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PRICE FORMATION WITH SPATIAL AND TEMPORAL UNCERTAINTY: An Analysis of the Role of the CBD

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1. Introduction

Some enduring location choices challenge the conventional models of competitive location allocation. One such is the persistence of market gardens around large urban centres that use locations that are highly valued because of their suitability for all manner of urban uses. These areas have been there since the earliest times, featuring prominently in von Thunen's original model of land-use [von Thunen (1826)] for instance. In spite of several revolutions in transportation, no reduction in unit transport cost has induced a wholesale relocation to cheaper, more distance locations, which would undoubtedly be technically possible under conditions of certainty. Some competing suppliers, however, have become established at locations much further out from the market centre, but they are not dominant suppliers in spite of land costs being possibly ten-fold lower. In other words, location and transport costs together do not offer a complete explanation of these horticultural businesses' differing location decisions.

It is the location of the distant, peripheral suppliers that is consistent with conventional models following von Thunen (1826)[1]. Such suppliers locate, according to conventional models, where the value of the product at the central business district (CBD), given existing prices, supply technologies and known demand, is sufficient for the supplier to pay more for the location than competing interests. The von Thunen model assumes, not explains, the existence of the CBD and argues that all product values decline at a characteristic rate with distance away from the CBD. The declining net value of products at greater distance leads to a declining rent gradient that producers can offer for land. The rent gradients of expensive products are steeper[2] than those of cheaper products, so that each product has a range of distance or "zone" around the CBD in which it outbids all competing land users. The same von Thunen model, however, does not explain the existence of growers using expensive

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[1] Conventional theory relating to space evolved from von Thunen, through Losch (1940), Isard (1956), Greenhut (1956), and Alonso (1964) and is well reviewed by Ponsard (1983), but has not yet had an impact on the core of economic theory. The conventional rationale is based on the essential features of distance costs, an early form of transactions costs, and increasing returns to explain the gains from central locations; neither feature is basic to classical economic thought. A further reason introduced here is the inherent and prevailing uncertainty across space from which this paper starts.

[2] Most high value products or services are dependent on having excellent market access. For a supplier to compete from a less favourable location with poorer information, there needs to be a significant saving in location rents, and so a steep rent gradient results. For the derivation and full explanation of rent gradients see Alonso (1964).

urban sites nor does it address the question of the role of the CBD itself, since it assumes that prices are known.

In many ways, the more distant, peripheral suppliers are equivalent to "exporters" in terms of the rest of the market garden suppliers, with much slower response times and poorer market information. The reasons why they are not dominant provides insights into their operational problems and, by contrast, the advantages of locations close to the price-forming centre. The key to the distinction lies in the ability to respond to valuable market information, but this has to be coupled with an appropriate operational strategy that maintains viability. It is both this difference in operations, and the type of market information that each values as a result, that enables both central and peripheral firms to survive in the same market conditions. This duo of supplier types is, in fact, typical of many industries, such as the local and large national bakers in the bread industry, and may well be general to all cases where imported and local products coexist.

This paper focuses on the distinction between peripheral and central locations and offers an explanation for the central role of the CBD. Under the assumption of certainty in the von Thunen model, and in all classical theory, there is no obvious need for spatially dispersed producers and consumers to avoid trading at the nearest convenient site[3]. Since both parties will be fully informed of their individual circumstances trades between them would seem highly feasible and efficient[4]. The only possible impediment to their trading is a lack of knowledge of the opportunity costs involved; for these to be significant, uncertainty must prevail.

The paper begins by establishing the essential role of uncertainty in generating market processes and elaborates the gains to all parties that are derivable. It then examines the essential spatial character of the process and its influence on information quality and efficient price discovery. The distinctive consequences of this at locations away from the price-forming centre are analysed. Finally the suggested model is used to show how centrally placed and

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[3] A recent expression of this difficulty in explaining the existence of cities using conventional economic theory can be found in Quigley (1998): "Without scale economies, there is no role for the city at all." page 130

[4] In fact efficiency applies only to the parties involved. Koopmans & Beckmann (1957) established clearly that the outcome of any series of individual trades was arbitrary and so lacked any satisfactory price-forming role for efficient market clearance.

peripheral agents differ markedly in available information, exposure to uncertainty, market opportunities and the processes essential for survival.

