G. Grantham, "Time's arrow and time's cycle in the medieval economy: the significance of recent developments in economic theory for the history of medieval economic growth", unpublished paper presented at the Fifth Anglo-American Seminar on the Medieval Economy and Society held at Cardiff 14-17 July 1995

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Dear Ian,

Please find attached the original paper in WORD and the Bibliography. You have my permission to post this on your website.

All the best,

George

----- Original Message ----- **To:** ian.blanchard **From:** George Grantham **Sent:** Monday, November 05, 2001 5:42 PM **Subject:** Re: Time's Arrow etc

G. Grantham, “Time’s arrow and time’s cycle in the medieval economy: the significance of recent developments in economic theory for the history of medieval economic growth”, unpublished paper presented at the Fifth Anglo-American Seminar on the Medieval Economy and Society held at Cardiff 14-17 July 1995

> "Absolute certainty is possible only in regard to (1) particular facts; and (2) deductions by strict reasoning from axiomatic premises, such as those of pure mathematics. Even sciences, which deal with concrete facts and conditions as definite and immutable as those of physics appear to be, cannot claim certainty over the whole of their area. In biological sciences the area over which certainty extends is relatively very small; and in the social sciences it is less than in those which deal with the lower forms of life." (Marshall 1919:673)

Few historians and surprisingly few economists who dabble in history appreciate the extent to which unacknowledged assumptions about how markets work influence conventional accounts of the development of the medieval economy. I do not refer to those elements of economic reasoning dealing with the extent of self-interested behaviour, which economists indulgently term 'rational', nor to the question whether a particular society was or was not a 'market', 'monetary', or 'capitalistic' economy'. These issues are relicts of a nineteenth-century mode of typological theorizing, which conceived economic development as a grand progress from lower to higher degrees of occupational differentiation, lower to higher levels of productivity, and from smaller to larger and more efficient forms of organisation. They are drawn from an historiography that told the great narrative of European civilization as the ascent from barbarism to civilization, from man's initial blissful state of unreflective autarchy to the condition of his full self-awareness as a social being. I refer instead to more limited but equally influential preconceptions about the nature of market processes in time. However much they may disagree about social typology and periodisation, historians and economists have typically concurred that markets work like the elementary textbooks say they do. If not impeded by combinations, transactions costs, or incomplete rights of private property, the forces of supply and demand work quickly and efficiently to secure an optimal allocation of resources. The problem of explaining economic performance in time, as Nobel Laureate and economic historian Douglass North puts it, is explaining the evolution of institutions regulating the structure of private incentives that impede or improve these allocations (North 1993). For North, the time does its work outside the market, on the structural factors that affect supply and demand. The way supply and demand interact to determine outcomes given the fundamentals produced by the passage of time is itself timeless.

Recently, an alternative vision the market has emerged within mainstream economics. It goes by a variety of names: path dependency, endogenous growth, general equilibrium search, the "new" trade theory, and coordination failure. While differing in particulars, these theories attribute a common importance to historical contingency in explaining actual market outcomes, which are no longer considered to be the necessary best of all worlds possible within a given structure of endowments and incentives, but one of many possible temporal accidents.[1]

Economists' rediscovery of the importance of narrative has potentially important implications for medieval economic history. It helps make sense of the recent findings that medieval agricultural productivity was often higher than conventional accounts assume, and it lends theoretical support to the growing body of archaeological discoveries and textual re-interpretation of early medieval documents indicating a higher level of productivity and economic performance in the early middle ages than historians have until now been prepared to accept. These findings have important implications for the relation of the medieval economic boom of the twelfth and thirteenth centuries to the economic and technological achievements of the later Roman Empire. The new approaches also provide the elements for a plausible model of long-waves of prosperity and economic regression in Europe's pre-industrial history that does not require Malthusian population dynamics or unexplained variations in the rate of innovation as its motive force.

This paper introduces the new approach and attempts to indicate where it seems to give insight and structure to the grander designs of medieval economic history. The first part describes (I hope not too aridly) the theoretical issues at stake and attempts to impart some of the flavour of the new view of market processes. The second part employs these insights to develop an alternative vision of the dynamics of medieval economic change. The tentative nature of this exercise needs hardly be stated. My intention is not to set forth a new dogma, but to demonstrate how open are the opportunities for a new synthesis of theory and evidence in medieval studies.

[1] The highly mathematical nature of this literature, which is due to the complexity of the dynamical issues addressed, makes it difficult for those who lack the necessary preparation to gain access to it. Good introductions can be found in Krugman (1991), Diamond (1984; 1987), and Arthur (1990), and David (1993).

PART I: ECONOMICS

PER ME SI VA NE LA CITTÀ DOLENTE

Inferno iii: 1

Markets: The Standard Model

As a social mechanism, the market coordinates individual decisions affecting the allocation of resources. The central element of this mechanism is a system of relative prices that diffuses information about costs and opportunities to all decision-makers, who then determine their allocations. Economic theory is mainly concerned with explaining how the prices are determined, and whether they signal accurately the true costs and advantages of any particular course of action. The canonical method of analysing market phenomena is to suppose that there exists in principle an equilibrium price set corresponding to each set of external circumstances. In the simplest exposition, these circumstances are summarized by the form and position of supply and demand curves, whose intersection identifies the equilibrium price and quantity exchanged. Mental displacement of these curves caused by a change in external circumstances alters the equilibrium price and quantity exchanged in predictable ways. In the extended versions of this apparatus, the prices and quantities exchanged of all commodities are simultaneously determined in a "general equilibrium". The process by which the market achieves this equilibrium is more complicated than that described by the supply and demand curves of a single market taken in isolation, but the underlying principle of simultaneous price and quantity adjustments by buyers and sellers is the same. Given the logical primitives of an economy, conventionally categorized as technology, individual preferences, and the distribution of productive resources among households, there is a unique market equilibrium.

The equilibrium approach to markets contains two logical properties that are important for its utilization as a tool in historical investigation. Firstly, it hypothesizes negative feedbacks to sustain market equilibrium, so that small momentary perturbations of price or quantity will not send the system careering off to a new and distant resting point. Secondly, it makes a neat analytical separation of causes from effects. Causes consist in the underlying conditions determining the shape and position of supply and demand functions; effects are what happens when these functions interact. To economists primarily concerned with developing policies, this separation is highly convenient, because it limits the range of possible explanations of a given event. If an economist were to observe (a) increased output, (b) technological change, and (c) falling prices, he would infer from this combination that technological change had caused the rise in output and the fall in price. If the same economist were to observe only prices and quantities, but was able to persuade himself that no change had occurred in the supply of resources, he would deduce *unobserved* technical change. The method of analysing displacements of economic equilibrium is known as comparative statics, and it requires that every observed change in economic outcomes requires an external cause. Historical explanation means tracing these causes, and in their absence, supplying them, for nothing happens by accident. As Bacon (1266-

1267: pars IV, dist. II, cap. I.) wrote in an analogous context, omne enim efficiens agit par suam virtutem quam facit in materiam subjectam ... et hanc facit tam substantia quam accidens. ... Et substantia plus quam accidens...Ethaec species facit omnem operationem huius mundi.[2]

How does economics achieve the impossible trick of empirically distinguishing cause from effect? To economists, a "cause" is something that alters the underlying conditions governing supply or demand, that typically generate a new equilibrium of price and quantity. Market participants are assumed to know what the price is at all times. In theoretical expositions of general equilibrium, this knowledge is broadcast by a fictional entity that declares the current price of every commodity, compiles the quantities that agents are willing to demand and supply at those prices, and adjusts prices upward or downward until the quantity supplied and demanded of every marketed commodity are the same. The metaphor for this is an auction, and the entity is conventionally called the Auctioneer. The sequence of prices he calls out is called <u>tâtonnement</u>, which is French for feeling one's way. The general equilibrium is known as Walrasian equilibrium.[3]

Walrasian <u>tatonnement</u> involves two patently unrealistic assumptions. The first is that a mechanism exists (the Auctioneer) by which all market participants are simultaneously made aware of every market price. Only under this condition does the aggregate response of buyers and sellers to the sequence of prices announced in the course of <u>tâtonnement</u> produce the correct movement to equilibrium (Fisher 1987). The second unrealistic assumption is that all the haggling that comprises the <u>tâtonnement</u> to equilibrium takes place before anyone ever <u>does</u> anything. Production, migration, investment, consumption, and work all have to wait until the equilibrium prices and the associated contracts specifying the quantities of the commodities to be exchanged are arrived at in the general auction. This assumption is intimately related to the distinction between economic cause and effect. The function of separating price-making from the execution of contracts to exchange goods and services is to ensure that the general equilibrium of prices and quantities maintains a strict correspondence between initial conditions and the market outcomes, which would not be the case if some contracts were agreed to and executed before the general equilibrium was achieved. If this were to happen the execution of the contracts would generate new information affecting the supply and demand of all the remaining commodities still in <u>tâtonnement</u>; market outcomes would depend not on specified initial circumstances, but on the temporal contingencies of contracting. This situation would greatly reduce the explanatory and predictive power of general equilibrium analysis. Economists have been understandably loathe to relinquish this power.

Walras' contemporary and theoretical peer understood perfectly the practical difficulties that stood in the way of analysing real markets as a general equilibrium. Explaining why, in real markets, firms do not ordinarily reduce prices below their "normal" level, Alfred Marshall observed that

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[2] "Every efficient cause acts by its own force which it produces on the matter subect to it....Substance [as cause] is more productive of it than accident ... This species causes every action in the world."

[3] After the nineteenth-century French economist Léon Walras who invented it.

> "Everyone buys, and nearly every producer sells, to some extent, in a 'general' market, in which he is on about the same footing with others around him. But nearly everyone has also some 'particular' markets; that is, some people or groups of people with whom he is in somewhat close touch: mutual knowledge and trust lead him to approach them, and them to approach him, in preference to strangers. A producer, a wholesale dealer, or a shopkeeper, who has built up a strong connection among purchasers of his goods, has a valuable property. He does not expect to get better prices from his clients than from others. But he expects to sell easily to them because they know and trust him; and he does not sell at low prices in order to call attention to his business, as he often does in a market where he is little known." (Marshall (1919:182).

This is not the economics of a market with perfectly free information to all participants.

