.
2150		0.00		Conquest by Gutians.
2050	Sumer	0.03 ?	a	Reestablishment: Late Sumer.
2000		0.10 ± 0.05	a	Peak.
1950		0.00	a	Collapse.
1750–1700		0.10 ± .05	a	Rimsin of Larsa.
1800	Babylon	0.03	f,c	
1760		0.15 ± 0.05	f,c	
1730		0.15 ± 0.05	f,c,a	Hammurabi's rule starts.
1690		0.25 ± 0.10	f,d,a	Peak size.
1530		0.10 ± 0.03	a	Kassite rule starts.
1400		0.10 ± 0.03	d,j	
1160		0.00	a	Conquest by Elam, until 1140 B.C.
1130		0.20 ± 0.05	a,d	Peak size under Nebukadnezar I.
1100		0.00	a	Assyrian control until 1050 B.C.
1050		0.15 ± 0.08	a	Reemancipation.
820		0.15 ± 0.08	a	Supports Assyria against Medes.
729		0.00	a	Assyrian control.
625		0.15 ± 0.05	a	Independence from Assyria.
610		0.25 ± 0.15	h,g,i	New Babylonian Empire.
562		0.5 ± 0.15	h,g,i	Peak size. Nebukadnezar II dies.
539		0.00		Persian conquest.
1700	Elam	0.08 ± 0.03	d,b	First mention around 2000 B.C.
1690		0.00	a	Babylonian control until about 1630 B.C.
1400		0.10 ± 0.03	d	
1160		0.20 ± 0.03	d,a,b	Babylon conquered.
1140		0.08 ± 0.03	a	Retreat to core area.
639		0.00	b,a	Conquest by Assyria, then Persia.

^a Reference code: See Table 1.

TABLE 3
Northern Mesopotamia

Date (B.C.)	Entity	Area (Mm ²)	Reference ^a	Notes
1850	Assyria	0.03	a	Old Assyrian expansion starts.
1800		0.10 ± 0.05	f,a	Northern Mesopotamia held.
1780		0.05 ± 0.03	a	Hittite attacks.
1730		0.15 ± 0.03	f	Shamshiad I.
1700		0.00	a,c	Babylonian, then Mitanni control.
1375		0.05	a,d	Middle Assyrian empire independent.
1250		0.15 ± 0.05	a,d	
1150		0.05	a,d	Aramaic invasion.
1080		0.4 ± 0.1	f	Tiglalpileser I. Peak size.
1050		0.05	c,a	Retreat to core area.
900		0.05	a	New Assyrian Empire starts.
880		0.15 ± 0.03	h,c	
860		0.4 ± 0.15	h,c,a	First cavalry.
824		0.65 ± 0.15	h,c,a	Advance into Syria. Peak size.
750		0.4 ± 0.15	a,h	Losses to Urartu.
727		0.6 ± 0.2	h,a,i	Syria, Palestine held.
700		0.9 ± 0.2	h,a	Hittites, Urartu conquered.
670	1.4 ± 0.3	h,i,e,d,f	Egypt held. Peak size reached.	
655	1.0 ± 0.2	a,i	Egypt lost.	
625	0.8 ± 0.1	a	Babylonia independent.	
616	0.5	c	Decay.	
608	0.00	a	Destruction by Medea and Babylonia.	
1700	Mitanni	0.00	d	
1450		0.3 ± 0.1	d,a	Peak size until 1375.
1360		0.05 ?	a	Destruction by Hittites.
1100		0.00		Assyrian conquest.
1200	Urartu	0.02	a	Formation of Curriti kingdoms.
830		0.08 ± 0.05	a	<i>Urartu Empire</i> starts.
800		0.20 ± 0.08	a	Peak size.
750		0.15 ± 0.05	a	Decline starts.
714		0.00	a	Assyrian conquest.