2. Price Formation with Spatial and Temporal Uncertainty

As a study of the optimum use of scarce resources, economics can be characterised, in a world of dynamic uncertainty, as a search for optimum responses to stochastic variations in scarcity levels. Given that agents' circumstances differ and also change individually through time, economic behaviour offers not only a means of extending the productivity of resources, by investing in infrastructure, for example, but also a means of smoothing out the impact of stochastic change by inducing offsetting behaviour among other agents. The comprehensive nature of this adjustment process is achieved both by quantitative adjustments, possibly involving trade, at existing prices[5], and, more fundamentally, through markets, and their price formation mechanisms in particular. An individual agent, besides storing sufficient surplus to cope with anticipated future deficit periods, can use markets to (a) benefit from any additional surplus that is above survival needs and (b) to offset unexpectedly large deficits. Every agent in the market is unwittingly induced to cooperate in this through the influence of price adjustments. Economists can surely be excused for getting a buzz over the sheer elegance and efficiency of the price mechanism and the comprehensive, system-wide adjustment that it achieves. Furthermore, all this is attainable without the need for fallible human design or control, including, arguably, that of the all-knowing Walrasian auctioneer[6] when the spatial realities outlined here are taken into account.

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[5] This quantitative pooling at existing prices is a form of aggregation, in effect, which has a well-known automatic advantage in reducing relative variability [See Fisher (1987) for a definitive statement]. Being accepted as a trader in a given market makes the responses to unexpected outcomes as potentially efficient as the total size of the market makes possible. An individual trader can thus enjoy benefits equivalent to being orders of magnitude larger in size.

[6] It has recently been argued [Heilbroner (1993) p.87] that Adam Smith was searching for such a mechanism to help explain the order created. This view, however, is not shared by the author.

2.1 The Process of Price Discovery

Efficiency is achieved by markets via the mechanism of price formation, in particular the determination of a price that relates the aggregate total demand of the represented traders, in a precise way, to the aggregate tradeable quantity in the market. It is largely this quantity, predetermined but unknown initially, that provides the driving impulsion for the determination of an appropriate market price, since demands are largely based on prior knowledge[7]. Thus both price and quantity have to be discovered by the process[8] of joint determination.

2.2 The Reward of Income Smoothing

In normal circumstances, aggregate shortages relative to aggregate demands result in a rise in the market price and this acts as a signal to ALL agents to adjust their affairs towards alleviating this unusually high price and so moving the market towards its equilibrium level. Individual agents confronted with an unexpected drop, say, in their marketable surplus quantity, and so contributing to a supply shortage, can benefit from a rise in the market price, so that their revenue will vary less than in proportion to their volume of tradeable output[9]. In the special case of a market demand of unit elasticity the total value of all sales will be constant regardless of the level of total supply. Note that any negatively sloped demand curve is sufficient to reduce the variation in any seller's total market receipts below that due to changes in quantity alone, as long as the change is in the same direction as that in total supply. This mechanism significantly reduces the average supplying trader's financial variability, and hence their costs from uncertainty. The steeper the demand curve the greater the reduction in seller's financial variability relative to the unforeseen changes in their tradeable volume and hence their potential market revenue at expected prices. Contrariwise, this same mechanism

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7 This is true even though demand levels relate to estimates of quantities needed in the future. Current information revealed during trading will be added to buyer's information, but it is most unlikely to completely dominate the preformed longer-term judgements that potential buyers bring with them.

8 This is a complex procedure involving both price and quantity assessments by traders, in which potential suppliers make price-related judgements about what quantity to sell in the current trading period, given their own available supply. Note that all traders have the opportunity to be "price-makers" by taking disequilibrium positions temporarily in anticipation that their non-optimum current position will produce a future profit, given their personal assessment of forthcoming market changes. The importance of property related financial security to sustain the risks involved here should not be overlooked; most traders, however, will prefer to use the market less riskily as "price-takers", ensuring only that they achieve the best possible current price.