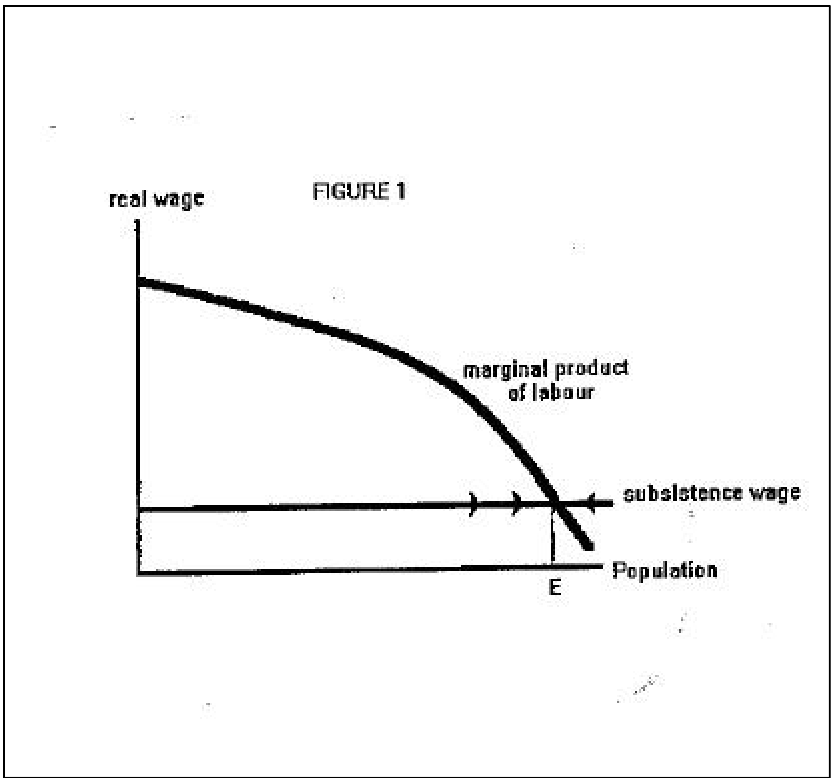
The classical vision of the market is fundamentally ambivalent about market processes in time. On the one hand, in demonstrating how prices incorporate dispersed pieces of information and disseminate it to dispersed decision-makers, classical general equilibrium analysis identifies the coordinating role of prices; on the other, it takes the process by which the prices are diffused to be like God's grace, freely bestowed upon marketing humanity for the good of all. Moreover, the information in market prices is not only costless to broadcast, it is also costless to produce. The time it takes for the market to compute equilibrium prices and quantities is not real (chronological) time, for which interest would have to be charged, but a timeless analytical interval set outside real time to give agents an opportunity collectively to decide before they act. It is through this convention that all the information incorporated in the exogenous set of causes is able to have its determinate effect on market outcomes. When everyone shares all the information present in the economy, the process of contracting and recontracting in general equilibrium will always produce the same outcome for a given set of underlying conditions.

If we relax the assumption that market information is free and allow that individuals must incur significant costs to find trading partners, the link between exogenous cause and endogenous effect is loosened. Instead of being aggregated into a single pool, the information embodied in the set of exogenous causes can be broken up into many smaller pools. What happens next will depend on who knows what, and who knows what will depend on who meets whom in the market place. The dependence of actual market outcomes on the contingencies of matching between buyers and sellers breaks the strict link between economic cause and economic effect. It does not wholly eliminate the link, but it means that given circumstances can have a multiplicity of outcomes.

What does all this have to do with medieval economic history? Consider the proposition that the economic boom of the central middle ages was triggered by agricultural innovation in the ninth or tenth century. This argument is conceived as a rightward shift in the agricultural supply function, and is supplied as a plausible cause for an observed increase in economic activity. An agricultural surplus supported a bigger population and maintained more people in non-agricultural occupations. The argument seems plausible, but the plausibility is deceptive. It provides no explanation of how peasants came to develop or adopt the new implements and crop rotations that were the basis for agricultural advance, nor how the craftsmen with whom they exchanged their surpluses discovered they had a new outlet for the products of their enterprise. No mechanism links the decisions of the two classes of actors to produce complementary surpluses. This is an example of implicit Walrasian reasoning; for growth to occur something exogenous has to change. That an agricultural surplus necessarily leads to a higher level of occupational specialization and division of labour is an argument ex post. It describes what has happened, but not how.[4] The usual argument is that the seigniors extracted agricultural surpluses from a dependent peasantry and exchanged them for luxuries. To whom did they sell these surpluses? How did corn, meat, hay, and vegetables raised on reserves and tenements get transformed into pepper, silk, and holy relics? Anyone can call up buyers from the vasty deep; but will they come when we do call for them?

Markets: A dynamic vision

We begin with the simple and work towards the complex. The economic model with which medieval historians are most familiar is that which describes the dynamic Ricardian-Malthusian relation between population density and real income. Its logical structure is depicted in figure 1.



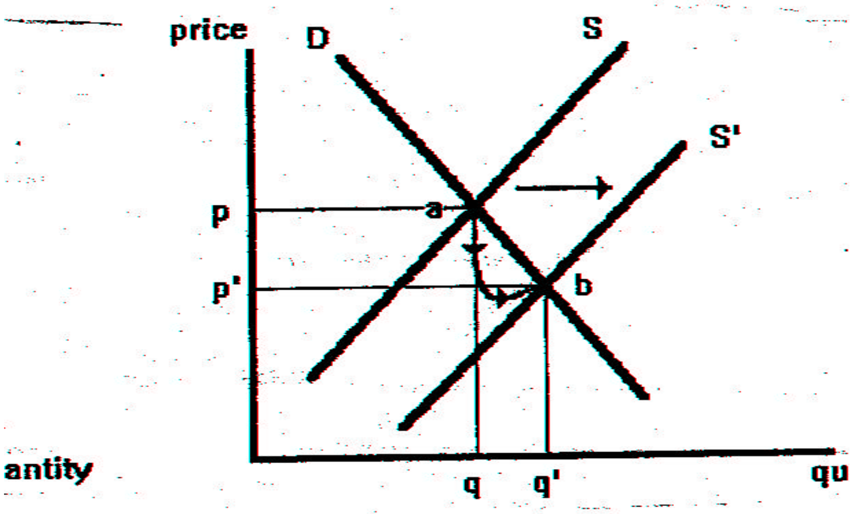
The horizontal axis measures the density of population; the measure on the vertical axis is real income or product. In the graph a downward sloping curve representing the marginal product of agricultural labour intersects a horizontal line representing the "subsistence wage". The point of intersection identifies an equilibrium population density denoted by E. The dynamics of the model are supplied by the response of population density to differences between the real marginal product of labour and the subsistence wage. By hypothesis, population is assumed to increase when the marginal product exceeds the "subsistence wage" and to decrease when it falls below it. Since the marginal product falls with rising population density, this reaction function determines a stable equilibrium. The model is a simple negative feedback system that

[4] In an earlier version of this paper, I raised the question of how market information is originally generated with a fellow economic historian, who argued that it posed no serious problem. When he was a boy, he simply set up a lemonade stand in front of his parent's home and started selling. What his example leaves out of the picture is that he set up business in an economy that was already highly specialized and in a context where the risks of the enterprise were non-existent. It would have been different had it been a question of setting up a store specializing in, say, organic produce that had to be bought from special suppliers.

predicts the consequences of exogenous changes in the "subsistence wage" and technology on population density and living standards.It is evident by inspection that a technological innovation raising labour productivity will induce population to expand, because it results in a shift upward and outward of the marginal product curve. Likewise, if the "subsistence wage" at which labourers reproduce themselves should decline, living standards will fall, as population expands to the point where the lower subsistence wage crosses the original marginal product curve.

Figure 2 depicts a more complicated negative feedback system. This is the familiar "scissors" diagram of supply and demand, whose blades intersect at the equilibrium price. The feedbacks operate on both sides of the market in response to excess supply or demand. When price rises, suppliers bring a larger quantity of goods to market and buyers take a smaller quantity off it, and vice versa. When the price exceeds the equilibrium value at which quantities supplied and demanded are equal, the resulting positive gap between quantity supplied and demanded (excess supply) causes the price to be bid down; when price falls below the equilibrium value, the negative gap between quantity supplied and quantity demanded (excess demand) causes the price to be bid upward. Here the negative feedbacks are produced by the reaction of unsatisfied buyers and sellers to situations produced by non-equilibrium prices. The dynamics of one possible path of adjustment to a shift in supply are indicated by the arrows. As in the Ricardian-Malthusian model, the assignment of cause is in principle simple. Whatever moves the supply or demand curve is a cause.

Figure 2



Negative feedbacks around an equilibrium point provide stability, since any disturbance moving one of the endogenous variables away from its equilibrium value sets up counteracting forces that re-establish the initial resting point. The equilibrium does not change unless one of the underlying conditions that determine it changes. It is this property that makes equilibrium analysis so useful in assigning causes. But economic processes are not all like this. Many work cumulatively, so that the dominant reactions reinforce rather than counteract the effect of an initial disturbance. These are called positive feedback systems, and in contrast to those dominated by negative feedbacks which produce single outcomes for a given set of initial circumstances, the same conditions typically imply a multiplicity of equilibrium outcomes. In such circumstances small displacements of the endogenous price and quantity variables can result in big changes in outcomes, and the same displacement can produce many different effects depending on how the cumulative process plays out in time. An important economic question and an equally important historical one, therefore, is how prevalent are such positive feedback situations.

One theoretically significant and historically important class of positive feedbacks in market economies is that generated by the subtle connection between private decisions to specialize--which implies producing with the intention of exchanging the output for other commodities--and the extent of market opportunity. Adam Smith captured this relationship in the opening aphorism of the Wealth of Nations: "The division of labour is limited by the extent of the market". This famous maxim is usually taken to be a statement of how market size affects the organization of work, but the causation is not one-way. Smith well understood this, but as his main focus was economic policy, he emphasized the way market size, which he believed to be influenced by policy, encouraged or dissuaded private decisions to specialize. Economists and historians have generally maintained this instrumental approach to the relation between the extent of market opportunity and the division of labour.

It is nevertheless evident that an individual decision made to specialize is itself a source of variation in the extent of the market, if by extent we mean the amount of aggregate demand for commodities. This is because aggregate demand is the sum of individual demands, and the only way an individual can exercise effective market demand in by having executed a prior or simultaneous sale of the specialized production he brings to the market. Only in this way can he procure the means of making a purchase. The supply he brings to market represents, at the price it is sold, the value of his demand for other commodities. Hence, every decision to specialize for the market is a potential addition to the market's aggregate demand.

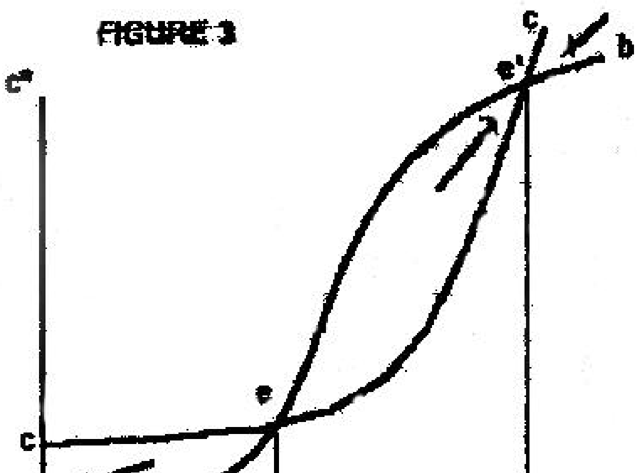
Because every person who participates in the market must sell in order to buy, coordinating the timing of the rencontres that lead to market exchange is a matter of considerable subtlety. In deciding whether to undertake specialized production, an individual has to have advance assurance that he will be able to find purchasers; but his potential customers are in exactly the same situation with respect to the market for their own specialities. The conventional model of market processes described in the first section of this paper assumes that individuals confront an existing market made up on anonymous buyers and sellers, and that they can respond to it according to the balance of advantages signalled by the price they expect to obtain there. This begs the question how the individual decisions that result in the market existing come logically to be taken.[5]

[5] The requirement that goods be sold before others are bought is not obviated by the existence of money or credit, since the person who lends means of payment of will have had to have sold something ahead of time, or at the very least will have had himself to have secured a credit-granting partner who will himself have had to secure credit-granting partners, and so forth. As shall be demonstrated below, the whole in an exchange economy is greater than the sum of its particular exchanges. On these issues see Diamond (1990) and Diamond and Yellin (1990).