^a Reference code: See Table 1.

in Southern Mesopotamia: the Sumer–Akadia–Babylon main line plus the more marginal, little-known but durable Elam toward the East. Table 3 has similar data for empires with a Northern Mesopotamian (or even East Anatolian) home base: the succession of Assyrian empires plus Mitanni and Urartu toward the North. A large number of other Mesopotamian city states are known, and some of them (like Mari) may at times have been relatively large, but area data are insufficient. The same applies to Aramaic states to the West (which seem to be small) and to mountain

TABLE 4
Anatolia-Syria

Date (B.C.)	Entity	Area (Mm ²)	Reference ^a	Notes
2000	Hittites	0.00	k,a	Arrival.
1750		0.05 ± 0.03	k	
1650		0.08 ± 0.03	k,d,a	Creation of Old Empire.
1530		0.15 ± 0.03	k,a	Peak size.
1450		0.15 ± 0.03	a	New consolidation.
1380		0.15 ± 0.03	a,k	Start of New Empire.
1350		0.25 ± 0.03	k	
1330		0.35 ± 0.03	k	
1300		0.40 ± 0.03	k,d	
1250		0.45 ± 0.05	k,f	
1220		0.45 ± 0.05	k	
1190		0.15 ± 0.05	k,a	Collapse: attacks by Sea People.
710		0.00	k	Assyrian conquest.
1630	Hyksos	0.08 ± 0.05	e,a	Churrites in Syria.
1650		0.65 ± 0.15	e	Egypt conquered.
1570		0.08 ± 0.05	e,a	Egypt lost.
1550		0.00	a	Egyptian advance into Syria.
800	Phrygia	0.02	a	Formation.
750		0.20 ± 0.08	a	
700		0.00	a	Collapse.
700	Lydia	0.02	a	Formation.
650		0.15 ± 0.08	a	
585		0.5 ± 0.15	a	Peak size reached.
546		0.00	a	Persian conquest.

^a Reference code: See Table 1.

people (such as Gutians and Kassites) to the East. The latter, though dangerous adversaries for the Mesopotamian states, did not seem to have any political organization beyond the tribal level before the development of the Medean empire. The question arises of how to treat conquests of Mesopotamian states by such tribes. In this paper the conquest of Akadia by Gutians (2150 B.C.) has been considered as an empire breakup with no new empire formed. The Kassite takeover of Babylon (1530 B.C.), however, has been considered as a continuation of Babylon under foreign rule. We are back to the problem of Hykso and Ethiopian rules in Egypt.

ANATOLIA AND SYRIA

The major Anatolian empire is that of the Hittites, with later brief appearances of Phrygia and Lydia. The East Anatolian empires of Mitanni and Urartu have been discussed in the Mesopotamian context. Hyksos are included because their core area was in Syria. The data are recorded

TABLE 5
China^a

Date (B.C.)	Area (Mm ²)	Notes
1900	0.10 ± 0.05	Prehistorical Hsia Dynasty.
1800	0.45 ± 0.10	
1700	0.40 ± 0.10	
1300	0.7 ± 0.1	Shang Dynasty since 1500 B.C.
1122	1.25 ± 0.15	Turkish Western Chou conquest.
1050	0.55 ± 0.10	Feudalization.
800	0.25 ± 0.10	
770	0.15 ± 0.05	Eastern Chou Dynasty starts.
600	0.05 ± 0.03	Central power fades; about 100 states.

^a References used: Herrmann (1966), Kinder and Hilgemann (1964), Eberhard (1950), and Holsti (1967).

in Table 4, and the corresponding curves are again shown in Fig. 1. The epitome of the aforementioned Mesopotamian practice of conquest without permanent administration is the ephemeral Hittite conquest of Babylon (1531 B.C.), 500 miles from the closest Hittite-held territory.

CHINA AND INDUS

Table 5 shows the data for China. The plot given in Fig. 1 shows an even more massive single peak than is the case for Egypt. This lack of detail may be real or due to my insufficient knowledge of such details.

