Structural Change in Interdependent Bureaucracies: Was Rome's Failure Economic or Military?*

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Previous explanations of Rome's decline fail to explain the frequency of civil war and the continued survival of the Byzantine empire. This paper demonstrates that symptoms similar to those observed in the Mediterranean region over the first millennium A.D. can result from a permanent shock to a system of interdependent bureaucracies. A decrease in military scale economies will lead to a contraction of territorial boundaries and an increase in tax levels. Historical evidence suggests that in the case of Rome, the shock took the form of a series of improvements in cavalry combat. © 1990 Academic Press, Inc.

I. INTRODUCTION

What determines the limits to the sphere of operation of a bureaucracy? This question is an important one, since most units of social organization, such as firms, governments, armed forces, and religious organizations tend to be hierarchically structured. The usual answer (see Tullock, 1965, or Williamson, 1967) has been that the upper limits to organizational size are set by the loss of control that occurs as the number of vertical levels increases. Recently, attention has focused on the behavior of individuals within such hierarchies.¹ Yet although Antle (1982, 1984) and Tirole (1986) have applied game theory to multilevel contractual relations, there has been no attempt to return to the earlier question of what it is that limits bureaucratic power. Moreover, like previous studies, the more recent models invariably examine one bureaucracy in isolation, whereas actual bureaucracies are usually found in interdependent clusters.

In economic history, the interdependence of economic and military

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¹ See, for example, Breton and Wintrobe (1986).
organizations was pointed out by Douglass North (1981) in *Structure and Change in Economic History*. Observing that "successes and failures in economic organization account for the progress and retrogression of societies," he noted that it was changes in military technology that "dictated change in the size and structure of political units." This paper proposes a means of formalizing North's ideas by means of a model of two interlocking bureaucracies, one fiscal and the other military. Each is dependent on the other, the soldier relying on the tax collector for his wages and the fiscal authority depending on the proximity of military force to extract revenue from the population. It is shown that technical change in one of these hierarchies will generally influence the limits within which both bureaucracies operate. In particular, the model predicts that a decrease in military scale economies will result in a contraction of a state's territorial boundary and an expansion in the share of total income captured in the form of taxes.

This model is used to examine the causes of the decline of Roman civilization in western Europe. Military explanations for this development, based on increased external pressure, have been offered by Luttwack (1976) and Ferrill (1986). However, such theories are unable to demonstrate why this collapse was accompanied by civil conflict that was at least as destructive as external invasion. Economic explanations for the same events have been proposed by Pirenne (1925) and Bernardi (1970). However, their approach is unable to account for the continued survival of the Byzantine empire subsequent to the fall of Rome and to the later rise of Islam.

The evidence presented here supports Altheim's (1952) thesis that the crucial factor was technological change, in the form of a series of improvements in cavalry warfare. However, the importance of the change was not simply that it favored the barbarian invaders, as Altheim argued. Rather, as Bean (1973) suggested, it was that cavalry fighting offered fewer possibilities for economies of scale than infantry warfare. However, this decline in scale economies was due less to a reduced need for centralized training, mentioned by Bean, than to the ability of individual cavalrymen to fight more effectively than individual infantrymen when isolated from their comrades. The improvement in cavalry combat made it easier for small mounted units to successfully oppose large contingents of foot soldiers, thereby raising the cost of controlling a given territory. Since Rome's centralized imperial administration was unable to extract the necessary increase in tax revenues, a decentralization of decision-making was required.

II. THEORIES OF ORGANIZATIONAL CONTROL

The idea that economic theory may be used to explain organizational structures is not new. In his paper on the nature of the firm, Coase (1937, pp. 390–394) argued that the lower limit to firm size is set by transaction costs. When it is too expensive to specify the relationship between two agents by contract, one of them may simply decide to purchase the services of the other. As for the upper limit, he believed that it is determined by increasing costs of coordination as the firm grows in size. Why should coordination costs depend on the size of the organization? In his analysis of government bureaucracies, Tullock (1965, pp. 142–156, 178–192) offered an explanation. As the number of layers in a hierarchy grows, there is more chance for noise to creep into the communications transmitted from top to bottom. In addition, the greater the number of subordinates, the smaller the sample of subordinate actions that may be verified by their supervisor. At some point, because of the increasing asymmetry of information and resulting loss of control, the contribution of an additional worker to output is less than the cost of employing him, and the organization stops growing. These ideas were modeled formally by Williamson (1967). Applying organizational theory to the firm, Williamson demonstrated that the optimal number of levels within a hierarchy is an increasing function of the degree of compliance with supervisor objectives.