Henri Pirenne perceived the coordination problem embedded in market economies with great acuity. In analysing the role of the great estate in the Carolingian economy, he observed that

> "what was new was the way in which it functioned from the moment of the disappearance of commerce and the towns. So long as the former had been capable of transporting its products and the latter of furnishing it with a market, the great estate had commanded and consequently profited by a regular sale outside. It participated in the general economic activity as a producer of foodstuffs and a consumer of manufactured articles ...[in] reciprocal exchange with the outside world. But now it ceased to do this, because there were no more merchants and townsmen. To whom could it sell, when there were no longer any buyers, and where was it to dispose of a produce for which there was no demand, because it was no longer needed? Now that everyone lived off his own land, no one bothered to buy food from outside, and for sheer want of demand, the landowner was obliged to consume his own produce." (Pirenne 1962:8-9)

We are not required to accept his view of the Carolingian rural economy as a naturalwirtschaft, which he drew from the conventional reading of the Carolingian polyptychs as documents describing the manorial administration of great estates[6] nor need we subscribe to his explanation of the contraction and subsequent restoration of commerce between the fifth and eleventh century to admit his fundamental insight: that the degree of specialization and trade are functions of



independent decisions made by individuals who have to find each other in time and space to reap

[6] They are now considered to be records of the system of fiscal administration inherited from the late Roman Empire (Goffart 1972; Durliat 1990),

the mutual benefits of trade. The relation between the size of a market and individual decisions to engage in specialized production can be worked out by a graphical device like Figure 3 (Diamond 1984).The horizontal axis represents the number of persons who have already produced goods for sale in a market. It can also be taken to represent an index of the quantity of goods available to be exchanged for each other. Each of these goods has a cost of production. The vertical axis measures the cut-off cost at which an individual who has not yet specialized, but has been presented an opportunity to do so, will refuse to accept the opportunity and remain unspecialized. One can think of such opportunities as arriving one after another in real time, and that to each of them is attached a different unit cost of production. This little fiction expresses the truth that no one is aware of all possible production opportunities; in the course of time a person will happen upon some of them, and in the same course of time the whole population of all persons will happen upon all of them. No individual, however, knows for sure what opportunities the future holds, and what they are going to cost until they appear before him. A person presented with such an opportunity thus has to make the following choice: to accept the opportunity to specialize and incur its cost, or to stand pat and wait for a better opportunity. Concretely this would be the case of a self-sufficient peasant deciding whether to enter the market.

The cut-off cost is denoted by c*. For any given cut-off cost c*, there will be projects involving specialized production that individuals would accept if they were to present themselves, and others they would find unprofitable and reject. The critical determinant of how much specialized production takes place is therefore the level of the cut-off cost c*. When it is high, most projects are feasible and there will be much specialized production; When the tolerance for incurring the cost of specialization is low, most potential projects will be rejected. The two cases can be seen to be associated with two alternative economic states: one in which most people are specialized and presumably highly productive, and another in which they remain unspecialized and poor. These alternative states do not depend on the state of technology, but on how intensively the possibilities it holds for a division of labour are exploited. This is determined by the cut-off cost for undertaking specialized production. The question is how the cut-off cost c* is determined by market processes.

To answer this question we must now consider the way trade actually occurs in most markets. When agents produce goods for the market, they usually produce to inventory, which they subsequently try to market. Some production may be undertaken on the basis of advance orders, but such arrangements imply pre-established market connections between producers and customers, which is what we are trying to explain. To sell goods out of inventory means having to find customers. As we have seen, however, the potential customers are themselves agents whose effective demand depends on their success in marketing <u>their</u> inventories. For anyone to make a sale, everyone has to be able to sell. This means buyers and sellers have to find each other. Real trade did not ordinarily take place between an individual and a large faceless market; it took place between identifiable parties, who bought and sold commodities in quantities that depended on how easy it was to sell them again.[7]

[7] Medieval historians are well acquainted with this phenomenon, for the records of individual trading enterprises are replete with instances in which a merchant had to wait in a port because no one there had the ability to take up goods when he first arrived, or who had to accept huge reductions in price in order to unload his stock. The French word for this kind of trade was "spéculation". The problem of thin markets was not confined to exotic ports of call or unusual commodities. Between March 2 and March 6, 1200, the price of a common sort of northern cloth (Stanforts) varied 40 percent at Genoa (Sivery 1984:153). To limit their risk merchants limited the

The positive feedback in market processes involving a search for customers stems from the fact that a person with inventory to sell has a better chance of making a sale the more there are of other persons with (different) goods to sell. This would logically hold if individuals randomly bumped into each other, but it also holds for more organized assemblies, because market transactions occur sequentially and not all at once. A person who came late to market or simply missed out on a sale that cleared the effective demand for his special good, would either have to wait to the next market in order to sell, or greatly lower his price.[8] The importance of transaction sequence in ordinary markets was recognized by medieval municipal authorities, who reserved the first hour of trading in basic provisions to citizens, so that they could fill their weekly requirements sheltered from the risk that market supply might be exhausted by early large sales to outsiders.[9] The greater the number of people gathered together to truck and barter, then, the easier it is for an individual to find buyers for what he has to sell, and sellers of what he intends to purchase. In effect, the greater the number of participants in a market, the faster each one can sell his inventory.

The positive externality between the degree of specialization in an economy and the size of the market should now be apparent. Because it costs something to market goods, the greater the number of persons who have already decided to produce for market, the lower are all the individual costs of marketing. This in turn affects the cut-off cost c*. If a person thinks he will have an easier time selling a specialized product, he will raise the cut-off cost that determines whether he undertakes or rejects an opportunity to specialize for the market. Decisions by different individuals to produce for the market thus directly affect each other, because the more people who decide to produce, the greater the number of traders, and the easier it is to sell what has been produced. This in turn raises the cut-off cost for accepting new projects to specialize. There is, however, a coordination problem embedded in this sequence of positive feedbacks. A person contemplating an opportunity to specialize market will not take into consideration the way his decision affects the profitability of others' decisions to specialize, which in turn affects the profitability of his own production. He might decide not to specialize when a decision to specialize would have made himself and all his potential trading partners better off. If one thinks of an economy in which potential producers were widely scattered in space, it is immediately

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size of the lots they were prepared to take in any given transaction. The size of the market thus depended critically on the number of persons participating in it. As the number of market participants rose, this constraint was relaxed. In Flanders, the average number of 30-meter cloths sold in wholesale cloth transaction rose from a maximum of 10 to 12 pieces before 1275 to more than 30 pieces in the early fourteenth century (Sivery 1984:167).

[8] It might be objected that a speculator would buy the goods at the expected price in the next market less holding costs. This reasonable proposition does not, however, explain how the speculator happened to be at the right time and the right place with the right amount of purchasing power. All such devices assume a smooth information-diffusing mechanism.

[9] This is not a matter of price protection. Sellers would come to market with an estimate of the price to be obtained that anticipated demands from large-scale dealers. But such demands would not be known with certainty. An exceptionally large demand that cleared the whole marketed supply might be expected to occur once in, say, ten markets. When it did occur, had the first hour of trading not been reserved to citizens, the normal flow of provisions to them would have been impeded. Economists usually argue that the large-scale dealers would have resold part of their stock to citizens at the equilibrium price that balanced the exceptionally high total demand and normal supply (regrating); but this need not occur, especially where costs of retail transactions were high and, as was commonly the case, conducted on credit.

evident why this had to be so. An all-knowing Person might arrange things so that each agent took a decision that resulted in all agents being better off; but the Person to whom medieval theologians attributed the continued existence of all things ordained otherwise. Men lived and worked in mutual ignorance of what they could do for each other.

Figure 3 has two curves. The upward sweeping curve cc' represents the relation between the cut-off cost c* and the steady-state level of aggregate inventories.[10] By the argument developed above, higher inventories of goods to be exchanged for each other will result in faster and higher sales. Since a higher stationary level of inventories implies a higher rate of production to match the higher rate of sales, the curve rises, because higher rates of production imply a higher cut-off cost for new opportunities to specialize. The curve begins above the origin because it is reasonable to suppose that there is some minimum fixed cost below which no project will be undertaken. Curve bb represents the relation between the level of inventories or number of specialized producers already in the market, and the cut-off cost for accepting or rejecting a productive opportunity. It begins at the origin, because if no one produces specialized goods to inventory, an individual presented with an opportunity to specialize will know that he has no chance whatever of making a sale, and will reject it out of hand. As the number of potential trading partners rises, it becomes easier to make a sale and the cut-off cost rises.

The diagram can be read as follows. For any given level of specialized production N, the curve bb tells us what the level of the cut-off cost is for any productive opportunity that presents itself to an individual who has not already specialized. The curve cc tells what the cut-off cost has to be to ensure that production equals sales at every level of aggregate inventory. If at a given level of N the cut-off cost for accepting new projects as determined by bb is higher than the cost as determined by the curve cc, people will accept enough projects to raise the level of production to inventory. If, on the other hand, bb is below cc, the cut-off cost is lower than what is required to maintain the current level of specialized production, and production to inventory will fall off.

The properties of these curves are important for grasping the ambivalent implications of positive-feedback systems for the size of the market. Suppose each unit of production to inventory is produced by one person, so that the horizontal axis measures both persons specializing and inventories. If fewer than x persons produce for the market, the cut-off cost that screens projects will be lower than what is required to sustain production at the current level. A person who is presented with an opportunity to produce at a cost above this level will wait for a better opportunity. Because bb lies below cc at points less than x, too many people wait. Inventories fall as production falls, and the cut-off cost for accepting new projects falls along with them, to the point where no one produces for the market, which literally disappears as a social institution. This was Pirenne's view of the Carolingian economy. The equilibrium level of specialization for any starting point to the left of x is therefore zero. This equilibrium is stable for initial market sizes smaller than x. A society with the misfortune to be entirely unspecialized stays unspecialized. For initial starting points lying between x and x' on the other hand, the cut-off cost for new projects lies above the steady-state cost. Enough projects are accepted to cause "inventories" to rise. But this increase in the number of trading partners causes the cut-off cost to rise even further, encouraging more production and creating more trading partners. As drawn, the process

[10] By steady-state is meant the level of inventories at which sales and production are equal, which implies a constant level of inventory.

continues until the level of production reaches x'. Level x' is also a stable equilibrium, since initial points to the right of it will cause inventories to fall, while initial points to the left (but not so far left as to fall below level x) will cause specialized production to rise. Level x, on the other hand, is unstable; a little movement one way or another causes the equilibrium to shift all the way to zero, or all the way up to x'.

The model depicted in Figure 3 is a parable, like all models. What is its moral? The same economy, as defined by the skills of its people, can produce widely varying results depending on how it lands, so to speak, on the spectrum of initial specialization. As drawn, there are only two stable end points; but this is an artefact of the drawing, not the economics. In principle, there can be infinitely many resting points, depending on how the cut-off cost c* changes with the changes in the level of overall specialization.

We have come a long way from our starting point. The difficult economics adumbrated in the preceding paragraphs is intended to show how the internal mechanics of a market economy consisting of people who must seek each other out in order to productively specialize is capable of producing many alternate states. In the example above, the end result depended on the initial starting point; but other possibilities are clearly present. What people <u>think</u> other people are going to do is as important in determining their cut-off cost as what people actually do. The possibility of self-fulfilling expectations raises its hydra-headed trunk. Not only may outcomes hinge on minor contingencies that shift the system from one side to another of an unstable equilibrium point, they can also hinge on how these contingencies affect the combinations of individual expectation. The source of cause has been displaced the objective conditions of endowments, tastes, and technology, to the world of pure subjectivity.