The Harappa culture in the Indus valley presents a major problem. City culture started around 2500 B.C., and the castles of city rulers are well in evidence. The identity and the territorial extent of these states are, however, not known. At a later period such a little-known culture would merely be ignored in our study because it is safe to guess that its states would not be among the largest ones of the time. But such a guess would not be safe in the Harappa case: With the post-Akadian Mesopotamia fragmented and with Egypt undergoing the interlude between the Old and Middle Empires, even an empire of modest size in the Indus valley could have been the world's largest around 2100 B.C. At the least, Harappa is likely to have had city states of the size of the Sumer ones. At the other extreme guess, the whole Indus Valley could have been at time united, as was the Nile valley. The tentative curve shown in Fig. 1 represents an intermediate guess.

SIZE, DURATION, AND SIZE-TIME INTEGRAL

To compare the various growth-decline curves given in Fig. 1, these curves should be characterized in terms of duration and maximum size of empires. This is not as easy as it may look. The maximum size is well

defined when the peak is flat (Egyptian Old Empire). When the peak is narrow, however, should we take into account the areas held fleetingly for a few years only (e.g., Assyrian conquest of Egypt), or should we try to indicate some sort of *stable* maximum size? If so, how should we draw the line between temporary campaigns and stably held territories?

As for duration, it is well defined when a state rises and falls suddenly between two foreign occupations (e.g., New Babylonian Empire). But how should it be defined when an empire slowly consolidates itself before emerging into history's limelight and then fades again into obscurity (e.g., the Hittites)? Following the practices of physics and engineering the "half-width" could be used, i.e., the duration of an empire at more than half of its maximum size. We are back to the problem of defining a meaningful stable maximum size.

The area under the size curve is much easier to define, and it also has a noteworthy meaning: It expresses the total extent of an empire both in space and in time. Some empires (such as the Egyptian Middle Empire) have a fairly large area under their curve in Fig. 1 because they last fairly long at a moderate size. The New Assyrian empire has an equally large area under the size curve despite its brief duration, because it reaches a huge size. The Hittite empire has a similar area under the curve by combining a brief peak with very long duration at a small size. To the extent that an empire's impact on world history depends on how much space it occupies for how long, the area under the size curve expresses that impact. In mathematical terms this area is the integral of size over time. When size is measured in megameters squared and time in centuries, then the size-time integral (I) has the units of square megameter-centuries (Mm^2C). Its values for various empires are shown in Table 6.

The problem of whether to exclude brief conquests and campaigns solves itself, insofar as the integral is concerned; such conquests are included but the addition to the total I -value may be negligible. Long and obscure formation and fading periods still present problems, e.g., in the Hittite case where the small size periods contribute as much to the total I as the better known peak period. In most cases, however, I can be measured unequivocally by square counting or other techniques applied directly to the curves given in Fig. 1. The error range must be expected to be large, since the error in I combines the errors made in estimating the sizes and the time periods.

The space-time integral enables us to define a maximum stable size (M) and a duration time (D). First, M is defined as the size level such that only 5% of the curve's I -value occurs above that level. In actual determination the level in Fig. 1 is gradually lowered until the area between the curve and the level becomes 5% of the empire's I -value. For some major empires the M -level is shown in Fig. 1 by a horizontal dashed line crossing the peak. For flat peaks (such as the Egyptian Old Empire) M is practically at the peak level. For sharp peaks (such as the New Assyrian Empire) an

