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Rational Expectations Equilibrium in an Economy with Segmented Capital Asset Markets

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Abstract: We develop a model of noisy rational expectations equilibrium in segmented markets. The noise emerges endogenously through intermarket effects rather than through exogenous supply noise from liquidity or naive trading as in standard noisy rational expectations equilibrium of the Hellwig type. Existence of and persistence of segmentation in equilibrium is established. A metric to determine welfare effects of the degree of segmentation is also derived. This metric is structurally different from the metric derived in the standard models and includes the latter as a special case. Empirical evidence from and observed characteristics of "real world" economies that support the economic intuition underlying the model are described in some detail.

JEL classification: D82, D83, G12

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1. INTRODUCTION

Grossman ((1989), p. 92) poses the following conundrum to show that costly information must have market value: "If competitive equilibrium is defined as a situation in which prices are such that *all arbitrage profits are eliminated*, it is possible that a competitive economy can always be in equilibrium? Clearly not, for then those who arbitrage make no (*private*) return on their (*privately*) costly activities. Hence the assumption that all markets, *including that for information* are always in equilibrium and always perfectly arbitraged is *inconsistent when arbitrage is costly*" (emphasis added).

This is a variation of the well-known Grossman-Stiglitz (1980) paradox that there do not exist opportunities to collect rents from private information in a *rational expectations equilibrium*, (REE) because the equilibrium pricing functional is fully revealing (of the private information) and thus becomes a *fully revealing rational expectations equilibrium*, appropriately abbreviated as FREE. Fully revealing rational expectations equilibria are empirically inconsistent with the widespread and well-documented practices of costly information search and profitable sale in financial markets.

This conundrum led to the discovery that if independent exogenous noise is added to the aggregate supply of securities, then rents to private information are assured because the REE is not FREE; that is, a *noisy rational expectations equilibrium* (NREE) emerges. A large literature exists on various aspects of NREE and information value in NREE (see, e.g., Hellwig (1980), Verrecchia (1982), Admati (1985), and Admati and Pfleiderer (1987) among others).[1] Of these, the recent work of Admati, and Admati and Pfleiderer is quite comprehensive with a number of new insights into the comparative statics of information allocation in the economy. We term these models the *standard integrated (market) NREE* models - *SINREE* models.

The assumption of exogenous noise in the supply of securities large enough to affect the trading strategies of agents is logically disquieting because it requires the juxtaposition of extremely rational and irrational trading strategies in the market. At a purely mathematical level, it simply is a modelling artifice that yields an NREE. The usual story to provide a rationale for the artifice goes as follows: There are naive or "liquidity motivated" traders in the economy who trade in the market, in *total disregard* of the

[1]It should be noted here that these citations are from the genre of research initiated by Grossman (1976), called the "parametric" REE models that assume constant absolute risk aversion (exponential utility functions) for traders' preferences over end-of-period wealth and multivariate normal distributions for all random variables (such as asset payoffs, asset supplies, and private and public information signals). There also exist more general models which do not impose any parametric restrictions on preferences and beliefs that show that a rational expectations equilibrium need not be full revealing. The reason here is that the dimensional size of the private information exceeds the capacity of the price functional to reveal it (see, e.g., Jordan and Radner (1982)). A more detailed literature survey is found in Ramamurtie (1990).

prevailing prices so that their trades add an irrational element to the supply of the securities to make it appear random to the informed and rational traders.[2]

In this paper we take a *fundamentally different* approach to modelling a parametric economy that yields an NREE. We derive an NREE *without exogenous supply noise*, but in which the noise in the pricing functional emerges *endogenously*. Our approach formalizes Arrow's (1974a, 1974b) long held and profound intuition that the information processing limitations of economic agents (and even machines) would make processing a gigantic schedule of contingent claims prices physically impossible. This would naturally result in market incompleteness across time and space. In the one period economy we posit here, we assume that similar information processing limitations segment the economy into different smaller conglomerations of assets that we term "regional markets." Economic

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[2]The issue of "liquidity trading" is rather controversial because it has two distinct aspects associated with it - one of a mathematical artifice that is necessary for the mathematical analysis in the SINREE models not to come to grief on the rock of the Grossman-Stiglitz paradox. The other aspect is whether or not it is possible to interpret the artifice in an economically meaningful way in the sense that it could characterize behavior of economic agents within the context of "economically rational behavior" which has, in all economic modelling of preference maximizing economic man (person), interpreted to mean the economic agents act to maximize their preferences over consumption bundles.