Theoretical demonstration that a market economy simultaneously possesses many sustainable states has important implications for historical interpretations of medieval institutions. This especially true of those interpretations which assume that medieval societies were poor because they lacked adequate resources and technology. In recent years, economist historians have argued, and regular historians have too readily accepted, an extreme functionalist explanation of medieval institutional practices that is predicated on the assumption that these societies were so tightly constrained by their environment, that they had no choice but to adopt practices that were efficient relative to the circumstances in which they were placed. Institutions were efficient, because such societies could not "afford" to waste productive opportunities. It follows that what one observes in the record is a long-term adjustment of techniques and institutions to exogenously determined circumstances. This point of view has been most forcefully propounded by Donald McCloskey, who with characteristically vigorous prose argues that had productive opportunities of any quantitative significance been available, they would have been exploited out of self-interest. In arguing that the scattering of plots in open fields could not have been irrational, he asks rhetorically, "Why would a starving peasantry throw away 10 percent of its output? This is the central puzzle." (McCloskey 1989:25) A similar position is taken by the English followers of Postan who take as axiomatic his hypothesis that English agriculture in the thirteenth century was sharply constrained by shortage of dung brought on by the increasingly limited availability of land for pastoral uses[11] (Fox 1984;198; Clark 1992). As shall be discussed below, this pessimistic

[11] Fox (1984:133) writes: "Few historians would doubt that many English rural communities approached a crisis in the relationship between people and resources in the hundred years before the Black Death."

assessment of medieval agriculture is not sustained by the evidence. The main point, however, is that an economy could be poor without being constrained to poverty by lack of resources. The "circumstances" might be incidental products of coordination failure, and small events alleviating such failures might put the same economy in a situation of high productivity. The problem with economic functionalism is not that it posits an economic adjustment to circumstance, but that it assumes this adjustment exhausts all the possibilities for change, and that only something from outside the economic system can cause it to grow.

It should now be evident why economic historians have been too quick to suppose that the growth of the medieval economy required a clear and present cause. If market processes involve costly matching of potential sellers and potential buyers, an economy can have many possible resting points. It is possible that long periods of expansion are simply the reflection of cumulative positive interactions between decisions to produce for markets and market size. What we may be seeing is not the effect of an exogenous increase in resources or of the means of turning them into final products, but a long traverse from one possible state of economic organization to another. I wish in the rest of this paper to explore this possibility through a number of examples. Time and the reader's endurance prevent full consideration of the pathways through which these cumulative processes of growth and decay make themselves felt, or to provide an exhaustive review of the evidence that leads me to believe that economic change between the fourth and fourteenth centuries A.D. is predominantly a matter of the dynamic processes described above.

PART II. HISTORY

Per correr miglior acque alza le vele

omai la navicella del mio ingegno,

che lascia dietro a sé mar si crudele

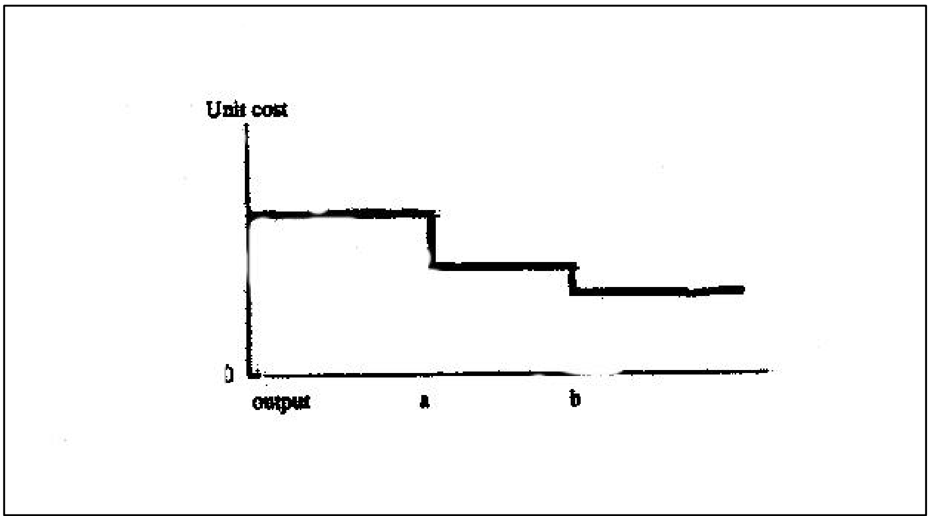
Purgatorio i: 1-3

Scale economies and positive feedbacks in technology

The positive feedbacks that cause multiple search equilibria are fundamentally temporal. If it were costless to wait for a trading partner, it would not matter how long it took to find one. Agents could accept high-cost opportunities and wait until someone turned up who was prepared to pay the right price. Expectations would eventually converge to something consistent with reality, and the economic system would reproduce itself over and over again until there was a change in the fundamental data. This state corresponds to the analytical long run, or steady state. Much economic history written by economists assumes it, partly on grounds of analytical expediency, as it is the only state in which all economic forces present will have worked themselves out; and partly in the belief that given enough time all latent productive opportunities will have been uncovered and exploited.

That this may not always be true may be inferred from the following simple example. Figure 4 describes an activity in which unit costs fall as the scale of operation increases. The level of aggregation at which scale is defined an activity within an enterprise, an enterprise, an industry, or even a region. In the present context it does not matter. What matters is that the realization of higher levels of productivity is associated with high output levels. If an enterprise or society never experiences output a, it will not uncover the range of falling costs. A society in which enterprises or regions operated only in range 0a knows only constant costs, and is ignorant of the potential gains that lie in regions of output above a and b. A technology may have latent potential for increasing productivity at high scales of activity, but if incentives to produce at such scales are not present the particular methods associated with t may never be discovered. This is one way (but not the only ne) the trading externality described between decisions to specialize and market size described in Figure 3 affected the so-called "fundamentals" of economies in the past. For most of the pre-industrial period, the possibilities for making fundamental breakthroughs in the state of the arts were modest; but the possibilities for raising productivity through specialization of people and general purpose tools were large. The division of labour is limited by and determines the extent of the market.

Figure 4



It is now necessary to sketch the argument to come. If most of the potential improvements in the medieval period depended on fuller realization of the benefits of the division of labour, then the key to medieval economic change lies in way the extent of the market evolved. Parts of the process of specialization and division of labour have been long evident. The history of the medieval cloth industry shows how growth in the market provided opportunities for increasing the technical division of labour, which led to falling costs and further extension in the market. The same history shows how fragile an economy dependent upon far flung markets was in the face of fiscal, monetary, and political shocks to trading networks. Because decisions to specialize interact with the size of the markets, such shocks could provoke prolonged declines in output and productivity, just as positive shocks could give rise to prolonged advances (Grantham 1993).

One of the features of medieval specialization in manufactured goods is that it was often highly urbanized, or at least highly concentrated in compact regions. The economic processes driving such agglomerating tendencies are similar to those described in figure 3, though somewhat more complex by virtue of the additional locational decisions which have to be taken into account. (Krugman 1991). The primary reason for industrial agglomeration is that market coordination of skilled workers is easier within a constricted space than it is in an extended space. This was especially important in those industries where the skills required were highly specialized and where continuous changes in the variety of product demanded by the market required rapid adjustments, as is still the case today (Scott 1988). For these reasons, and others connected with fixed investments in transportation infrastructures, the development of manufacturing in the middle ages, as in the nineteenth century, tended to be highly localized. The degree of local specialization in textile production indicated by the late medieval Flemish militia lists is as high as that of nineteenth-century Lancashire (Prevenier 1983; Derville 1983). Such levels of occupational specialization are exceptional, but they are evidence of a dynamic market process dominated by the costs of search and coordination.

Urbanization involved investments in transportation to carry bulky raw materials to the towns and (in some cases) carry produce away. The construction of these facilities, which include quays, canals, river improvements, bridges, causeways and pavement, are part of the process of response to market opportunity and in a broad sense part of the division of labour. It is becoming increasingly evident that by the end of the thirteenth century, the more urbanized parts of northern Europe had attained a level of transport productivity that was not markedly inferior to the best achievements of the eighteenth century (Masschaele 1993; Derville 1978). This is even more true of the less developed regions, where progress before the coming of the railway was even slower.[12]

The evolution of commercial institutions and the construction of commercial networks is part of the same dynamic process. Any time that the market expanded enough to sustain the fixed costs of further specialization, it provoked further steps in the same direction. The important thing, however, is that this is an integral part of the process of changing market size, not its cause. Historians of medieval Europe seize the process of institutional change nel mezzo del cammin, and suppose that its events were causes of growth rather than its consequence. But if market processes are cumulative, and also reversible, what historians observe may be incidents in a long fluctuation moving the European economy through a multiplicity of temporary equilibria, within a technologically and, to a considerable degree culturally, stable environment. Medieval growth may not have been something new, but instead constituted a recovery of an earlier episode of sustained growth growth that had begun sometime in the sixth century BC with the establishment of commercial links between the civilizations of the Mediterranean basin and the Celtic heartland of west-central Europe, but had suffered a temporary but major setbacks in the third sixth centuries AD. New evidence tending to support this hypothesis will be presented at the end of this paper.

The critical question is what happened to technology. Did it change exogenously or endogenously? The argument here is that it ws endogenous in the sense that growth in market outlets probably lies behind most of the adaptive innovations constituting the core of medieval technical progress. Growth in market demand for specific commodities permitted some producers and some regions to undertake more extensive divisions of labour, which in turn gave rise to innovative adjustments in both organization and techniques. Although such improvements cumulatively raised overall productivity, few demanded conceptual leaps of the kind Mokyr (1990) calls "macro-innovations".[13] This gradual but sustained adjustment of inherited techniques to the enlarged scale of operations made possible by the expansion of the market for specific commodities followed a long period of economic contraction during which many methods of large-scale production current in classical times were abandoned and lost. The history of the productivity of the medieval iron industry prior to the development of the blast furnace may be taken to illustrate this point.

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[12] Owing to the chance survival of a parchment containing the register of the minutes made by an Italian notary active at the Fair of Troyes in 1296 we have direct evidence of a regular transport service linking the Fairs to the towns of the Midi and how long it took to move commodities (Bautier 1945). The delay allowed for delivery of merchandise from the Fairs of Champagne and the French Mediterranean ports was 20 to 23 days by the high road east of the Cevennes, which avoided the territories held by the Empire. This is the same time required by scheduled transporters to make the shorter trip by the Rhone valley in 1837 (Bautier 1961:117). The average distance covered per day was 24 to 28 kilometers, which is exactly the speed maintained by early nineteenth-century teamsters. The hardest part of this route, which passed through the difficult mountains separating Le Puy from Alès, was heavily travelled and kept in good repair; some parts were paved so well that four centuries later, when it had long been abandonned, the inhabitants thought it had been the work of the Romans (Bautier 1961:122).

[13] The only one that comes to mind is the twelfth or thirteenth-century invention of the crankshaft, which transformed rotational forces into reciprocating ones and vice versa (Usher 1954).