TABLE 6
Size and Duration Characteristics of Empires^a

Empire	Core location	Size-Time integral <i>I</i> (Mm ² C)	Maximum stable size <i>M</i> (Mm ²)	Adulthood date <i>A</i> (B.C.)	Duration time <i>D</i> (centuries)
Hsia-Shang	China	6.2	0.85	1350	4
New Empire	Egypt	4.4 ± 1.3	0.8 ± 0.2	1500	5
Old Empire	Egypt	2.3	0.35	2800	5
New Assyrian	Mesopotamia	1.7	1.0	700	0.8
Middle Empire	Egypt	1.5	0.45	2000	3
Hittite	Anatolia	1.5	0.4	1320	1.3
Harappa	Indus	1.3 ?	0.2?	—	—
Late Period	Egypt	1.0	0.5	715	1.9
Akadia	Mesopotamia	0.8	0.65	2310	1.0
Babylon (Hammurabi)	Mesopotamia	0.8 ± 0.3	0.2 ± 0.05	1700	2
Elam	Mesopotamia	0.8 ± 0.3	0.1 ± 0.03	1600	10 ?
Hyksos	Syria	0.5	0.6	1650	0.8
Lydia	Anatolia	0.5	0.4 ± 0.1	610	0.6
Mitanni	Mesopotamia	0.5 ± 0.2	0.25	1500	1.4
Middle Assyrian	Mesopotamia	0.45	0.25	1090	0.5
New Babylon	Mesopotamia	0.4	0.45	610	0.7
Babylon	Mesopotamia	0.4 ± 0.15	0.12 ± 0.05	1000	2.5
Urartu	Mesopotamia	0.25	0.18 ± 0.05	810	0.9
Phrygia	Anatolia	0.15 ± 0.05	0.18 ± 0.05	760	0.6
Old Assyria	Mesopotamia	0.12 ± 0.05	0.12	1800	1.0

^a Empires are listed in decreasing order of size-time integral. Entities with $I < 0.1$ or $M < 0.1$ are omitted. The data are taken from previous tables and from measurements based on Fig. 1. Possible error range on I and M is 20%, unless a wider range is shown, and 10% on D .

appreciable but operationally well-defined section of the peak is neglected. Errors in I have a blunted impact on M : An error of 30% in New Assyria's I -value would alter its M by less than 10% (assuming that the upper peak shape remains the same). The 5% level used in the definition of M is of course arbitrary. Using, for example, 2% instead would, however, alter the M levels only marginally.

Duration also can now be defined. First, "adulthood date" (A) is defined arbitrarily as the date at which an empire first reaches 80% of its eventual M , and "failure date" (F) is defined as the time when, after reaching M , the curve again for the first time falls to 50% of M . Duration is defined as the interval from A to F : $D = F - A$. Although the levels 0.8 and 0.5 M are chosen arbitrarily, they seem to express best what is felt to be important about empire size curves. The reason for not choosing 0.5 M for both definitions (as usual for half-times in engineering) will become clear in subsequent papers where we also define a "growth time," a notion of little use in early history because growth curves cannot be determined with sufficient precision.

The values of M , A , and D are listed in Table 6, and the value of F can

be easily found from $F = A + D$. A sample calculation will clarify the use of the definitions. Square counting in Fig. 1 yields $I = 4.4 \text{ Mm}^2\text{C}$ for the Egyptian New Empire, 5% of which is $0.22 \text{ Mm}^2\text{C}$. The level above which $0.22 \text{ Mm}^2\text{C}$ of the integral area is located is determined by square counting in Fig. 1 to be at 0.85 Mm^2 . Hence $M = 0.85 \text{ Mm}^2$. The level $0.8M = 0.68 \text{ Mm}^2$ is first reached by the curve around 1500 B.C. Hence $A = 1500 \text{ B.C.}$ After reaching the peak the curve falls to $0.5M = 0.42 \text{ Mm}^2$ around 1000 B.C. Hence $F = 1000 \text{ B.C.}$, and $D = F - A = 500 \text{ years} = 5 \text{ centuries}$.

It was stipulated earlier that two successive empires with the same core location are said to be distinct only when the gap between them lasts longer than 30% of the first empire's duration. Now this duration (D) has been defined. The gap duration (G) is measured at the first empire's $0.5M$ level. Thus, in the case of Egypt's Old and Middle Empires $D = 5$ centuries for the Old Empire. At the level $0.5M = 0.17 \text{ Mm}^2$, the gap between empires lasts for about 2.7 centuries so that $G/D = 2.7/5 = 54\%$, which is more than 30%. Hence the two empires are distinct. For purposes of measuring the I for each empire, the low point on the curve is taken as their separation date.

According to the gap criterion, all empires listed in Table 6 are distinct. The late Egyptian period is found to represent a single entity despite the 10-year interruption caused by the Assyrian conquest. In China the first break in continuity occurs around 750 B.C.