Although these studies were important in clarifying some of the determinants of organizational structure, they did not attempt to model explicitly the behavior of individuals within a hierarchy. Consequently, their results were not necessarily compatible with individual choice. More recently, developments in the theory of contracts have provided a powerful tool for reexamining this question. To do so, it is necessary to restate Tullock’s communications problem in terms of an asymmetry of information among individuals within a hierarchy. In the typical formulation, two individuals share a risk that results from an uncertain environment. However, the outcome also depends on an action taken by one of the individuals (the agent) that the other (the principal) cannot observe. The principal therefore faces an additional source of uncertainty known as moral hazard: in favorable states of nature, the agent can reduce his effort without being detected by the principal. To prevent slacking, the principal must revise the agent’s incentives to induce him to supply more effort in states of high return.³

A major difficulty with this simple principal-agent model is that it neglects the intermediate supervisory level present in most real-world bureaucracies. As soon as a third person is added to the structure, an additional problem arises for the principal: the possibility of collusion

³ The principal-agent problem is studied in detail in Grossman and Hart (1983).
between supervisor and agent. Antle (1982, 1984) modeled the relationships among the owner of a firm, its manager, and an auditor hired to monitor the behavior of the manager. He showed that if the auditor and manager have better information than the owner, the challenge for the owner is to design an incentive plan that induces them to reveal the truth. Such a game, he showed, need not have a unique equilibrium.

Tirole (1986) examined some of the implications of Antle's analysis in greater detail in the context of a simple three-person game. In this game, the principal hires an agent but is unable to determine whether the final outcome (for example, the level of profits) is due to the agent's effort or to productivity shocks that the principal cannot observe. To monitor the agent, the principal therefore employs a supervisor who is better informed but still has less information than the agent himself. In favorable states of nature, Tirole found, there is an incentive for the agent to bribe the supervisor to distort the information reported to the principal in a manner favorable to the agent. The restructuring of rewards to eliminate collusion further reduces the efficiency of the system.

One difficulty in the application of the Tirole formulation to actual bureaucracies is the assumption that the quality of information is constant: the supervisor either observes or does not observe the productivity shock; collusion either can or cannot occur. As a result, it is difficult to capture the gradual loss of control as an organization increases in size that is featured so prominently in the earlier research on bureaucracies. Another problem is that the three-person hierarchies of the Antle and Tirole models exist in a vacuum, whereas a typical real-world bureaucracy tends to supply outputs to and receive inputs from other bureaucracies. The following section therefore proposes two extensions that increase the realism of the contractual model of bureaucracies: first, information asymmetry is assumed to increase with distance, and second, the principal's income depends on the relations between two interlocking bureaucracies.

III. THE STATE AS A SYSTEM OF INTERLOCKING BUREAUCRACIES

Since the provision of public goods is generally not profitable under voluntary exchange, some nonmarket means of motivating the producers of such goods is required. A state may therefore be viewed as a territory within which a dominant group holds a recognized right to raise tax revenues in exchange for providing public goods. The state organization must be able to generate rewards in order to encourage productive effort on the part of its employees; in other words, it must have the power to tax. And it must be able to protect its agents from rival centers of power; that is, it must have the capacity to apply force. Collecting tax revenues and applying force are both specialized activities. Accordingly, most historical states have assigned each of these tasks to a distinct hierarch-
chical structure. The generation of rewards is the role of the fiscal bureaucracy, while the application of force is the role of the military apparatus.\footnote{Note that a part of the output of each bureaucracy will be self-consumed while the rest will be exported to the other sector. The tax collectors will generate revenues not only for their own salaries but also for those of the soldiers. Soldiers loyal to the principal will put down rebel troops and also discipline tax collectors guilty of malfeasance.}