Owing to the survival of the records of Cistercian monasteries and lordships situated in the iron-bearing hills of eastern France, the growth of iron output is a well-known feature of the economic upswing of the twelfth and thirteenth centuries (Braunstein 1972; 1987; Verna 1983). Interpreting the meagre inventory of iron tools recorded in the polyptych of Carolingian abbeys two and a half centuries earlier as evidence of metallurgical penury, Fossier and Duby concluded that one of the keys to the medieval economic renaissance must have been innovations in ferrous metallurgy and the installation of smiths in the villages (Fossier 1987:72-73; 1988, 56-58; Duby 1962: 196-98). The problem with this hypothesis, which was advanced to explain the increasing productive capacity of rural Europe, is that it postdates the penetration of iron and iron-working craftsmen in the European countryside by nearly a thousand years. The ubiquity of iron tools and agricultural implements after 500 BC is demonstrated by the extensive distribution of iron plough shares, scythes, sickles, hoes, spades, rakes, tires, and axle bindings in the Celtic archaeological record (Bretz-Mahler 1971; Jacobi 1974; Wells 1984; Baranova 1989). Such wide diffusion of implements in constant need of repair and re-hardening could only have been sustained by an equally extensive distribution of blacksmiths (Sandars 1962). These rural artisans had substantial, though imperfect, understanding of how to affect the hardness of the metal by carburization (Ehrenreich 1985), an art essential to renew working edges of farm tools.[14]

If Europe experienced a medieval 'metallurgical revolution', then, it would have had to have been a significant breakthrough in smelting technique, rather than a colonization of rural districts by blacksmiths. There was, however, no fundamental change in the method iron-making before the late thirteenth or early fourteenth century, when the blast furnace altered both its scale and chemistry (Geddes 1992:171-73). Until then, medieval iron-masters employed the same basic method of inducing a reduction reaction in iron ore as their Celtic and Roman ancestors. This consisted in heating iron ore with charcoal in small bowl-shaped or "pit" furnaces into which air was forced by hand-operated bellows through nozzles or "tuyères". Within the technical parameters of direct reduction of iron ore to iron, there were three ways of increasing the productivity of the smelting furnace: to augment the capacity of the furnace bowl, which required simultaneously increasing the number of nozzles and the capacity of the bellows to provide an adequate air supply; to dig a pit to take molten slag that would otherwise extinguish the fire; and to increase the height of the furnace by placing a ceramic "chimney" on it charged with alternating layers of charcoal and ore, which induced a stronger convection current that gave the higher temperatures needed to reduce large quantities of ore in one melt (Pleiner 1980:397-98). The last two techniques are connected, since a larger melt produced more slag (Tylecote 1980).

None of these improvements necessitated radical advances in metallurgical understanding. Multiple tuyères and slag pits go back to the age of copper (Tylecote 1980:211), and the convection properties of "stove-pipe" furnaces could hardly fail to be noticed by specialists working continuously with heat. Early Saxon ironworkers employed re-usable chimneys up to two meters tall (Tylecote 1973). By the end of the twelfth century, a few iron-masters were experimenting with even taller furnaces and had begun to use waterpower to drive the bellows and forge hammers. A water-powered bloomery is known to have operated in Sweden between

[14] A rare contract from the end of the twelfth century between the Abbey of Saint-Martin de Sées and its blacksmith enjoins the smith to reharden axes, hoes, and shares purchased by the Abbey. "C'est nous qui trouverons les nouvelles haches, les nouveaux socs, coutres, hoyaux, trépieds et grilles, mais c'est le fèvre qui les armera de son acier." Translated by Mathieu Arnoux (1990), reprinted in Brunel et Lalou (1993:245-46) I am indebted to Dr. Pierre Portet of the Archives Nationales for this reference.

1150 and 1250, and it is unlikely that the experiment was confined to this region, as the first documented English bloomery using an air blast dates to 1196 (Magnusson 1988; Geddes 1992:173-74). From here it was but a short step--though a rather long metallurgical one--to the full-fledged blast furnace of early modern times. Ultimately the continued growth in the scale of bloomery furnaces led to a true innovation, in the development of the two-stage smelting and refining process that reduced the ore first to high-carbon cast, and subsequently refined this intermediate product to low-carbon wrought iron. It is therefore permissible to view the development of the blast furnace as a natural outgrowth of increasing scale of individual furnaces in the twelfth and thirteenth century. Continuous experience with the large quantities of ore and comparatively high temperatures generated in large water-driven bloomeries almost certainly led to the discovery that cast iron could be refined into wrought iron by burning off the excess carbon absorbed by the ore during the long melts characteristic of the larger bloomery furnaces. This experience was sustained by the increasing demand for iron that had resulted from the fourteenth-century development of artillery.

Changes in scale of individual furnaces can be traced by the size of surviving blooms. By late antiquity, iron masters on the continent were producing blooms that weighed up to 20 kilograms, although 10 kg seems to have been more usual (Pleiner 1980:414). In the early middle ages, bloom weights appear to have fallen back to 5 kg (Tylecote 1965; 1992). The subsequent increase in productivity noted by Fossier and Duby was indeed spectacular. By the fourteenth century bloomeries in England were making blooms weighing more than 100 kilograms; by the fifteenth century a bloom of nearly 200 kilograms had been achieved (Tylecote 1965). Most of this improvement, however, occurred late. Down to 1200 most blooms probably did not exceed 20 kilograms, the sharp rise after that date being due to the application of waterpower to drive the bellows. The five-fold rise in furnace productivity between 700 and 1200 AD had merely permitted medieval ironmasters to recover the productivity level attained by their Celtic and Roman ancestors. This was almost certainly a matter of increasing the size of individual furnaces. The application of the waterwheel to power bellows was also essentially a matter of increasing scale of the furnace, and had economic circumstances been more favourable, even this paradigmatic medieval innovation probably would have been taken up by the ironmasters of classical antiquity.[15]

In any case the level of productivity achieved by classical iron workers was high enough without the aid of the water mill. The immense quantities of iron available at short notice to the Roman authorities is indicated by a five ton hoard of over 900,000 nails left behind on the site of a Roman fort on the Scottish frontier that was abandoned in 87 AD after having been occupied only five years. The nails had been cut and hardened to exact specifications (Tylecote 1992:62-63). Stores of this magnitude had to be mass-produced. The works that produced the iron that went into these and other common articles were also large. The remains of most of these works have been

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[15] It is now accepted that the waterwheel was widely diffused throughout Roman Europe by the fifth century (Holt 1988:2-5). But this diffusion occurred at a time when the European economy was tending to contract, so that iron-makers did not have strong incentives to develop an expensive capital-intensive technique associated with marketing iron on a large scale. Even so, the application of waterpower to problems of iron-making was not entirely neglected. The ninth-century polyptych which lists the possessions of the Abbey of St-Germain-des-Prés reports six mills in a backward ironworking region of the Perche existing in a state of neglect and disrepair (Lohrmann 1989:371), which suggests that waterpower had been once applied and then abandoned when the level of demand fell off.

destroyed by subsequent smelting activity on the same sites, but one major iron-working site active between 500 BC and 0 AD on the Italian coast opposite Elba survived virtually unmolested into the last century. When it was first measured by a French mining engineer in the 1850s, the iron-laden slag at Piombino stretched 600 meters along the beach in a ribbon l6 meters wide by two meters deep. It is estimated that this amount of slag represents the residue of an average daily iron output of 1.5 to 3 tonnes. (Voss 1988). Yet this huge operation did not even endure to the end of the Roman Empire. Smelting there ceased around the beginning of the Christian era, and by the early fifth century the remains of what must have been the world's largest iron works were little more than an occasion for poetic reflections on the ravages of time by a Roman administrator making his way slowly up the Italian coast towards his home in Gaul[16] (Rutilius Namatianus 1961 [ca 420 AD]: ll 349-370, 408-414). A smaller but still quite extensive smelting works consisting of 40 furnaces was active in the Holy Cross mountains of southern Poland in the fourth and fifth centuries AD, and is thought to have marketed some of its output in the Empire (Radwan 1965).

The way early iron masters achieved high levels of output and productivity was to increase the division of labour at the smelting site. Smelting involved a number of subsidiary processes in which increasing the specialization of workers and simple equipment could bring about substantial economies of scale.[17] By multiplying the number of furnaces on a site and keeping them continuously in operation by employing teams of men to charge and discharge them, which allowed the highly skilled men who controlled the melt continuously at work, an iron works using pit furnaces could produce a high output with modest numbers of labourers. The works at Piombino probably employed fewer than 500 men, no doubt organized in independent teams that worked iron ore on their own account and took orders from merchants who were responsible for marketing the final product.[18] One can envisage a relatively flexible response of this kind to growth in the market. By the end of the Late Iron Age, most iron employed in Western Europe was probably produced under these conditions, although most of the evidence of early large-scale iron works has been destroyed by later exploitation of the same sites[19] (Bretz-Mahler 1971:153-54; Ehrenreich 1985:17-19). Batteries of small furnaces continued to operate in the early middle ages (Leroy 1988), but there is no disputing that output and productivity fell as the economy

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[16] *Agnosci nequeunt aeui monumenta priioris;*
Grandia consumpsit moenia tempus dax.
Sola menent interceptis uestigia muris
...
Cernimus exemplis oppida posse mori.

[17] A simple example is the use of screens to sort the pieces of roasted ore charged in the furnace. At low levels of production this would have been done by hand (Ehrenreich 1985:20-21).

[18] Assuming each smelt produced a bloom of 5 kilograms a daily output of 1.5 tons implies 300 smelts. Assuming each furnace employed two men to operate the bellows and made five blooms per day, 120 men would have been required on the bellows. One can suppose, therefore, that such a works could have been operated with fewer than 500 workers.

[19] Early methods of smelting extracting only a small proportion--roughly a 25 percent--of the iron held in the ore, which made the slag heaps of the Iron Age a primary deposit for later generations of ironmasters employing the blast furnace. The destruction of this record is a major source of selection bias in the interpretation of early iron-making capacity.

contracted. Between the fifth and sixth centuries the number of furnaces at the works in Poland fell from 40 to 3 (Radwan 1985:144-45). In England and Ireland the size of blooms fell from 8 or 10 kilograms to less than 5 (Tylecote 1965:158).

When we consider a history that stretches out nearly 1800 years from the Celtic development of the "high" furnace to the even higher blast furnace, we find great movement, but it is a fluctuating one that occurred within fixed parameters. Over this long period there was much learning and adaptation, but it was learning and adaptation called forth by sustained economic opportunity, but little true innovation. Had the demand been absent, it is unlikely that chance discovery would have generated the same result. Innovation in the iron-making sector of the economy was endogenous, not exogenous.

To multiply instances of a general proposition is tedious, but a few well-known examples of how the expansion of the market induced technical improvements help to buttress the argument that the inherited fund of traditional technique contained a large latent reserve of productivity that did not depend on major intellectual breakthroughs to sustain extensive specialization of skilled (and unskilled) workers and the development of special-use tools from general-use archetypes. Langdon's demonstration of how ploughs and harrows became increasingly differentiated in the thirteenth century is an example of how general purpose tools could be modified to perform specialized tasks without diverging from their archetype (Langdon 1988). Unger's history of medieval shipbuilding illustrates how increases in the demand by transporters for shipping space induced ship builders to make modifications in ship design. He observes that notwithstandng the huge increase in the size of ocean-going vessels and improvement in hulls and sail plans between 600 and 1600, "the essential body of information about the performance of vessels in water did not change over the millennium" (Unger 1980:24). The development of ship design and construction during this period was mainly connected with the growth of bulk carriage; but bulk maritime carriage was also a feature of classical and pre-classical economy[20], so that much of the improvement was by way of recovering old designs. Roman grain carriers were as large as any ship built in Europe before the sixteenth century, and were better built. The high level of woodworking skill employed to construct a Roman ship was lost when demand for for bulk carriers declined in the early medieval period. The medieval method of constructing boats on frames rather than putting them together like a piece of fine furniture as the Roman shipbuilders did was essentially a way of getting around the shortage of skilled labour at the cost of a higher input of wood (Unger 1980:37-42; 104-105). We are not warranted to suppose that late medieval advances in marine technology were unique, or that had a large-scale maritime trade in northern Europe been allowed to develop and grow in the early Christian centuries, Roman builders would not have lighted on the same solutions to the problem of managing large ships in storm-wracked waters. The medieval improvements are endogenous, not exogenous discoveries.