Inspection of Table 6 shows that the Hsia-Shang empire has the largest size-time integral ($6.2 \text{ Mm}^2\text{C}$) but that the total of all the Egyptian empires is even larger ($9.3 \text{ Mm}^2\text{C}$). Mesopotamian empires have a combined integral of only $5.4 \text{ Mm}^2\text{C}$, and for Anatolia it is $2.6 \text{ Mm}^2\text{C}$.

The largest stable maximum size is reached by Assyria, followed by Hsia-Shang and Egypt's New Empire. In duration Elam seems to lead by far, with 10 centuries. This apparent durability may, however, be due to our lack of information about the breakdown periods of this small entity, which for so long a time interacted with Mesopotamia. Among major regions, Egypt clearly leads in duration, with two empires each reaching 5 centuries of duration at mature size. Error ranges indicated in Table 6 must be kept in mind before overly firm conclusions are drawn.

TRENDS IN SIZE CONCENTRATION

The lowest curve illustrated in Fig. 2 shows the size of the largest empire at any given time plotted versus time. Throughout the period considered Egypt dominates: Out of the total of 24 centuries, Egypt harbored the largest empire for more than 14 centuries.

The middle curve given in Fig. 2 shows the combined area of the three largest empires at any given time. The data are listed in Table 7. The curve is smoother than the single empire curve, since empires often feed on each other. The cutoff at three empires is, however, arbitrary. Sometimes the

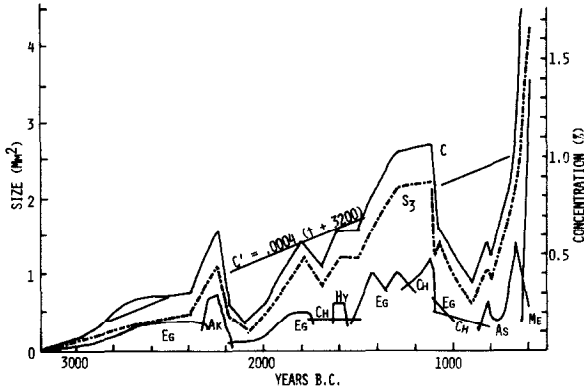


FIG. 2. Worldwide territorial concentration trends, 3000 to 500 B.C.: size of the largest empire, size of the three largest empires combined (S_3), and the concentration index (C). The data are taken from Table 7.

top three empires are of nearly equal size, whereas at other times the largest one dwarfs both runners-up. In determining the size concentration throughout time, we should take into account all empires but give the smaller ones systematically decreasing weightings. Also, the percentage of the world total dry land area would be more informative than square

TABLE 7
World Territorial Concentration Index (C),
and Combined Size (S_3) of the Three Largest Empires

Year (B.C.)	C (%)	S_3 (Mm ²)	Year (B.C.)	C (%)	S_3 (Mm ²)
3000	0.08	0.15	1600	0.61	1.25
2900	0.11	0.20	1500	0.61	1.25
2800	0.20	0.25	1400	0.83	1.8
2700	0.26	0.35	1300	0.97	2.1
2600	0.27	0.40	1200	1.04	2.15
2500	0.29	0.45	(1110)	1.05	2.15
2400	0.30	0.5	1100	0.63	1.3
2300	0.52	0.9	(1080)	0.63	1.40
(2250)	0.61	1.1	1000	0.48	1.0
2200	0.23	0.4	900	0.34	.7
2100	0.14	0.25	(824)	0.55	1.05
2000	0.22	0.5	800	0.48	.95
1900	0.42	0.8	700	0.90	1.85
1800	0.57	1.25	665	1.18	2.35
1700	0.43	0.85	600	1.45	H3

^a The data are taken from Fig. 1 and Tables 1 to 5. C (in equivalent percentage of world dry land area) was calculated using Eq. (1). A list of the three largest empires and their sizes is given in Taagepera (1978).

kilometers or megameters. A suitable index is the geographic concentration percentage used by Michaely (1962):

$$C = 100\% \cdot \left[\sum \left(\frac{S_i}{S} \right)^2 \right]^{1/2}, \quad (1)$$

where S_i is the area of a particular country and S is the world total dry land area (133 Mm², without Antarctica). The summation covers in principle all sovereign entities of the world, including tribal and isolated family possessions. Because of squaring, however, only a limited number of largest entities have a detectable effect on the value of C . This is precisely what we want to obtain, without having to impose arbitrary cutoff levels.