9 Note that supplier's risks can include, in theory, total supply failure; assistance from the market mechanism discussed here only applies in the presence of some positive supply.

that reduces the costs of uncertainty for sellers does the opposite for buyers. Thus buyers' unexpected changes in demand levels cause price changes in the same direction, due to the positive slope of supply curves. In the short term, especially, when supply responses are particularly steep, increases in demand will raise unit prices sharply; decreases in demand will benefit from falling prices as well. Thus the consequences of unexpected outcomes are relatively lessened for sellers and relatively exaggerated for buyers, all of whom are necessarily encouraged to contribute to smoothing the aggregate adjustment, via the change in price.

The startling thing about this whole process is the stark contrast between the seemingly almost trivial nature of the elemental parts, the individual trades, and the quite magnificent feat of coordination and collective response that emerges, "as if by a hidden hand"[10]. In this it shares a marked similarity with the process of evolution; both can conjure in some the strong conviction that a supervisory agent must be involved[11]. For markets, at least, all that is necessary, however, is that (a) potential traders are numerous in number and anxious to search for the most advantageous deal[12] available, (b) some learning opportunity exists for all in the market from each transaction, and (c) there is a distinct spatial and temporal framework to trading, by which aggregate quantities are formed into discrete values. In short, there needs only to be many searching agents concentrated in space and time, given the realities imposed by uncertainty and distance costs[13]. Note that this is a significant claim that contrasts starkly with the great bulk of the standard literature, which is based on deterministic theory as stated above. It is, however, an approach that is consistent with most economists of the Austrian school[14], especially Hayek whose great contribution to economics includes trenchant criticism

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[10] For an informative treatment of the importance of this familiar claim, and its significant limitations that suggest that too simiplistic a blind faith in it will be highly risky, see Hahn (1981).

[11] See footnote 6.

[12] This is the key element in achieving efficiency and implies that markets are anonymous, impartial and efficient. This also means that efficient markets cannot be discriminatory or in any way biased against any particular individual or group (see Arrow (1998) for an analysis of non-discrimination by rational market behaviour). However, all potential traders in the market may well be subject to credit and trustworthiness assessments in order to partake.

[13] For a recent and innovative attempt to model the market price formation process without resort to "an exogenous Walrasian auctioneer" see Spulber (1996), where the time costs of search are utilised to achieve a convincing model of the equilibrating mechanism that markets generate. Note that time and space together would improve the power of the model and its realism still further.

[14] For a recent and highly commendable review of the Austrian school and its potential to extend mainstream economic theory see Endres (1997).

of standard theory's reliance on the implausible assumption of certainty, as outlined in Hayek (1945).

3. The Essential Spatial Structure of Markets

The significance of spatial and temporal concentration of agents relates to the market process by which specific aggregate demand and supply levels are discovered. This discovery process is complex and involves all those striving to acquired relevant information on which to decide the quantity that each will trade and the price involved. Eventually varying views are blended into a commonly shared pair of values: the market price and the aggregate volume of trade. To make this possible agents must gather together at a single, market centre and for a limited time period within which all trade must be complete. Within the limited trading period only those demands that are immediately actionable and supply quantities close enough to be available to a new owner, on the same basis, are significant. All more distant considerations and influences of which traders have some knowledge, contribute to their buy or sell decisions, but are excluded from any greater involvement in the final determination of actual trades. This exclusion is essential to enable agents to clinch deals and so essential also for the market process to operate[15]. The details of the process are outlined below.

As previously suggested, uncertainty about price follows from uncertainty about actual supply quantities, but the direction of this causality is neither simple nor uniform from all perspectives. It is noteworthy that in the price formation mechanism, causality is reversed between the aggregate market mechanism and the operation of individual agents. The system uses the discovery of aggregate quantity, Q, driven by potential buyers seeking supplies, and often forced to raise their offer price to meet their future needs, to finally establish the total available quantity and the closing market price, P. For the individual agent utilising this new market information, however, it is P, or, more particularly, the agent's local p_i derived from it by adjusting for the unavoidable costs of distance, that is deemed to determine subsequent

[15] A specific market can vary markedly from other markets and through succesive time periods. Arbitrage, subject to the same constraints of time and space, will ensure that such variation is strictly limited by profit opportunities proportional to any locally extreme values. Where variation is critical, markets in future responses can development and further integrate values across space and time.

quantity. Of course, in an uncertain world neither of these two distinct market relationships is at all exact:

(i) markets lack perfect information about the appropriate P, because of uncertainty about the future.