A final example of evolving productivity within a static state of the arts can be taken from the medieval history of written communication. Clanchy (1979) has demonstrated that the great surge in literacy and the use of written documents in medieval times occurred in the early thirteenth century, most it in connection with documents recording official and commercial transactions. By the 1270s, manorial bailiffs in England were supposed to maintain current rolls

[20] Ships as large as 450 tons are known to have been operating in the eastern waters of the Mediterranean as early as 1200 BC. The one best documented was employed in carrying grain (Casson 1971:36).

listing by name all males over the age of twelve, and to read them out twice a year, which indicates that near everyone with administrative responsibilities knew how to read and write (Clanchy 1979: 31-33). Historians have long recognized the streamlining of formulas employed in legal obligations like bonds and letters of exchange occurring at this time, but the writing itselfs and the support on which letters were penned also evolved as the demand for written documentation exploded. Cursive script developed out of book hand to accelerate writing in royal chanceries, whence it spread to the production of lay reading matter, both because it was a cheaper and quicker way of producing books, and because the books were meant to be read by men who saw more of business documents written in cursive than they did of liturgical books draughted in traditional formal script. (Clanchy 1979:100-101). Scripts that were originally idiosyncratic and chaotic converged to a few standard models, through an interaction between scribes and hand-writing readers that bears a striking parallel to the development of the modern typewriter keyboard (David 1985).

Perhaps the most striking change illustrating the effect of demand on technique, however, was in the support on which words were inscribed. From the abandonment of papyrus as a writing medium in the final third of the seventh century (Levison 1946: 178) to its reappearance in the late thirteenth, the permanent support for written communication was vellum or parchment. The extraordinary durability of this medium, to which we owe our vastly superior knowledge of medieval economic life as compared with the economic life of classical antiquity, was offset by the extreme difficulty of writing on it with a quill pen. To put his thoughts down on parchment a scribe had to scrape off any surface irregularities and rub and polish the support to stop the ink from running (Clanchy 1979: 89-90). Not surprisingly, most writing was reserved for making fair copies for permanent archives, like saving a computer text or calculation on hard disk. Although businessmen and others requiring aide-mémoires in larger numbers that could conveniently be managed with wax tablets made notes on strips of parchment that were subsequently discarded, the greater facility with which words could be put on paper caused the vegetable support to displace the older medium for ephemeral note-taking. This displacement of the written word from parchment to paper occurred in the course of the fourteenth century, and it brought writing materials full circle back to Roman practice. For essentially the same reason: the enormous mass of ephemeral written communication required to sustain a specialized economy could not be otherwise produced. That virtually no classical business media survive is no warrant for analysing the ancient economy as though it functioned solely on the basis of the spoken word. We know from the Theodosian code and a few surviving papyri concerning taxes that the fiscal administration of the Roman Empire could not have existed without a mass of paperwork, which included keeping records of every tax-payer's assets and obligations in triplicate. The complex clearing mechanism that was erected on this system of tax-extracted income streams not have functioned in the absence of widespread literacy and a huge production of paper (Durliat 1990). The history of writing in medieval times parallels that of iron and boat construction, with the difference that the early artifacts of this technology were lost early, probably not so much by deliberate destruction, as through the slow combusion of decay.[21]

What is apparent from the above discussion is that technology cannot be automatically taken as an independent datum in explaining long-run economic change, especially in the medieval period

[21] Medieval accounts from the early middle ages occasionally mention papyri deposited in ancient religious foundations, and supposedly documenting ancient rights and immunities that crumbled into illegible fragments when brought into the open. For examples, see Clanchy (1979:119-120).

when the basic technology was inherited from a society that economically was much more advanced. Inventions do occur, of course, but before we attribute major change to a cultural burst of genius[22] we ought to consider the interaction between market size, the scale of regional and individual enterprise, and the unfolding of the latent potential of existing technologies. It is in this complex of relations that I believe the secret of Europe's medieval economic growth is to be found. The kind of innovation that is the product of experience, upon which Adam Smith placed great emphasis in his account of the division of labour, is like the situation described in figure 4. Innovations come as a consequence, and not as a cause, of expanded activity. They may be thought to be latent in the same way that a scale economy is latent. This relation between scale, learning, and innovation also has a down side. Techniques may be lost for lack of demand to sustain them. Positive feedbacks reinforce each other; but they can reinforce contraction as well as expansion.

Trade and the Agricultural Economy

The main argument against the proposition that medieval economic growth was mainly a matter of more extensive division of labour is that the gains from the division of labour did not extend to agriculture, and that once allowance is made for specific innovations like the mould-board plough, horse-collar and three-course rotations, the most important sector of the economy was locked up by the Law of Diminishing Returns. According to this argument, unless the supply of agricultural commodities responds elastically to growth in market opportunity, any prolonged spell of ecnomic expansion will inevitably be shut down by rising costs of food and raw materials. The discouraging connection between the growth of the economy and the increasing difficulty of wrenching extra produce from a fixed supply of land lay at the heart of Ricardo's pessimistic assessment of the possibilities for long-run progress in his own time, and it survives in the modern Neo-Malthusian synthesis of pre-industrial history.[23] This synthesis represents the core of medieval macro-economic history. A few citations from eminent medievalists of the last generation may be produced as evidence in support of this claim.

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[22] The following quote by Lynn White is an extreme, though by no means an unrepresentative example. "The expulsion of spirit from the objects of nature, the conviction that mankind, by God's will, exercises a rightful rule over all of nature, the idea that time is a unique resource to be conserved and utilized to man's advantages, and the belief--never universal, but sufficiently widespread to be socially operative--that labour is virtuous, are Judeo-Christian alterations of contrary Greco-Roman views that do much to explain the remarkable contrast between the technological style of antiquity and that of the western Middle Ages. The technology of Frankistan became amazingly innovative largely because it was so closely integrated with a specific and dominant faith, Latin or Roman Christianity." (White 1989: 663)

[23] "Any pre-industrial economy was obliged to accept certain limits to growth set by the fact that the land was almost the sole source not only of food but of the great bulk of the raw materials used manufacture. Since land was in fixed supply, production could only be expanded by obtaining larger and larger outputs from each existing acre of farmland or by breaking in inferior land, but at some stage it seemed unavoidable that diminishing returns would take hold, making further expansion progressively more difficult and costly. All pre-industrial economies were therefore by definition subject to a form of negative feedback, unable to engender changes capable of securing rising real incomes for the mass of the population." (Wrigley 1988:34)

"Even as demographic growth was a prime motor of agricultural progress, so agricultural progress was an essential prerequisite of the Commercial Revolution. So long as the peasants were barely able to insure their own subsistence and that of their lords, all other activities had to be minimal. When food surpluses increased, it became possible to release more people for governmental, religious, and cultural pursuits. Towns re-emerged from their protracted depression. (Lopez 1976:56)

"J'ai dit que l'essor de l'Europe du xi^{e} siècle était le fait d'une 'réussite agricole'. Or, que rélève les sources du ix^{e} siècle, sinon une emprise très précaire des hommes sur le sol cultivé, sinon des techniques très primitives et inefficaces? (Duby 1979:112)

"Fluctuations in foreign trade cannot directly account for new fields, new villages, more crops and more animals, indeed more men, in the thirteenth century, or for the decline in the area and output of medieval agriculture in the later Middle Ages." (Postan 1973: xx)

"Population was increasing,...The output of agriculture, though expanding, could not keep pace with increasing numbers to be fed. The ever greater dependence on poorer lands and the impoverishment of some of the old lands raised the real cost of food in terms of resources which had to be devoted to the production of additional quantities of grain." (Postan 1972, p. 270)

"Ressort de l'expansion tant qu'il subsiste de la terre vierge à convertir en labours, elle [demographic expansion] devient l'élément premier du blocage lorsque s'amorce la retombée des défrichements et que stagne la productivité du travail. Passé 1280 ou 1300, la pression [démographique] se transforme en saturation. Au regard des capacités de production de son économie, le coeur de l'Occident est alors en état de surpopulation." (Contamine et al 1993:211).

The weight of this authority and the long tradition of scholarship that stands behind it demand respect and response. It is incumbent upon us not only to demonstrate how the facts as we know are incompatible with it, but also to explain how the Malthusian hypothesis came to be accepted almost unquestionably by historians, to the point where facts that threw doubt on the doctrine of increasing scarcity of land were rejected as implausible <u>a priori</u> or explained away. The best example of outright rejection is Edouard Perroy's dismissal of the French population estimate of 15 or 16 million advanced by Ferdinand on the basis of the 1328 hearth returns.[24] Lot's conjectures are now considered to be on the low side. Similar scepticism greeted Postan's conjecture that the English population in 1300 might have been as high as 7 million souls, although in the end Postan had his way by arguing the case for overpopulation. I begin, therefore, with a brief review of the history of the belief that medieval and early modern societies faced a Malthusian trap having its source in scarce land and impoverished agricultural technology.

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[24] "Les célèbres conjectures de F. Lot, d'après l'état des feux de 1328, aboutissent à compter 15 ou 16 millions d'âmes en France, d'où une densité rurale de 35 à 38 habitants au km², si forte que cette masse humaine n'aurait pu être assurée." (Perroy 1949:168n).

The doctrine that agricultural improvement is a precondition for economic growth originated with the classical economists of the eighteenth and early nineteenth century, who can be said to have imposed the construction of an aggregate agricultural production function with strongly diminishing returns to labour on the data as an act of analytical necessity. This is especially true of Ricardo (1965 [1817]), who required diminishing returns for stable equilibrium in the general equilibrium model he invented specifically to analyze the incidence of taxation. Ricardo's hypothesis of diminishing marginal returns to doses of labour and capital applied to a fixed quantity of land became and remains one of the building blocks of economic analysis. The primary empirical support for Ricardo's proposition is the long-run behaviour of the ratio of agricultural prices to nominal wages, which rises in periods of population growth and falls in periods of demographic contraction. Since the real wage can be assumed to reflect the marginal product of labour, the inverse relation between population density and real wages has usually been taken as incontrovertible evidence of the Law of Diminishing Returns, and by extension the limited agricultural possibilities imposed by a stagnant agricultural technology and a fixed supply of land.[25]

Economists' investigation of long-term price and wage series originated with Adam Smith's hunt for a useable standard with which to measure long-run changes in wealth (income). Because he believed that the labour content of a bushel of wheat had not significantly altered since the twelfth century, Smith thought a workable metric for converting goods to a fixed common standard might be developed by deflating their prices by the price of corn, the long-term variation in which was mainly affected by the supply of silver.[26] The original purpose of compiling medieval and early modern prices was thus to measure changes in the price level. This is a macro-economic phenomenon, which is most efficiently studied by constructing indices of average prices to represent tendencies. Smith's enquiry was continued in the nineteenth century by economists Thomas Tooke and William Newmarch (1830-1857), and eventually entered the world of history in the person of J. Thorold Rogers. It was Newmarch's address to the International Statistical Congress of 1860 that inspired Rogers, then a rural curate who had acquired an interest and concern for his labouring parishoners, to undertake a systematic compilation of prices and wages recorded in the records of college and religious foundations. Like Smith, Newmarch considered the prices to be a homogeneous series that

"represent the more simple units through long periods of years. The price of the leading kinds of grain represents the many values of a description of raw produce, which in itself changes but slowly as regards quality, and the production of which through considerable

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[25] The Law is also sustainable by a logical argument. If diminishing returns did not obtain, farmers could reduce rental outlays by producing the same output with the same non-land inputs on smaller amounts of land. Since we do not commonly observe this, it must be because the transfer of inputs from a larger to a smaller extent of land reduces the marginal product of those inputs. I am not here contesting the law of diminishing returns per se, but to its employment as a description of aggregate production possibilities. If the arguments about multiple equilibria developed above are correct, the whole is definitely not the sum of its parts, each of which may individually exhibit diminishing returns to the fixed factor of production, without this implying that the aggregate agricultural production did in the relevant ranges of output.