Consider how these two structures interact, beginning with the fiscal apparatus. In Fig. 1, the expected area of the state (the external margin) is measured on the horizontal axis, while the expected share of taxes in total income (the internal margin) is measured vertically. Let population and production be spread uniformly over territory; Assume that a single principal has contracts with a number of identical spatially distributed tax collectors. Assume further that the principal is able to observe the level of output of each agent but not the agent's effort or the level of exogenous shocks to productivity. The principal therefore appoints a supervisor to oversee the agent. Let the probability that the supervisor is able to observe the agent's effort and the probability that the principal is able to verify the supervisor's report both diminish with distance. Then, following Tirole (1986), the net tax receipts received by the principal from each additional unit of territory he controls will diminish, since the cost of each unit of the marginal agent's effort will increase. Accordingly, marginal net tax receipts net of collection costs as a fraction of income will be a decreasing function of the total area administered.\footnote{It might be thought that tax farming, as practiced by the Roman Republic, would prove an effective means of coping with control loss of this kind (see Levi, 1988). However, there proved no effective means to prevent distant tax farmers from collecting more than the rates stipulated by law, thereby weakening the long-run tax base. As a result, early in the Principate, tax farming in imperial provinces was replaced by the state fiscal bureaucracy (Webber and Wildavsky, 1986, pp. 113–119).}

This situation is illustrated by the marginal fiscal revenue curve, FF, in Fig. 1.

If the generation of reward and application of force are specialized tasks, the principal will have a second set of contracts. These new contracts will be with spatially distributed soldiers and the officers hired to supervise them. Assume once again that information asymmetry increases with distance. Then the cost of obtaining the minimum military effort required to keep each additional unit of territory controlled increases with the distance of that unit from the capital. The positively sloped curve, MM, illustrates how the marginal cost of military control rises with the area of the state.

How large will the typical state be in terms of population or area? How centralized will it be in terms of the share of total income that will be extracted in taxes to be used for collective rather than individual
purposes? Assume that the dominant group in the state attempts to maximize its total tax revenues net of collection costs and the cost of territorial control. The answer will then be determined by the point E in Fig. 1, where marginal tax revenues net of collection costs are equal to the marginal cost of military control. The equilibrium values of the average tax share and the total area are given by the coordinates of the corresponding point, G, on the average revenue curve, AA.

The marginal cost and revenue curves in Fig. 1 are drawn for given technologies. Consider next the manner in which technological change will affect the positions of the military-control curve. Suppose that a regional commander rebels against the central authority. The principal will attempt to put down the revolt by sending a larger force than that controlled by the rebel leader. Let $\alpha$ be a parameter that is close to but less than unity. Furthermore, let $r(n)$ be the ratio of the expected cost of an enemy casualty for an army of $n$ soldiers to the expected cost for a larger army of $\alpha n$ soldiers when the two bodies engage in combat.\footnote{These costs will include not only wages and equipment amortization but also logistic considerations such as the cost of supplies and transport (see, for example, Engels, 1978).}
If this ratio is equal to one, regardless of the value of \( n \), then there will be no economies of scale in military technology. Accordingly, the cost of controlling the territory around a state’s capital will be high. If, however, \( r(n) \) is greater than unity for armies smaller than \( n^* \) and less than unity beyond \( n^* \), then there will be economies of scale up to the optimal size, \( n^* \). A central authority maintaining a standing force of the optimal size could then control a large territory around its capital, at a reduced cost defeating any opposition in detail.

Thus, the height of the military marginal cost curve, \( MM \), will be determined by scale economies. The greater are military economies of scale, the lower the share of the state’s total income that must be devoted to military control. In Fig. 1, military costs are expressed as a fraction of total income. The greater are military economies of scale, the lower will be the left end of this marginal cost curve. It will then rise from left to right as distance gradually weakens hierarchical control.

How will a decrease in military scale economies (a decline in \( n^* \)) affect the limits to the state’s power? By raising the cost of controlling a given territory, a decline in military scale economies will shift the military-equilibrium locus upward to a position such as \( M'M' \). At the new optimal point, \( G' \), the external margin has shifted inward \((dx < 0)\), the total area of the state decreasing. At the same time, the internal margin has shifted upward \((dy > 0)\), the public share rising. In intuitive terms, an innovation that reduces scale economies weakens the capacity of the center to offset the effects of distance and leads to a shrinking of territorial boundaries. At the same time, the decrease in information loss that occurs as the borders contract enables the fiscal bureaucracy to strengthen its hold over economic activity. The rest of the paper will be devoted to an historical example that illustrates these results.