On the first count as a mathematical artifice, it has served its purpose well. It is obvious that without this artifice, we would not have the very interesting and powerful economic insights of the SINREE model, especially that found in the recent work of Admati (1985) and Admati and Pfleiderer (1987).

Controversy essentially swirls around the attempts to provide the artifice a meaningful interpretation in economic models based on the assumption of the rational economic agent. In a recent lucid survey Leroy ((1989), p. 1612) has put this matter succinctly as follows: "By renaming *irrationality trading* as 'noise-trading' (Fischer) Black (1986) avoided the *I*-word, thereby *sanitizing irrationality* and rendering it palatable to many analysts who in other settings would not be receptive to such a specification" (emphasis added).

This is the central dilemma. What we wish to point out here, and this will become clear in the paper, that the segmented market model we present here *completely* avoids this dilemma because there is *absolutely* no irrational trading in our model. Yet we are able to generate intermarket *trading noise* whose mathematical form is identical to that assumed in the SINREE models. Consequently, as well shall elaborate in more detail later, we can accommodate all SINREE models and their powerful insights as partial equilibrium models of each regional market in a meta model of a segmented market economy (we are indebted to Edward J. Green for alerting us to this interpretation). Thus there is not need within our model to abandon the insights of such seminal work as that of Admati (1985) and Admati and Pfleiderer (1987), a price we believe is too high to pay to avoid a controversy that is rendered moot in our model.

agents who hold assets in these regional markets have *common knowledge* (see e.g., Aumann (1976), Binmore and Brandenburger (1988), among others) about the entire structure of their regional market but not about the structure of other markets. In regards to these other markets, they only know of their existence. There is also a "central market" of all publicly known and traded assets that is common knowledge among all economic agents in the economy. Finally, *all* economic agents are *rational with respect to their common knowledge* and there are *no liquidity or naive traders* in the economy. Our economy admits multiple risky assets and one riskless asset as numeraire. Ausubel (1990), independently of us, has recently constructed a non-parametric model without exogenous noise, with different assumptions and characteristics.

Traders in each regional market trade in their regional market and the central market with whatever private information they have. Figure 1 provides a pictorial intuition of the most basic case of one central market and two regional markets. The model, of course, is capable of accommodating every possible configuration of one central market and arbitrary finite number of regional markets. The discussion on the results is to be taken in this general spirit. After trade, the economy stabilizes into a noisy rational expectations equilibrium with the following characteristics:

1. Each trader's rational price conjectures about his regional market and the central market securities are fulfilled in equilibrium.
2. The "noise" in the NREE price functional is *entirely* a consequence of *intermarket price effects* on regional market prices resulting from the activities of traders in other regional markets transmitted through the prices in the central market. To highlight

this crucial feature we assume that supplies of securities are *not* random. All traders know exactly the number of securities issued and outstanding.

3. The form of the endogenous "noise" terms that emerge in the segmented economy RE pricing functionals in each regional market from intermarket effects in mathematically indistinguishable from the *a priori* assumed form of supply noise term in the SINREE models.

4. Segmentation of the economy persists in equilibrium - there is no convergence toward an integrated market.

5. If the economy begins as an integrated market as in a SINREE model, then we prove that segmentation can never be precipitated in such an economy under the usual assumptions of independent noise (independent of asset payoff random variables) found in the SINREE model literature.

6. The parametric form of the segmented market NREE admits an incremental "information-value" metric that has a nice closed form. It is distinct from the SINREE "information-value" metric developed in Admati and Pfleiderer (1987). Using this metric we provide some insights into different types of information producing activity such as regional market spanning, or within market information, or both.

The terms "regional markets" and "central market" should *not* be construed in the narrow traditional sense of regional exchanges such as the Pacific Stock Exchange and the New York Stock Exchange. On the contrary, we consider all listed stocks and other securities in all *public* markets in one country as the tradable assets in the central market.