[26] See Smith(1776): Book I, chapter 5 and "The digression on silver" in chapter 11, where he considers whether the silver price of grain was influenced more by changes in the supply of silver or in the ease of raising grain by investigating the course of English grain prices since the twelfth century.

intervals of tine, implies the application of the same amount and kind of labour, skill, and capital. In like manner the wages of the commoner kinds of agricultural labour represent, for long periods, the money price of almost the same kind and amount of services rendered by labourers seeking employment under the same conditions." (cited in Kadish 1989: 26).

To Rogers, the history of prices and wages opened up the history of the welfare of the common man. His stupendous archival labours were replicated and improved upon by William Beveridge (1939) and others in this century, whose work constitutes the main empirical support for the Ricardian hypothesis.

The spirit of Smith's original enquiry into the evolution of average living standards was thus never lost. Rogers believed that they were determined by legislation[27] but his data could be readily deployed to demonstrate Ricardo's hypothesis that they were determined by the "subsistence" wage. In either case, it was the average that mattered. If prices and wages observed on any particular date differed from each other, the variation could be ascribed to special circumstances of secondary importance relative to the momentous demographic and technological forces driving long-run economic change. Price and wage data were compiled with a view to averaging them into indices whose movement over time revealed the essential dynamics of the medieval and early modern economy. When professional medieval historians began to collect information on yields, they adopted the economists' strategy of conflating the data into an average yield, which they interpreted as an index of agricultural productive capacity. This is especially evident in studies inspired by Postan, who, although perfectly aware of the large regional variations in yields and productivity, attributed them to idiosyncrasies of soil fertility and population pressure. Following the example set by Abel (1980 [1935]), he related the index of yields to Beveridge's "national" price and wage series. The effect of these apparently innocuous preliminary operations was to dress up data that were in fact heterogeneous into a form more suitable to the macro-economics of a modern integrated economy than that of a pre-industrial one. In this macro-economic construction, the law of aggregate diminishing returns reigned supreme.

Historians nevertheless find it difficult to think in terms of averages. The "average" is a statistical construction, not the individual persons or events whose restitution to many historians constitutes the true object of historical enquiry. Such historians attempted to explain individual anomalies in the evidence on yields and cropping systems. But instead of rejecting the Ricardian-malthusian model, for which there seemed to be no alternative other than the one proposed by Marx, they explained the anomalies by methods not unlike those employed by pre-Copernican astronomers to fit the epicyclic mechanisms of Ptolemy's heavenly model to increasingly accurate stellar observations. As the range of data increased, so did the complexity of Ricardian-Malthusian explanations employed to explain them.

It was the apparent inconsistency between the chronology of contraction of arable on individual demesnes and rising prices in the late thirteenth century that led Postan to develop his ecological

[27] Rogers beliefs were an odd mixture of Tractarianism and Manchester liberalism, which he associated with liberating the direction of policy from the special interests of the landed class. He adored Cobden, who was related to him through the marriage of Cobden's sister to his brother (Kadish 1989:20-21).

explanation of declining yields on marginally situated estates, which he argued had entered the range of strongly diminishing returns at different dates.[28] Fox's (1986) ingenious attempt to explain manorial differences in the timing of the transformation of two-course into three-course arable rotations is in the same mould. He argues that because the three-field system reduced the amount of fallow land available for pasturing livestock, it could only be introduced on soils fertile enough to sustain more intensive cropping with a reduced stock of animals. Many townships never adopted the three-course rotation in the middle ages because they lacked the requisite store of fertility, while others adopted it early because they possessed it. To account for the group of manors that shifted from one rotation to the other, Fox conjectures that they were probably situated in "intermediate" environments, "which might initially have opted for the less intensive system, but which, under pressure, could change to more intensive arrangements without undue prejudice to yields" (Fox 1986:544). All this is predicated on an iron law of land scarcity, which forced peasants to portion out the arable between men and the animals that sustained them. It is never explained why animals displaced by the expansion of the arable could not be maintained on oats, the yield of which was highly responsive to additional ploughing input.[29] In these constructions are revealed the lengths to which fine scholars have gone to shoehorn the facts of agricultural evolution into a supply-determined explanatory framework.

What is the alternative? The simplest one is that systematic regional differences in the prices farmers received from the sale of their produce induced them to vary the intensity of cropping and the level of agricultural inputs per hectare. To suppose that farmers tailored their expenses to the returns they expected to receive as a result of making them is no more than to hypothesize an agricultural supply function. We shall review below some evidence bearing on the elasticity of the response of agricultural supply to price. First, we must show how this alternative differs from and in a way completes the Ricardian synthesis. What is mainly required is that we abandon the tradition of treating medieval price and yield data as single-valued indices of population pressure and technology, and instead examine the rich cross-sectional array of regional data for what it can tell us about medieval agriculture and its markets. The crucial step is to treat these data as independent observations on local conditions of supply and demand, rather than as random deviations around a national or regional mean. When we do this, a new and more favourable picture of medieval agricultural capabilities emerges, and with it support for the view that agriculture did not effectively limit the possibilities for economic expansion between the sixth and the sixteenth centuries.

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[28] According to Titow (1969:52), "Since the phase of marginal reclamation had been reached on different estates at different points in time, one would expect to find considerable differences in the time by which the state of diminishing returns was reached on different estates -- hence the difference in the timing of the contraction of arable cultivation from one estate to another."

[29] Oat yields are a better indication of agricultural intensity than wheat yields, because coming after a winter cereal, oats were sown in a seedbed much infested with weeds, to which they were highly sensitive. As long as the demand for oats was limited to the needs of farm draught animals, farmers economized on the team and labour input dedicated to them, and yields were low. Where outside demand for oats emerged, however, they intensified cultivation by ploughing before Christmas. The rise in horse-drawn transport everywhere raised the demands for oats. This is clearly evident in the astounding rise in the yield of this cereal--it was significantly greater than the rise in wheat yields-- that Turner (1982) has documented for the Industrial Revolution. Medieval historians would do well to trace the yield of oats spatially and temporally.

The key to regional agricultural differentiation is the way transport costs define economic space. To the classical economists the defining characteristic of land was that it is fixed in supply. This fixity is, however, an analytical characteristic. Ricardo's readers and to some extent Ricardo himself too readily identified the analytical concept of land, which is something that has no supply price, with physical land, or what Von Thünen called der boden an sich. As Marshall pointed out, however, land's fertility and quantity can be increased or decreased by human action. Land is not fixed. What is fixed is the logical property of geometrical extension. A point on the world's surface always bears the same geometric relation to every other point on earth. Unlike fertility and quantity of land, this geometry can never be affected by market demand. The spatial relation between points on the globe is, he remarked, "the foundation of much that is most interesting and most difficult in economic science." (Marshall 1966: 121).

It was because they were situated differently with respect to major markets that medieval farmers did not have equal market opportunity. Trade in agricultural commodities reflected this inequality; regions remote from towns and ports exported goods and services whose value was high relative to the transfer cost, while less remote districts concentrated on the commodities for which the ratio of unit price to unit transport cost was low. Because all regions produced subsistence foodstuffs, however, cereals and fodder crops were grown everywhere. At each point in a space defined by points of concentrated demand for foodstuffs and raw produce farmers grew crops whose farm gate price fell as the distance from such points increased Campbell et al:1993). It is this relationship between distance and market opportunity, distorted to be sure by the particularities of local transport systems, that allows us to identify the agricultural supply function for pre-modern societies (Grantham 1989). A higher farm gate price induced farmers to incur the extra expense of increasing applications of labour and capital. (The hectares could not be increased without increasing transport costs.) Rising labour and capital intensity raised yields. Average yields, however, might not change, or at best might change only slightly as a consequence of the intensification induced by the growth of urban demand. If the share of total population inhabiting towns were low, the regional impact of concentrated demand on farming methods would be limited to a small region, and the high yields induced by it would be averaged away by a much larger number of observations drawn from unaffected districts. One also expects average yields to be low in a rural society that employed a land-intensive technology. Why should farmers expend valuable labour and capital to raise food they didn't need and couldn't sell?

When we consider the cross-sectional array of yields and other agricultural data, now vastly augmented by Campbell's patient labours in the demesne accounts of the thirteenth and fourteenth centuries[30], it is impossible to treat them in a Ricardian way. Yields are high near the great towns, and fall with distance from them. Patterns of cropping intensity display the same general pattern. Population density is higher around towns, but the living standards were also higher, as evidenced by continuous immigration. Ricardian diminishing returns imply that workers (and capital) emigrate from places where the returns are falling towards regions where they are holding up. Diminishing returns imply regional convergence; what one observes is regional divergence.