IV. THE TRANSITION FROM EMPIRE TO FEUDALISM

One of the most frequently studied sets of changes in territorial boundaries and in state intervention is that which accompanied the fall of Roman civilization in Western Europe between the second and ninth centuries A.D.\(^7\) This section first describes the challenges to Rome’s hegemony and then discusses possible explanations for the observed boundary changes.

Military Problems of the Later Roman Empire

By the reign of Marcus Aurelius (161–180), it was evident that Rome’s traditional defense system based on legions of disciplined foot soldiers was under increasing external and internal pressure. A serious threat

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\(^7\) Recently, a German scholar, Demandt (1984), identified some 400 different explanations for Rome’s fall.
came from the Parthians who in 162, after a half century of peace, invaded Syria with their cavalry-based army. Beginning in 166, the middle Danube frontier was penetrated by the Germanic Marcomanni and Quadi, whose tactics made use of mixed cavalry and infantry units. In the following decade, the lower Danube came under attack from the Sarmatians, horsemen from central Asia.

Worse still, Roman response to the threats was weakened by the most serious internal divisions since the beginning of the principate. In 193, civil war broke out following the assassination of the unpopular emperor Commodus. It was only after 4 years, during which Roman legion was pitched against Roman legion, that Septimius Severus (193–211) came out on top. These three themes—incursions along the Rhine and Danube, war with Persia, and civil war—recurred with increased intensity over the following century and a half, particularly during a period of near-collapse from 235 to 268.

The Roman Response

Rome eventually survived these difficulties. Indeed, the external borders at the end of Constantine’s reign in 337 were very similar to those at the death of Augustus over 300 years earlier. In fact, however, a number of profound changes had occurred, all of them increasing the cost of controlling territory. Most obvious was the increase in the total size of the army. From 300,000 at the death of Augustus, it had grown to 400,000 under Septimius Severus and to 500,000 under Diocletian (284–305). In addition to this increased labor, the army fought with a much greater stock of capital for defensive purposes. The major cities were now walled and the empire was surrounded by a powerful network of fortifications laid out in depth.

A further change was the gradual abandonment from the first century

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There is some disagreement over the extent to which the German tribes such as the Marcomanni or subsequent federations such as the Goths and Alemanni used cavalry prior to the fifth century. According to Dupuy and Dupuy (1986, pp. 134–136), only the Franks were primarily foot soldiers, the other German tribes mixing cavalry with infantry. However, Luttwak (1976, p. 71) and Ferrill (1986, p. 144), citing Thompson (1958), argued that the Germans fought primarily on foot. An interpretation consistent with the available evidence is that from Caesar’s time the Germanic cavalry had been good but limited in numbers. Gradually, over the first two centuries A.D. the Germanic tribes in the northeast, such as the Goths and Vandals, who came into direct contact with steppe nomads from Asia, gradually improved their cavalry and increased its relative importance (Darko, 1937, p. 142). Further westward diffusion of the use of cavalry as the dominant arm was, however, very slow, perhaps because of lack of adequate pasture for large numbers of horses (on this last point, see Ferrill, 1986, p. 142).

The most important difference was the addition of Britain, which had occurred in the first century A.D.

Dupuy and Dupuy (1986, pp. 147–148).

Luttwak (1976, p. 176).
A.D. onward of Rome's traditional emphasis on heavy infantry supported by small numbers of light cavalry armed with missile weapons. Heavy cavalry with spears were introduced under Trajan (98–117), with armored heavy cavalry appearing under Hadrian (117–138). By the second half of the second century, mounted auxiliaries of all types represented roughly one-fifth of the total number of troops. By the time of Constantine, this percentage had increased even further: cavalry made up one-quarter of the average Roman army, with the percentage much higher in the eastern regions which faced the Persians and Arabians. Moreover, instead of being assigned a secondary status behind the legions, the cavalry became the elite division of the army, the legions having been stripped in size from 5000 to 1000 men each.

Other changes suggest that military practice was evolving to adapt to new conditions. In order to reduce its vulnerability to heavy cavalry, infantry was forced to adopt tighter, more phalangeal formations. In these denser groupings, relying increasingly on flat barbarian-style shields for protection, Roman soldiers gradually abandoned body armor. Combined, these measures had the unfortunate consequence of leaving foot soldiers more vulnerable to missile weapons, particularly bows and arrows, whose use sharply increased. The result was inevitably an increase in the number of casualties and hence in the cost of waging war.