(ii) individuals may strive to respond in a deterministic way to a given P, via their local p_i, but lack total control over quantity.

Furthermore in the real world there is usually a significant time lag between actions and effects that allows scope for further imprecision, even in the absence of distortions arising from any transaction costs. None of these sources of error are independent of location of individuals relative to the central market.

3.1 Market Information and Location

Markets involve real people with fundamental needs for a safe haven and a means of finding or creating sustenance for maintenance within close proximity of that haven, since travel takes time and time is scarce. Opposing this need for safe, private space is the need for social contact, which brings a further spatial dimension to the problem. Add the benefits of trade and specialization to this sustenance activity and the collective spatial structure becomes considerably concentrated. Social groups select central places of easy communication that become centres for the transfer of information, including importantly, economic information and so trade. Markets eventually become established at these centres and evolve a set of rules to facilitate their efficient functioning[16].

Markets, thus, are spatial phenomena based on the aggregation of information from a wide

[16] Hernando de Soto, a Peruvian economist and politician, has argued cogently in an Economist review [de Soto (1993)] that much of the success of developed economies has resulted largely from (a) the wide-spread acceptance of property rights, and (b) the protective efforts of the owners of property rights. In particular, owners of locations used for markets have obtained protection in the form of restricting trade from occurring elsewhere. Unwittingly, this made the market process more efficient by concentrating the number of potential traders and so enlarging the size of the market. Today, high street traders often attempt to curtail the establishment of competing suburban developments, in parallel fashion. Theoretical support for the essential role of clear property rights in permitting efficient market development can be traced through Webber (1972), Alchian (1974), Furubotn & Pejovich (1974) and most recently Weimer (1997).

area in which all activity, including consumption and production, occurs. Since information is clearly unevenly spread throughout this concentration process, uncertainty, which is surely merely the inverse of information[17], must also vary across locations. The process that conveys information to a central market place and the effect on price-quantity relations is described next.

3.2 The Central Accumulation and Assessment of Information

The broad spatial structure of a market centre in its simplest form, i.e. one with only agents or simply-structured entrepreneurial firms and without outside influences like imports or exports, starts with a large area in which economic activity is conducted. Agents have property rights over parcels of land on which they conduct various activities, including production and consumption for which trade is advantageous. Agents are mobile and able to search out potential trading opportunities, but are neither perfectly informed nor necessarily perfectly honest.

Agents are very well informed about the quantitative data relating to their own property and locality, noting that this knowledge includes all the quality dimensions of their demand and/or supply quantity, but they are less sure of the prevailing market price unless they have recently consulted many other agents[18]. Visits to the market centre are the most reliable way of obtaining good information, especially relevant market information. Trades may occur away from the centre but these do not contribute significantly to market price formation except by their negative effects on aggregate volumes, i.e. their diversion of volume reduces the efficiency of the price discovery process since the market becomes "thinner". Such isolated trading is also more risky, especially for the less well informed party.

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[17] This statement relates to the widest definition of uncertainty about future events, whether or not they be known, rather than an agent's state of awareness. For a rational agent who can ascribe zero weight to some information, there is no distinction between states of knowledge; in particular ignorance can never be more or less blissful than having relevant information.

[18] In a sense this paper can be seen as an extension of the asymmetric information model of trading initiated by Akerlof (1970) in his now famous study of the markets for "lemons". The uneven knowledge about quality and/or quantity (q_i) is shown here to be confronted by an imbalance, typically opposite, in the knowledge of prices.