If one empire is much larger than all others ($S_1 \gg S_i$ for $i \neq 1$), then C equals the percentage share of that empire out of the world dry land area ($C = 100\% \cdot S_1/S$). If, however, several top empires are of comparable size, then they all boost the C -value. This value ranges in principle from 0% (when all sovereign units are infinitesimally small) to 100% (when one empire occupies the whole world).

The concentration index, C , is closely related to the Herfindahl-Hirschman index of industrial concentration and the Greenberg linguistic diversity index (both of which omit the square root and the multiplication by 100%) and to the Rae and Taylor index of fragmentation, which essentially subtracts the preceding index from unity. The notion of concentration is related but not identical to that of inequality (which can be measured using the Gini index), which would be zero, if all components were of equal size, regardless of whether these equal shares be small (low concentration) or large (high concentration). All indices mentioned here are discussed and referenced in Taagepera and Ray (1977).

A sample calculation of C for 1300 B.C. is given as follows:

Egypt	$(1.0)^2 = 1.00$
China	$(0.7)^2 = 0.49$
Hittite	$(0.4)^2 = 0.16$
Babylon	$(0.1)^2 = 0.01$
Elam	$(0.1)^2 = 0.01$
Assyria	$(0.05)^2 = 0.00$
	$\sum (S_i)^2 = 1.67$

$$C = \frac{(1.67)^{1/2}}{133} = \frac{1.29}{133} = 0.0097 = 0.97\%$$

In this example the combined effect of all empires is the same as that of a single empire of size 1.29 Mm². Note that Egypt alone is already 1.0 Mm². Neglecting Babylon, Elam, and Assyria would change C only minimally—by 0.005%. This tells us that we have not lost much by omitting even smaller empires.

The upper curve given in Fig. 2 shows the evolution of C throughout the period. The data are shown in Table 7. The pattern is quite similar to that

of three empires combined. The C -curve fluctuates about equally to the two sides of the line

$$C' = 0.0004(t + 3200), \quad (2)$$

where t is time in years, with B.C. years counted as negative. No theoretical implications should be seen in that purely empirical approximation, except that concentration has been generally increasing. A first peak concentration occurs around 2250 B.C. (with Akadia and Egypt's Old Empire), and a second one occurs around 1200 B.C. (Shang, Egypt's New Empire, and Hittites). Marked periods of deconcentration occur around 2100 and 900 B.C.

CONCLUSIONS

Available size data on all empires from 3000 to 600 B.C. have been recorded in terms of dry land area. Resulting plots of size versus time are shown in Fig. 1. They should help in visualizing the relative size and location in time of various empires. Many an empire that looms large in our traditional view of history, especially through the Biblical tradition, is seen to be rather small in size and even more so in time.

The size-time integral has been suggested as a direct measure of an empire's impact on history, insofar as this impact depends on sheer size and duration. Operational definitions of duration and of maximum stable size have been deduced from the integral, and so has a criterion for continuity or distinctness of successive empires with the same core location. All these characteristics have been tabulated for empires considered.

Apart from these characteristics of individual empires, Michael's geographic concentration index has been proposed as a measure of the territorial concentration of the world system as a whole. This index tends to increase throughout the period.

Around 800 B.C. a new power makes its appearance: Medea-Persia in Iran. By 600 B.C. its size dwarfs everything previously seen. In the time span 608 to 525 B.C. all surviving empires this side of China vanish forever under the Iranian impact. A new period is starting. Medea is shown in Fig. 1 and 2, but its size data are not listed since it properly belongs to this new period. A subsequent paper will continue the analysis of empire sizes from about 600 B.C. on.

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