The Internal and External Margins of the Roman State

The changes in military techniques just described were accompanied by shifts in what earlier sections of this paper defined as the state's internal and external margins. Consider first the internal margin, as represented by the Roman fiscal system. Over 90% of Rome's revenues came from taxes on agriculture. By the end of the third century, the proceeds from taxes assessed in monetary terms were no longer sufficient to pay for the greatly increased military system required to defend the borders. Accordingly, Diocletian introduced a ruthless system of taxes in kind whose aim was to assure that his troops were adequately pro-

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12 Luttwak (1976, p. 186).
13 That is, 80,000 mounted troops of all types out of a total of 400,000 (Luttwak, 1976, p. 71).
15 Dupuy and Dupuy (1986, p. 150).
16 Ferrill (1986, pp. 50, 145).
17 Vegetius, the late fourth or fifth century Roman military historian, lamented, "Our soldiers fought the Goths without any protection for head and chest and were often beaten by archers" (Ferrill, 1986, p. 129).
18 The bulk of these tax receipts were generated by a combined land and poll tax assessed on land and on the rural population (Jones, 1974, p. 83).
The result was a sharp increase in effective tax rates. Even these measures, however, were not sufficient to guarantee the necessary manpower. He therefore resorted to annual conscription, compelling landholders to provide men from their estates. His eventual successor, Constantine, took the further step of requiring the sons of veterans to serve in the army.

Turn now to the question of territorial boundaries. During the period of relative peace of the first and second centuries, Rome had added Dacia (Rumania) and the critical Rhine–Danube triangle, the agri decumates, in upper Germany to its empire. In the third century, however, barbarian pressure forced the abandonment of these lands and withdrawal to the Rhine–Danube frontier. For long periods in this century, particularly during the reign of Gallicenus (253–268), large sections of the empire were virtually independent. It was only under Aurelian (270–275) that Roman control was reestablished in Gaul and the eastern Mediterranean.

By 292, Diocletian realized that under existing conditions the empire was too vast to be administered from a central point. Accordingly, he divided it into four regions: he himself controlled Thrace, Egypt, and Asia; his associate or “Caesar,” Galerius, administered the Danube provinces; his co-emperor or “Augustus,” Maximian, controlled Italy and Africa; the other Caesar, Constantius, ruled Gaul, Spain, and Britain. At the same time, Diocletian greatly decentralized the civilian administration, setting up a separate bureaucratic structure within each of 12 dioceses into which he divided the empire.

There are of course many ways to slice a cake. Following the resignation of the leaders of this tetrarchy in 305, there were two decades of intermittent civil war before the son of Constantius, Constantine, took control of the entire empire once more. He in turn instituted a series of reforms which have come under intense criticism from Gibbon to the present. The most important change was to strip the borders of their best troops to permit the formation of mobile cavalry-based field units (comitatenses) stationed centrally. As Luttwak has explained, the result

19 Luttwak (1976, p. 179).
20 Although few tax data are available for the fourth century, complaints of abandoned land and overtaxation dating from the reign of Diocletian indicate a substantial rise in the tax share of income compared to earlier centuries. These tax increases seem to have continued during the fourth century. By the reign of Justinian in the Eastern Empire (527–565), the tax share of agricultural production was a quarter to a third of total output, or two to three times the level of the Roman Republic (Jones, 1974, p. 83–84).
21 Ferrill (1986, p. 43).
22 During the interval from 259 to 274, Postumus established a provincial empire in Gaul, Britain, and Spain. Similarly, from 259 to 271, large sections of the eastern Mediterranean, including Egypt, fell into the hands of the Roman Arab Odenathus and his wife Zenobia.
23 See Ferrill (1986) for a summary of this debate and a cogent presentation of the case against Constantine.
was a deepening of the defense-in-depth strategy initiated by his predecessors. Henceforth it would be much less probable that invaders would be stopped outside of or at the borders. The idea was essentially to delay any major incursion by use of border troops (limitanei) until the field army could be brought into play. Since the bulk of any fighting would occur on Roman territory, however, this strategy in effect implied a shrinking of the effective frontiers of the empire to a dimension which could be controlled by mobile centrally-located forces.