Price discovery occurs only in the central location where sufficient numbers of potential traders, well informed about their own volumes, compete for the best deals[19]. From this can emerge both information about aggregate levels of supply and demand quantities, and hence an appropriate market price[20]. The key feature of such price-forming market centres is that the number of searching traders is sufficient to give confidence that pressures to change the terms of potential trades, including especially, the unit price involved can only arise on the basis of an imbalance between the aggregate quantities of supplies and demands, so that a new price is accepted as common to all. Both temporal and spatial concentration are essential for this process to operate effectively[21], as Koopman & Beckmann (1957) established.

3.3 The Transfer of New Information from the Centre

A market clearing price from such a centre is valuable new information that is disseminated outwards and is influential for all agents' subsequent decisions. Time and imperfections in communications ensure that a degree of uncertainty is introduced progressively with distance, remembering that the material costs of distance must be added to other transaction costs. This transfer of information is part of the continual adjustment of the whole market towards an equilibrating position, but one that is of course continuously disturbed by stochastic variations in quantities. The dissemination of information about the market, especially the price, is driven by three distinct needs of agents:

(i) guidance for investment decisions and trading opportunities,
(ii) risk aversion within strictly constrained resource levels, and
(iii) a concern about being duped in any possible local trade.

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[19] Many argue that the rapid developments in electronic data communication weaken the importance of centrality. However, the widespread dissemination of market information has most effect on "price-takers", who get no special assistance from the equilibrating price mechanism being discussed. In reality, more efficient communication is most likely to shorten response times and intensify the advantages of centrality for price-makers, at least. It also enlarges the scope for misrepresentation.

[20] The spatial and temporal dimensions of the market are important in setting limits on quantities. Only those responses that could be actually exercised, in a technical sense, within those limits can be considered, even though further demand or supply responses, like imports or exports, might be attracted otherwise. Note that in the absence of precisely defined market volumes, of both demand and supply, a market clearing price could not be formed.

[21] A rather old "economist" joke makes essentially this point; an economics professor restrains a young colleague from stooping to pick up a $100 bill with the observation that it wouldn't be lying there if it was real. While the jibe against such blind faith in markets may be amusing, the professor's credibility surely rises steeply with the density of pedestrian traffic passing by the apparent free good.

The last concern over making unnecessarily disadvantageous trades deserves a brief comment. Although, as is normally relied upon, no agent will accept a trade that is not beneficial, the gains from trade can only be objectively judged against the standard of the ruling market price. In the absence of competitive bidding, isolated potential traders enter what is essentially a bi-monopolistic bargaining game, in which each side is armed with asymmetric information about either quality or price. Not surprisingly, the possible outcomes can range extremely. Confident knowledge of the state of the market[22] is the only effective safeguard that any agent can gain against being duped by superior information or bargaining skills[23].

Knowledge of market conditions can be gained by searching across the entire market for evidence of those quantities available and those needed, as well as observing individual trades. The costs involved in this would, however, be prohibitively high, even if the time required could somehow be reduced sufficiently to yield relevant current information. Alternatively, contacting those agents known to be involved in a particular section of the market should provide similar information far more cheaply; the more agents contacted the better, remembering that some may be less than forthcoming or prone to errors. The preponderance of well-informed agents will be found at the market centre during trading periods, when relevant information will be standardized, consistent and completely up-to-date, ensuring that making a trip there is likely to be cost effective[24] , even for traders dealing outside of the centre.

To summarize: high quality information about q_i is known locally and communicated imperfectly and selectively to the market centre, where the best possible estimate of aggregate Q can be formed. This results in the market price, P, being formed and so knowledge about P will always be most reliable at the centre. This knowledge about P is then disseminated to provide local prices, p_i, elsewhere. Agents, in turn, respond to p_i by acting to produce an

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22 Confidence about the market can only come with experience and regular contact with the best informed traders.

23 Note that misrepresentation about quality that is shown to be acute may be offset by legal redress, at a cost, in the case of formal contracts. For a formal analysis of the value of information when forming contacts, and the ability to acquire it, see Cremer & Khalil (1992).