The term "asset market" used here has a much broader meaning than the usual meaning accorded to it in textbooks and the popular press.[3]

The "regional [asset] markets" envisaged here mean *any* collection of assets such as real estate, small or large privately held corporations, and other tangible or intangible assets owned by a group of economic agents and traded among them through exchange, barter or auction but whose characteristics are not known to other economic agents outside this group. A more appropriate term for a regional market would be a "Pareto syndicate" as broadly developed in Amershi and Stoeckenius (1983). Some examples of segmented markets are provided after we discuss the results. This discussion will highlight the major distinctions between our segmented market model and the standard integrated market model.

The constructive proof of the existence of a rational expectations equilibrium in segmented markets requires extensive and non-trivial analysis. We only provide the main steps of the proof here. A detailed proof can be found in Ramamurtie (1990).[4] It is

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[3]We consider the stock of *any* commodity - from coins and stamps to nuclear reactors, from managerial talent to management strategies, from data bases to large or small scale research and development activity, from cash on hand to a stream of contingent cash flows - as an *"asset"* if its valuation relative to the numeraire commodity is positive. An "asset market" is then simply a formal or informal institution in which some or all of the assets in the economy are traded, either by transfer of title or securities based on the asset. Thus financial assets are also included in our definition.

[4]There may exist a more direct proof based on some fixed point argument, but having tried that approach using a comprehensive set of fixed point results (as in Zeidler (1986)), we were not able to derive one. The problem lies in the fact that unlike the Hellwig fixed-point technique in the SINREE models, our model requires a simultaneous resolution of several fixed points, one for each regional market. The approach used in Ramamurtie (1990) and here is to assume the form of the price functional for each regional market with an intermarket trading noise term and to show that this is indeed fulfilled in equilibrium. This results in a rather involved, non-trivial exercise in the algebraic properties of multivariate normal distribution with and without conditioning and simultaneous solution of non-linear equations in the moment matrices of these distributions. The technique of proof may prove to be useful to other researchers, and thus, we have included a condensed proof here.

reassuring to have the existence result (which surprisingly requires almost no additional restrictions over those found in the SINREE literature. On the contrary, it requires less - we do *not* need noisy supply!) The reason is (as we shall discuss later) that market segmentation in the U.S. economy or the global economy is almost a self-evident fact, and having an equilibrium model in hand that captures segmentation's essential features, and an existence result that is persistent (non-transient) is valuable for explanations and predictions of observed asset trading activity.

In addition to the existence itself, the results based on the form of the pricing functional are also of much economic interest. For example, results (2), (3), and (4) imply that in each regional market, the *endogenous* noise term that enables traders in those markets with private information to derive rent does not require the artifice of "liquidity" traders of the SINREE models.[5]

An important observation that arises from the endogenous noise results is that to an outsider observer, the behavior of the prices and trading strategies in each regional market in our model would be empirically indistinguishable from the partial equilibrium analysis of the same market with "supply (liquidity trading)" noise as in the SINREE model. It follows from this observation that rather than justifying the noise term in the SINREE model through liquidity trade, one can visualize our model as a general equilibrium *meta-*

[5]Mention should be made of a recent interesting model proposed by Allen and Gale in which "liquidity trade" emerges endogenously to produce price volatility. This is a consequences of investors not knowing for certain their multiperiod consumption utilities at time zero and being forced to take positions in a time-segmented market (short term and long term holdings, but not both). When investors suffer "preference shocks," they are forced to liquidate asset holdings for immediate consumption resulting in noisy supply. The key feature of the model that precipitates this is the assumed institutional segmentation of the market into short-term and long-term holdings.

model in which each regional market can be analyzed by partial equilibrium analysis exactly as is done in the SINREE model. Since the mathematical structure of the noise terms is identical, the partial equilibrium analysis of each regional market yields all the insights of the SINREE model restricted to that regional market. Conversely, as mentioned in footnote 2, the nice insights derived in the SINREE model need not be jettisoned because the controversial exogenous noisy supply term can be discarded and replaced by our endogenous noise term.[6] Precisely for this reason we derive additional insights on intermarket effects

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[6]It is appropriate here to make a distinction between our assumption of segmentation in an economy, which is an issue of lack of common knowledge, and "liquidity trading," which is an issue of economic choice behavior. Let us first dismiss the facile observation that both phenomena ultimately are the result of the "*costs*" of information processing. Without any specification of the functional nature of these costs, the observation has no economic substance. The substantive distinctions are found in the nature of the two assumptions as well as empirical facts to support them. This we shall now delineate as crisply as we can.