Subsequent events showed that even this strategy was overly ambitious. Upon Constantine’s death, the empire was divided among his sons and nephews. It was seldom to be controlled by a single person again, the division into eastern and western sections becoming permanent in 395. In 476, the Western Empire was extinguished; its former territory was divided among the four main Germanic groups—the Franks, Visigoths, Ostrogoths, and Vandals. Although the regions held by the latter two peoples were later recovered temporarily by the Eastern Empire, Rome never regained its former boundaries. Finally, between the seventh and ninth centuries, western Europe broke up into more than a dozen nominal states composed of hundreds of virtually autonomous counties and duchies.

Military and Economic Explanations of Rome’s Failure

At present there are two main groups of theories that attempt to explain the failure of Rome. According to one approach, the reasons for the fall of Roman civilization and the subsequent rise of feudalism in western Europe were military, the principal factors being increased external pressure and the responses chosen by Rome’s military leaders and their successors. However, the difficulty with this explanation is that many of the principal battles of the fourth century were not between Romans and barbarians or Persians but between Romans and other Romans and allied troops. Similarly, in the eighth century, the leaders of the Franks

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25 Among modern historians, Jones (1964) and Ferrill (1986) placed the crucial events at the time of the barbarian invasions in the late fourth and fifth centuries. Ferrill, following Luttwak (1976), argued that earlier decisions by Constantine—the barbarization of the army and the creation of a central reserve—weakened the capacity of the Empire to respond to this threat. However, for Brunner (1887) and subsequent scholars of the rise of feudalism, the crucial change occurred at the time of the Arab invasions of the eighth century, when Charles Martel reorganized the Frankish kingdom on feudal lines.

26 The Roman armies that fought the Persians at the Tigris River in 363 and the Goths at Adrianople in 378 were considerably smaller and total Roman casualties probably lower than in the great civil war battles of Adrianople in 323, Mursa in 351, and the Frigidus in 394 (Eggenberger, 1985; Ferrill, 1986).
spent at least as much time fighting among themselves or against other Christians as they did fighting Moslems.27

An alternative approach argues that the causes of the change were what might be termed economic; namely, increased red tape, higher taxes, class conflict and a decline in agriculture, trade and industry.28 If the problem was economic, however, it must be explained why the Eastern Roman Empire survived the barbarian invasions and, although reduced in scale, the rise of Islam. More generally, any attempt to explain the reduction in the size of political units between the first and the ninth centuries must deal with an obvious fact. For over a millennium after the sack of Rome in 410 A.D., no European state with dimensions approaching those of the Roman Empire was ever reestablished, except for brief intervals, despite declines in barbarian and Moslem attacks and the revival of trade.

The Technological Factor

Ultimately, the search for a coherent explanation for the observed contraction of territorial boundaries and decrease in market activity hinges on the isolation of a factor that was irreversible. For this reason, outbreaks of disease or climatic variation in the homelands of nomadic peoples are not satisfactory candidates since their effects would tend to disappear within a few generations.29 Similarly, disruptions to trade or the formation of interest groups within a given social structure are unacceptable because they too are likely to be temporary. In a penetrating essay, White (1964) suggested a possible candidate for such a factor, namely, the introduction of the stirrup into warfare. He argued that in permitting horse, rider, and lance to be joined into a single fighting instrument the stirrup made possible a new type of warfare based on mounted shock combat. In the near-barter economy of the eighth-century Frankish kingdom, the only means of financing such expenditure was to endow an equestrian elite with land and the rights to its income.

Since White was concerned with the emergence of feudal institutions, he did not analyze in detail the implications of previous developments in mounted combat. However, as the German historian, Altheim (1952),

27 In the words of White (1964, p. 11), "Martel turned his attention to Islam only after he had consolidated his realm."

28 Rostovtzeff (1957), Bernardi (1970), and others have dated Rome’s decline in the fourth and fifth centuries and explained it by internal economic collapse. Their versions are quite consistent with Olson’s (1982) thesis that over time the formation of interest groups within a society gradually reduces economic efficiency. Pirenne (1925) and Friedman (1977), however, place the transition in the eighth and ninth centuries, arguing that the principal factor was a decline in trade (resulting perhaps from the Arab conquests).