24 The information that is necessary for markets to work efficiently is only a small fraction of the total information known to all traders, ie. the aggregation process is far from simple. For example, in an undifferentiated market all details of individual suppliers, and the reasons for consumer's demand, are irrelevant.

appropriate output q_i; the actual q_i that results, in some subsequent period, is aggregated into a total market supply, Q, at the market centre, and so on. In the absence of market trading it is the relationship between local price p_i, which always higher than the market P because of distance costs, and local quantity q_i that really matters for local, as opposed to market, trading. Spatial realities, however, ensure that p_i and q_i behave largely independently of market P and Q, principally because any given q_i is only weakly related to Q, as argued next.

3.4 The Relationship between Local Prices and Quantities

Even in a market where the basic relationships of supply and demand are well specified and known widely, there is every chance that, locally, no such relationship applies. The main reason for this is that variability and uncertainty about the outcome of events is far from uniform across the whole market area. Individuals are variably prone to accidents and mistakes, as well as sins and omissions, so too are specific groups like firms and organizations; add to this the weather/climate differences between places and it is clear that the spatial distribution of actual outcomes is bound to be highly variable from place to place.

A further element reinforcing this is that both supply and demand quantities are involved in causing market price adjustments, and rarely are both sides of the market subject to similar sets of chance factors. The major exceptions may be small centres, where physical conditions vary little across the limited span of the market area, and some intermediate markets. In the latter, the demand for inputs and services in manufacturing or the market for store stock in primary industries for instance, may show some complementary between demand and supply levels. For the most part, however, and in large markets especially, the conditions influencing local demand and local supply levels will be quite different. This is most pronounced within small localised areas, and certainly in peripheral positions relative to the market centre. Importers and exporters, for instance, experience far higher levels of uncertainty of returns than other operators, mainly because the market price in the receiving market is set completely independently from production conditions. Even within one country local conditions can produce similar outcomes of nil correlation between price and quantity, as the following demonstrates localised events like Wimbledon clearly raise the level of local demand for strawberries, yet this cannot be guarantied to raise the market price of strawberries set at Covent Garden, London's dominant produce market. The price would rise for sure only if the

extra demand at Wimbledon dominated the normal throughput of Covent Garden, which caters normally to London's 12 million or so consumers and many visitors. In other words, unless the local Wimbledon demand, qi, is well related to the market throughput, Q, there is no basis for a negative relationship between qi and pi. The larger the total market the smaller the influence of qi on Q and so the weaker the relationship between qi and pi. Thus local suppliers relying on local prices cannot benefit from the income smoothing that central market price formation typically provides. Likewise, local buyers are exposed to considerably greater uncertainty as their normally variable demand levels have to cope with a highly unpredictable local price.

4. The Spatial Structure of Markets Enabling Price Discovery in a World of Temporal and Spatial Uncertainty

Bringing together the findings of the various sections above, it is possible to describe the process by which prices and quantities are discovered and incomes determined in a world of temporal and spatial uncertainty. The setting within which this must apply needs noting as a world in which, besides uncertainty, everyone needs their space for all aspects of life. They also accept the advantage of specialisation, and the necessity for exchange or trade it creates, as highly effective in raising the efficiency of resource use. The need for trade creates in turn the need for central markets. Such markets are mechanisms of discovery that operate continually to resolve the collective ignorance created by permanent demand and supply uncertainty. Markets, then, are sequential processes driven by variations in quantities and charged with evaluating both actual quantities and the price that maximises the total benefits from exchange. Variations in quantities arise because expected needs and planned output, and the actual outcome at some later time, differ. Individuals form plans on the basis of current expectations about the future but fail to achieve their intentions precisely; if it were not so, prices would not need to change frequently, and decentralised trading would be less risky.

As shown above the risks of decentralised trading are not uniform but an increasing function of distance from the market's centre. Agents with the most to gain from reducing these risks, typically by being frequent and active traders, will be prepared to purchase locations close to the centre; the competition for a decreasing number of potential locations nearer to the centre

ensures that location values rise steeply. Such costly sites near the centre or CBD will allow easy and, if used enough, cheap access to the exchange venue, so that owners not only can benefit from better trading opportunities, but also, and more importantly, can acquire superior knowledge about future prospects within their market. It is the latter, and the better production decisions made possible, that mainly justifies the cost of the location. Thus particular markets will be supplied by distant producers who trade only in the CBD because of prohibitive risks, and so lower returns, in the absence of good information, from local trade; if the latter does occur it is not fully part of the market.