This divergence is nowhere more evident than in the exceptionally high yields estimated from the rent-farm receipts of Flemish religious houses. These estimates indicate that farmers in Picardy

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[30] For an extensive bibliography see Campbell and Overton (1991), and Campbell, Galloway, Keene and Murphy (1993).

and Flanders regularly obtained yields exceeding 25 hectolitres per hectare, and even reached levels of productivity that are at the maximum possible under cultivation using traditional varieties of wheat and organic manure (Derville 1987a, 1988a). The Flemish data are exceptional, but in the context of the 10 to 12 hectolitres per hectare commonly considered to be the average medieval attainment, the 17 hectolitres inferrable from Neveux's (1980:64) indices of productivity in Cambrésis is equally extraordinary. Seventeen to 20 hectolitres was also the expected yield on the huge Cistercian farm outside Paris at Vaulerent, probably the largest grain-growing farm in Europe.[31] The demesne farm of Gennevilliers belonging to the Abbey of St Denis ordinarily yielded 20 hectolitres (Fourquin 1966:30). Further west near Chartres yields ranged between 14 to 18 hectolitres (Chédeville 1973:213-14). What is significant about these early fourteenth-century yields is that they are identical to those recorded in the same regions at the beginning of the nineteenth century (Allen and O'Grada 1988; Farcy 1985:421)[32] Yields in southeast England also reached 18 to 20 hectolitres per hectare in the second half of the thirteenth century (Campbell, 1983a 180), as did Isabella de Forz's manor of Little Humber in Yorkshire (Mate 1988) and the Sussex demesnes of Battle Abbey (Brandon, 1972: 417).[33]

The yields reported above are mainly drawn from farms in regions exposed to exceptionally strong demand by urban centres of consumption. They tell us what was possible using only medieval technology, and they demonstrate beyond a doubt that medieval farmers were not seriously limited in their ability to extract more food from the land by an inadequate stock of technical knowledge. The yields were not obtained by manual methods of cultivation on garden plots, but reflect the performance of large farms that employed draught animals to cultivate fields and deployed small armies of hired workers at peak periods in the year to harvest the crop, just like similarly organized capitalist farms did three centuries later (Derville 1987c, 1988b; Moriceau and Postel-Vinay 1992; Moriceau 1994). Medieval farmers had approximately the same capacity to extract food from the soil as the farmers of the early eighteenth century, and this is probably true of farmers in the eighth and ninth century as well[34] (Delatouche 1977; Durliat 1978; 1990). As Campbell, Derville and others have shown, high medieval yields were gained techniques similar

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[31] In 1315, finding it increasingly difficult to recruit lay brothers to work for room, board, and possible salvation in a century of diminishing religious fervour, the white monks leased the buildings and 227 hectares of demesne arable to a "peasant" named Pierre Bove. The lease stipulated that Bove was to be released from his obligation to deliver rent whenever the yield fell below 12.5 hectolitres per hectare. If rent constituted as little as one third of gross output, the expected normal yield at Vaulerent should have been 17 hectolitres (Higounet, 1965: 51-52). According to Higounet the break-even yield was 15 hectolitres, which would imply an expected normal yield of more than 20 hectolitre per hectare. Higounet's estimate is based on the Paris setier of 1.56 hectolitres. My estimate uses the more probable Meaux setier of 1.26 hectolitres.

[32] See also the census returns in the Archives National, F20 258, "Mémoire statistique du département de la Seine-et-Oise (An 9)" Arrondissement of Pontoise; Archives Départementales, Seine-et-Oise, 13M5, "Questionnaires cantonnaux," Enquête agricole 1837. Canton d'Argentueil).

[33]. My transformation of the net yield assumes a tithe of 10 percent and harvest and threshing expenses at 20 to 30 percent of the gross yield, the latter proportion based on Walter of Henley's cost breakdown.

[34] I do not have space to develop the case for the high productive potential of Carolingian agriculture, which is based in part on a re-interpretation of the Carolingian polyptiques as fiscal documents and in part on archaeological evidence and agronomical considerations. For a recent airing of evidence indicating that the horse collar and heavy plough probably predate the medieval centuries see see Amouretti (1991).

to those to be employed three centuries later. Farmers sowed legumes in rotation to increase the supply of nitrogen--though they planted beans, vetch, and peas rather than the clover and sainfoin leys put down by later farmers[35]--and they ploughed and harrowed more frequently (Campbell 1983, 1988; Derville 1987c, 1988b). This required more labour input, as did extra weeding and heavier sowing, but the labour input in ploughing, harrowing, and manuring could be reduced by making replacing oxen with horses and by increasing the size of operating farms and fields. Larger farms allowed the labour and teams to be more efficiently distributed across tasks, while larger fields saved ploughing time by making it easier to turn the teams at the end of the furrow. None of these adjustments to markets involved technological breakthroughs, and they are to be found in other places and other times where demand warranted an extension of large-scale commercial farming (Moriceau 1994). The only difference between the technological endowment of thirteenth- and seventeenth-century farmers is that the former, for reasons that have yet to be resolved farmers in northern Europe apparently did not have access to clover or sainfoin.[36]

To summarize, the evidence from cross sections indicates that the response of agricultural productivity to price was strongly positive, and that the most important determinant of the price of subsistence foodstuffs was city size and distance from farm to city. Hoffman's (1991) analysis of the rental rolls of the Cathedral of Notre Dame suggests that total factor productivity rose as the distance to the centre of Paris fell. I detect a similar relationship in data from the agricultural censuses in the same region in the early nineteenth century (Grantham 1989). Not only did farmers work their holdings more intensively when they benefitted from close proximity to cities, they also used their inputs more productively. The same amount of labour and capital applied in a farm by a large town produced more output than it did on a farm a hundred miles a way. If this were due to exogenous technical change, the pattern would be hard to explain, for how could districts so close to each other differ so much in their agricultural technology, and why do these differences persist for centuries? It is more reasonable to attribute the differences to endogenous response to opportunity. But this means that agriculture was responsive and not limiting.

I believe that closer examination of the temporal record will show the same mechanisms at work. Neveux (1980) found that the most important determinant of agricultural intensity in the Cambrésis of northern France was the prosperity of the Flemish and Hainault cities downstream. Bailey's (1989) study of the economic development of the Breckland shows that a region once thought to have been brought into cultivation late because it had marginal lands was in fact integrated into the London market through trade in produce other than cereals. Stephenson's (1988) study of late medieval fleece weights provides confirmatory evidence that productivity was responsive to price. His series peaks in the early fourteenth century when aggregate demand for English wool was at its height; it declines in the later fourteenth century when wool prices were falling.[37] The most plausible explanation of the temporal variation in fleece weights is that the

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[35] [note on clover here

[36] I have systematically searched the botanical literature and find no reference to evidence of farmers cultivating (domesticated) varieties of clover or sainfoin in northern France before the fourteenth century. The plants do not appear in northern herbals before the fifteenth century, although they were cultivated in Mediterranean Europe by the Christian era and were bred for resistance to cold by the 4th century, which would seem to indicate a northward extension (Mathon 1905; Zeven and Stemerdink 1986; Zohary and Heller 1984:1)

[37] A regression of the twenty-five year average fleece weight on the twenty-five year average deflated price between 1208 and 145 yields a price response coefficient of 0.362, which means that fleece weights fell by .36

declining price of wool reduced incentives to maintain the stock of highly productive sheep. These are straws in the wind, but they all blow in the same direction. The work of pulling together the regional yield data for England that Campbell is directing will, I believe, confirm these findings.

Conclusion

The burden of this paper's long argument is that medieval growth stemmed from endogenous responses to market expansion that fed on each other in a ring of positive feedbacks. It remains to be determined what set this process in motion, and when it was set in motion. The increasingly persuasive evidence that the Merovingian and Carolingian economies were extensively provided with local markets, which were linked with each other through thin networks maintained by travelling merchants (Settimani 1993) would seem to indicate that it might have taken only a slight nudge in the right direction to start growth rolling. We are, after all, dealing with a society that had a strong sense of private property and knew markets. I therefore think that Jones' (1993) attempt to explain the early development of Saxon markets in England by a fall in transactions cost brought on by the need to raise money for the Danegeld to be partly right and partly wrong. It may be partly right in that transferred cash concentrated purchasing power and may have contributed somewhat to effective demand. It is surely wrong in making out the English exchange economy of the eighth century to be a market-less society where most exchange was motivated by non-pecuniary intentions. Marcel Mauss has had an exceptionally good run in medieval economic history, but we must face up to the fact that his theory of gift exchange betrays a nineteenth-century view of the progress of civilization and the conservatism of individual cultures. Anyone who seriously examines the archaeological record of the late Roman and early medieval economy, not to mention the pre-Roman Celtic economy, will find a market economy. We know a lot about gift exchange, because this was what was recorded, in letters between the great and in the literature created for their entertainment. Markets expand and contract through the internal dynamics we have been exploring. We do not need to invent a taxonomy of mentalities to explain these fluctuations.

Recent scientific work unrelated to the issues at hand has unearthed an important piece of evidence bearing on long-run variation in Europe's economic prosperity (Hong et al 1994). In the two and a half mile deep glacier that covers most of Greenland are deposited particles of dust, pollen, and smoke that float around the upper latitudes of the northern hemisphere. In this minute debris are to be found particles of lead released into the air as by-products of smelting copper and silver. In the frigid arctic atmosphere crystals grew on these particles, and the snow flakes fell century after century onto the Greenland ice. The density of the particles per vertical inch of this ice measures the rate of production of copper and silver. What do the cores extracted from the ice tell us? From a low level of background pollution, the rate of deposition started to rise around 5000 BC, with the discovery of cupellation. It continued to rise through the Bronze Age, but the great acceleration in production begins around 500 BC and continues into the early Christian era. It peaks in the early 2nd century AD, and declines gradually to around 900 AD, when production starts to grow again. For a hundred years or so, growth is rapid, and then it tails off until the discovery of the mines in Peru and Mexico. Accleration is again rapid from the eighteenth century to the present. The graph of this history is shown below in Figure 5. What does it show?

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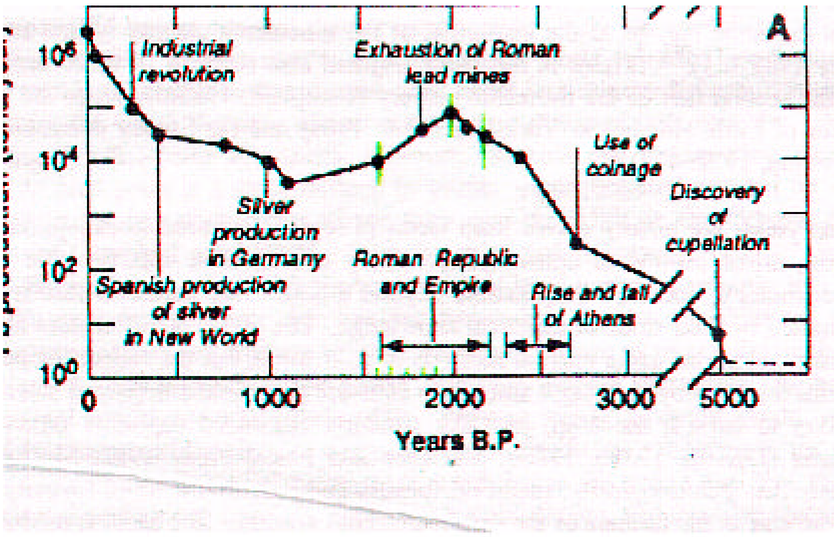
percent for each one percent decline in price.

Silver production in the first century AD was about as high as it was in the early eighteenth century AD. Nearly two thousand years for the world to recover the production level that prevailed in the Roman Empire at its peak! The medieval contraction is real but modest; about 25 percent from 200 AD to 900 AD, which is the same order of magnitude as the decline experienced by the western economies during the 1930s. Much was lost, but not all.

Figure 5



Source: (Hong et al 1994:1842)

Most of the silver produced before the last century was employed in coinage, the demand for which was mainly determined by the level of economic activity. The long-term fluctuation in silver smelting is readily explained by variation in the level of real demand for specie, which in turn was determined by the level of transactions between specialized producers. I believe these data, which are the only index we currently possess of economic activity in the very long run, demonstrate that economic change in the pre-industrial European market economy was one of fluctuation, not basic advance. The endogenous market interactions uncovered by the new economics of market processes provide a rational mechanism for these fluctuations. If almost everything important is endogenous, and if positive feedbacks dominate negative ones over long periods of time, this is what we should expect. Of course, nothing temporal ever is the same, and a prolonged period of growth induces accumulations of skill and understanding that can lead to real advance. History is a helix, not a circle. In the medieval era, however, its gradient was not steep.

lo tempo è poco omai che n'è concesso,

e altro è da veder che tu non vedi

Inferno xxix:11-12.

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