29 On outbreaks of contagious disease as a possible cause of Rome’s decline, see McNeill (1976).
has argued, the impact of innovations in cavalry warfare on Roman civilization began many centuries earlier. In 53 B.C., the Parthians annihilated a Roman legionary army under the triumvir Crassus at Carrhae in Syria. Their tactic was to use heavy cavalry to force the Roman foot soldiers into tight, static formations where they made easy targets for mounted archers.\footnote{Luttwak (1976, p. 43).}

The heavy horses that made the new type of warfare possible had been developed several centuries earlier in eastern Iran.\footnote{The first to exploit if not invent these techniques were the Sarmatians, an Indo-European people from central Asia who used a combination of light cavalry, eventually armed with bows, and heavy armored infantry, equipped with lances and long swords. By the beginning of the first century, the various Sarmatian tribes controlled an extensive territory extending from the Caspian Sea in the East to the Danube in the West (Millar, 1981, pp. 284–291).} They were strong enough to carry armored riders and their weapons along with additional armor to protect the horses themselves from enemy missiles.\footnote{See McNeill (1963, pp. 321–322).} Not only were the horse and rider better protected, but they also made up a greater mass for shock combat with infantry. A further and equally important improvement occurred in the first century A.D. when the saddle began to be introduced into Roman territory to replace the horse blanket or saddle cushion.\footnote{White (1964, p. 7).} The result was a more stable platform for bowmen or lancers. Combined, then, these two innovations greatly strengthened the position of cavalry relative to its traditional competitor, the infantry.

What connection could there be between improvements to cavalry combat and the inward shift of territorial boundaries? Altheim argued that since the barbarians were better horsemen than the Mediterranean peoples, it was inevitable that they should eventually capture the throne. But if so, why were the Roman boundaries never restored? A possible answer lies in the concept of military scale economies. Bean (1973, p. 208) argued that because centralized training was less important for cavalry than for infantry, a greater emphasis on cavalry permitted decentralization.

However, the key lies not in training economies but in the effect of the size of a military force on its destructive power, as measured by the ratio of casualties suffered by the two sides when a small force came up against a larger one. In the case of infantry, from the Spartans onward it had been realized that there was safety in numbers, that a wall of shields could not be broken easily by opposing troops or light cavalry.\footnote{As Luttwak (1976, p. 43) observed, from the time of Sparta onwards cavalry had been obsolete against disciplined foot soldiers.}
However, the soft underbelly of such a force—its flanks and rear—were vulnerable. Accordingly, the objective of classical infantry battles was to attain local numerical superiority by flanking, enveloping, or penetrating an enemy's line. Casualty figures for ancient battles are notoriously unreliable; however, there is considerable evidence that if one infantry army could disrupt its opponent's shield wall, the losses it inflicted were far greater than those it suffered itself.35

In short, there were great economies of scale in the use of disciplined infantry. It was these scale economies that in 23 A.D. permitted a force of 150,000 Romans and roughly the same number of auxiliaries to control and protect a population of 50 million in an empire which stretched from the English Channel to the Nile.36 They formed what Luttwak (1976) has called a preclusive defense system, designed to suppress any potential threat outside of the borders before it could spill over into Roman territory. Although the legions included small detachments of cavalry (reintroduced under Augustus), the Romans relied on the auxiliary units for the bulk of their cavalry support.37

In the case of cavalry, economies of scale appear to have been minimal. Military theorists from the Byzantine emperor Leo VI the Wise writing in the ninth century to Clausewitz almost a thousand years later noted the slightness of the gains to the coordination of cavalry combat and the effectiveness of cavalry against infantry only as long as the numbers fighting remained small.38 As a result, any change that favored cavalry relative to infantry may be seen to have reduced the economies of scale in applying military force.39 This conclusion is supported by estimates showing roughly equal casualties to both sides in battles of the fourth century A.D., after the proportion of cavalry to infantry had been con-