Thus producers relate the chosen location, and its value, to the benefits to be gained from central market access for both trade and especially information to guide future production. Consumers, on the other hand, are likely to be quite dispersed in general because their location choices are dominated by their *alter ego* that drives the activity which creates their income. Consumers' reasons for incurring the costs of access to the market are dominated by the cost of search to find a suitable product or service, when subject to uncertainty, and especially to be confident in their beliefs about the ruling market price. The consumer's need to search for good price information is part of maximising their net benefits, especially when market information is inherently unreliable, as shown above, and only made acceptable by reference to the central market. Admittedly the advent of modern communication technology has made central market information readily available outside of the centre, with far shorter delays than ever before. Such information, however, must always be dated, and adding to this the necessary delays involved in applying it leads to all responses being based on historic data for all price-takers based outside of the market.

Both consumers, and importantly producers, can do better by acquiring reliable judgements about the future state of the market. Even as price-takers such superior prior knowledge will allow better efficiency of resource use. In addition, the opportunity for price-making strategies is created; these involve adopting short-term disequilibrium positions from which future gains are possible. The key to success in such activities is the quality of information about future quantities of both aggregate demand and aggregate supply; a central location is virtually essential to superior judgements, or speculations, about the future.

5. Market Gardeners and Central Markets

The location choices of market gardeners, which conflict with existing location models and provided the stimulus for this paper, can now be understood in terms of the centralised price-discovery model in the presence of uncertainty. Market garden crops are intensive, short-season, harvestable over a significant period and of rapidly deteriorating quality once harvested. Demand is highly dependent on the weather and so causes much variability in price, if supply quantities remain much the same. However, with good quality market information and a short enough response time, market gardeners can adjust their supply levels to suit demand conditions. This requires a substantial and ongoing presence in the market-centre and good contact with market information sources of proven ability. With these advantages a market gardener achieves higher returns, on average, and this goes some way towards justifying their expensive locations close to the centre. In addition, the superior knowledge of market behaviour into the future makes possible a further strategy that reinforces their on-going viability. This involves using a succession of short-term crops within the growing season. The harvest period of each crop in the succession is ended as soon as its rate of return falls below the level required to maximise the average rate per unit of time. The return to land is maximised by this although the return to each crop is lower than static profit maximisation could achieve[25]. Each of the critical decision points, short, medium and longer term, can vary from season to season and rely heavily on sound judgements aided by central market opinions. Such growers are price-makers using their ability to sustain positions of short-term disequilibrium by delaying harvest in poor conditions and heavily supplying later at more favourable prices, as well as foregoing normal static profit maximisation to achieve superior long-term performance. However, an alternative approach is also possible and often coexists in the same markets.

Some growers supply these same markets from very different locations, that lack the same degree of close contact and response rate to the market. These more peripheral suppliers enjoy significantly lower location costs but have poorer market information, slower response times and higher transport costs. Their impact on the central market is similar to that of exporters supplying a distant market; they are strictly price-takers relying primarily on lower

[25] Forestry rotation models, among several others, share this same characteristic.

production costs to maintain viability. They frequently specialise in a single product and adopt normal factor optimisation that maximizes the return per crop, because response times make rapid successions impractical and land scarcity is less pressing[26]. The difference in production patterns between the two types of suppliers opens up an important profit opportunity for the peripheral suppliers when competition from the higher quality, local suppliers ceases as the latter withdraw from the market in order to maintain their crop succession.

A third spatial form for such firms is also observed around some large cities. In such cases the owning entrepreneur no longer dominates the two primary functions of production and market assessment. While it is often the case that strengths in these two roles are highly complementary and reinforcing, there are economic advantages for further specialisation, especially when land costs are specially high and high quality communication exists. Here the entrepreneur is likely to keep the dominant marketing role and employ a manager to supervise production, provide information about it to the entrepreneur and to carry out decisions taken in the centre. This eases the time constraints on both roles, but is vulnerable to quality losses from communication lapses, lower production performance and management conflicts. Potentially there are gains realisable from generally improved decisions, and quicker response times, or an extension to more distant, cheaper locations, but the firm's fortunes are now dependent on the joint performance of the two key roles, and that introduces both inflexibility and sensitivity to management stresses[27].

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[26] In effect this can be represented as the opportunity cost of delaying the revenue from the succeeding crop dropping to zero. See Scitovsky (1971) for a full analysis of dynamic, as opposed to static, efficiency. Seasonal patterns of growth frequently make crop sequences discontinuous in the absence of expensive environment changing investment. A closely related and active research area is Option-Price Theory, which was recently reviewed by Nobel laureate Robert Merton [Merton (1998)].

[27] This model is basically applicable to all modern firms that maintain a head-office in the CBD from which production and marketing decision are issued to production units situated well outside at cheaper locations. The location options for such production is a different problem entirely and much dependent on the spatially related influences on factor supply, especially labour. For a complete analysis, but without the benefit of the spatial dimension, see Shi & Yang (1998).

6. Conclusions

The central finding of the paper is that market centres are caused by the efforts of agents to cope with spatial and temporal uncertainty. With the prevalence of continuous variability across space and time, efficient exchange between agents is highly desirable and requires all agents in the market to assemble in a single location at the same time. Only by doing so can the aggregate quantity of potential consumers' demands and the available supply quantities from many dispersed locations be assessed for immediate transfer at a price that maximises the aggregate benefit. This also sets a limit on the market's geographic extent, without which a definitive market clearing price is unattainable. The incentives motivating individual agents to contribute to the central aggregation of information arise from the benefits to be attained from partaking in the "pooling" of their situation, through trade[28], with the other participants in the market, and the high costs of failing to search for the best available opportunity. Spatial centralisation is essential to the price-forming process, making feasible economic exchanges to the real advantage of all within the extent of the market, but in doing so it also introduces greater spatial variation between localities in the degree and effective cost of uncertainty. These latter costs essentially increase exponentially with distance from the centre, making peripherally located agents similar to exporters and importers, who utilise the market from outside, but always as pre-committed price-takers, in any given market period[29]. Such outside traders exercise important links between price-forming centres using spatial arbitrage to ensure that all prices move in unison, within the limits imposed by the unavoidable costs and delays of distance.

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[28] An exactly similar case is usually made for trade in general. See for example Wong & Yang (1998) who state "an increase in the size of an economy ... enlarges agents' scope for trading off economies of scale for consumption diversity, per capita real income, the number of goods and productivity increase with the size of an economy if there is a fixed cost in production. This implies that international trade will increase per capita real income and productivity because the size of the pooling economy in the integrated world market is larger than any individual country". (page 186 in Arrow, Ng and Yang (1998).

[29] Recent support for the essential role of market centres in economic systems can be found, albeit based on restrictive assumptions, in Quinzii & Thisse (1990), and for the influence of uncertainty on optimal location in Katz (1984).

Many rich new opportunities for extension of this work arise, both in theoretical developments encompassing an additional spatial dimension into economic theory[30] and in analysing many challenging applications. Among the latter are the as yet unclear impacts of new retail centres, such as malls and suburban centres, within established markets of most modern cities. Two pressing questions in need of resolution relate to the appropriate limiting price margin, relative to the centre, for long-term stability and efficiency, and the implications for efficient pricing with such trade diversion and the consequent "thinning" of the central market. The latter is especially interesting in the context of electronic trading on the inter-net, which introduces similar effects. The model developed in this paper suggests that such trading will be unworkable as a general process, and in the absence of a related conventional market, unless some means can be found to restrict trading temporally into distinct time periods and some mechanism is developed to allow reliable predictions of future market conditions. Hopefully, this paper's spatial model of price-formation can contribute more than a starting point for such work.

[30] A number of earlier attempts exist [Greenhut (1974), Eaton and Lipsey (1977), Greenhut (1978), Dorward (1981) and Greenhut (1981)] but none have dealt with the spatial needs of price formation, which is clearly of the fundamental core of economics. Recently a noted authority on spatial economics referred to the value still to come from further assimilation: "Thus it remains an open question whether mainstream economics ignores something essential in neglecting space." - Arnott (1987) page 430.

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