35 For example, Carthaginian casualties at Zama in 202 B.C. may have been more than ten times those of Rome. At Pharsalus in 48 B.C., Pompey's losses may have outnumbered those of Caesar by more than seven to one (Dupuy and Dupuy, 1986, pp. 71, 110).
36 Luttwak (1976, p. 16) and Ferrill (1986, p. 26).
37 Luttwak (1976, p. 43).
38 Leo the Wise advised the commanders of his well-drilled cavalry-based armies to avoid shock combat with the undisciplined Frank and Lombard cavalry. "So formidable is the charge of the Frankish chivalry with their broadsword, lance and shield that is best to avoid pitched battle with them" (quoted in Dupuy and Dupuy, 1986, p. 219). Clausewitz (1956, Vol. 1, p. 294) recommended that cavalry be used alone against infantry only when the latter was dispersed. "Useful as cavalry may be against single bodies of broken demoralized troops, still when opposed to the bulk of the beaten Army it becomes again only the auxiliary arm."
39 One might have expected increased use of cavalry to lower the cost of controlling territory by permitting more rapid movements of centrally based forces. However, this off-battlefield effect seems to have been more than offset by reduced scale economies on the battlefield.
siderably increased. In addition, increased use of cavalry appears to have enhanced the possibility for a beaten army that had suffered heavy losses to escape with the remains of its force intact and available to fight again at a later date.

Improvements in Cavalry Warfare as an Explanation of Rome's Decline

It is time to draw the threads of the discussion together. It has been shown that the beginning of Rome's decline can be dated in the latter half of the second century A.D. From the outset, this decline was characterized by a reduced capacity to defend the empire's borders against external threats, by frequent civil wars, by increases in taxes, and by reductions in the territory that the Romans attempted to control from a central point. These changes coincided with the introduction of a number of innovations in cavalry warfare which reduced the economies of scale in applying military force.

In terms of Fig. 1, the resulting increase in the marginal cost of controlling territory led to an upward shift in the marginal-cost curve, MM: a higher level of taxes was required to control a political unit of a given size. The increase in state intervention and the shrinking of effective territorial boundaries that accompanied these technological changes are predicted by the theoretical model. It may be seen that the new equilibrium will be at a point such as G', to the northwest of the original equilibrium at G. In other words, there will be a rise in the level of taxation and a decline in the size of the typical political unit.

Thus Rome's decline seems to have occurred for both military and economic reasons. The external margin of the latter half of the second century could be maintained only by resorting to a level of taxation which, because of its crippling effects on economic incentives, could not be sustained. Or to express the same idea differently, with the new position of the state's internal margin separating public and private activity, the empire was vulnerable to the attacks both of hostile external enemies and of its own generals. Each could offer better protection than the imperial administration at the same level of taxes but within a narrower set of borders. The precipitating factor, however, appears to have been a series of innovations that reduced military economies of scale.

40 In the battles between Constantine and Licinius in 323 A.D., each side suffered very heavy losses. Similarly, at Mursa in 351 A.D., Constantius and Magentius may each have lost 25 to 30% of his soldiers (Dupuy and Dupuy, 1986, pp. 152-153).
41 Compare, for example, the civil war battles of the first century B.C. with the three battles mentioned in the previous footnote and the civil war of 314 A.D.
V. CONCLUSION

This paper has been concerned with the determinants of the limits to bureaucratic power. A model of a three-person hierarchy consisting of principal, supervisor and agent, developed by Antle (1982, 1984) and Tirole (1986), was extended to the case of dual fiscal and military bureaucracies. It was argued that as the distance of the boundaries from the center of the state increases, the quality of information available to the principal diminishes. As a result, he gradually loses control over the supervisor and the agent. The discussion then turned to the effect of technological change on the equilibrium of two interdependent bureaucracies. A decrease in economies of scale in the application of military force was shown to result in a contraction of territorial boundaries and an increase in taxes as a share of income.

An attempt was made to examine possible causes of the decline in Roman civilization that occurred between the second and the eighth centuries in western Europe. Military explanations for these developments were criticized for being unable to demonstrate why this collapse was accompanied by more frequent civil conflict that was at least as costly as external invasion. Economic explanations were found to be unable to account for the continued survival of the Eastern Roman Empire after the fall of Rome itself. It was argued that the explanation for these events lies in the gradual adoption of a new military technology, namely, heavy cavalry. However, the importance of this innovation was not that it favored the barbarians who had developed it, as Altheim argued. Rather it was that the strengthening of cavalry reduced the economies of scale in the application of military force. The introduction of the first two components of this new technology, the heavy horse and the saddle, in the first century A.D. was followed by the contraction in effective external boundaries and the rise in taxation which the theoretical model predicts. The introduction of the final component, the stirrup, into the Frankish Kingdom appears to have precipitated the final eclipse of Roman civilization in western Europe and the rise of feudal institutions.

REFERENCES