First, the assumption of segmentation is a statement about the *structure* of the institutions for trading. Since institutional structure is readily observable, we provide in the text of the paper several commonly observed, long-standing structural features of the global and American economies that seem to suggest that market segmentation is more or less a self-evident reality.

Liquidity trading on the other hand is a statement about economic *choice behavior* that is fundamentally inconsistent, as Leroy (1989) has correctly noted (see footnote 2), with the maintained hypothesis of rational choice in economic theory. Therefore, if there is substantial empirical evidence of such behavior, then not only is our model suspect but all received economic theory that rests on the maintained hypothesis of rational economic choice is also suspect. To date we have not come across such evidence.

Second, there is nothing in the literature which speaks to the *appropriate size*, in a measure-theoretic sense of the positive measure of economic agents in an economy with a measure-space of agents that results in just the right amount of trading noise. Put another way, what is the size of the group of liquidity traders that results in enough noise to enable rational traders to hide their private information, but does not tilt the economy into *chaotic trading* in which rational traders lose money by being rational. In contrast, we speak to the size of segmentation - all we need is *one* large privately held firm or professional partnership, or *one* technological innovation for segmentation to be precipitated and persistent.

Finally, we do not address the issue of *how* segmentation came about. We simply take the structural configuration of the global and American economies as an empirical fact and proceed to the analysis of economic phenomena in such an economy. There may or may not exist a well-defined initial "big-bang" homogeneous belief configuration in the economy in the sense of Harsanyi (1967-68) from which by some incredibly complex (at least as it seems to us) process of differential information entitlements, the economy becomes segmented. We have no interest in this process since it does not add to or subtract from the theory and economic insights developed here. By this we are not saying the problem is not an intellectually challenging one - only that its resolution is not necessary for our purposes. Nor is its resolution necessary to distinguish segmentation from liquidity trading, since we also do not have such "big-bang" Harsanyi type of model that results in a group of traders engaging in liquidity trade.

These then, are the critical distinctions between the assumptions of segmentation and liquidity or noise trading.

of information acquisition and allocation rather than provide a partial equilibrium analysis of individual regional markets because many important insights in this respect have already been derived in the work of Admati and Pfleiderer.

Results (4) and (5) are rather crucial, both in intrinsic theoretical sense and providing a theoretical basis for observed market structures. Result (4) says that *in equilibrium*, segmentation persists. Hence, if an economy starts with segmented asset markets, the economy can never endogenously integrate through segmented trade. Furthermore, although the regional markets generate externalities on each other through trade in the central market which are impounded in the pricing functionals, the pricing functionals neither reveal the other markets' asset characteristics, nor do the pricing functionals price the central market assets identically. This phenomenon provides considerable scope for financial analysts and other arbitrageurs to "span" subsets of each market and create mutual funds that improve investor welfare over what they get under the status quo. We will discuss these welfare effects of intermarket arbitrage presently.

Result (5) shows that segmentation is an "if and only if" condition. That is, an economy with integrated markets can never precipitate segmentation in equilibrium under the usual assumptions on the supply noise term in the SINREE models. What this says is that in order to study the economics of observed markets which are obviously segmented, the segmented market approach that we have adopted here is indispensable.

Finally, consider the significant issue of information arbitrage in (6). We believe that the detailed analysis of information arbitrage will provide the main empirical content of the theory of segmented markets. It is work noting here that the existence of information arbitrage is the essence of the point made by Grossman (1989) at the beginning of this section. The point also bears upon the ongoing debate about "market efficiency" (i.e., informational efficiency rather than welfare efficiency. We shall show that information arbitrage opportunities, as is to be expected, are greater in segmented markets than those in the SINREE model. The analysis is also more involved than in the Admati-Pfleiderer (1987) SINREE case. We show, based on the information value metric derived here, that a *strict increase* in welfare is not guaranteed by a simple increase in the assets of an investor's portfolio with assets from the other market. The increase is critically dependent on the mean excess returns (over the riskfree asset) of the additional assets, the information provided about the payoff structure and its effect on the variance and precision of the excess return conditional and unconditional variance-covariance matrices. Nevertheless, the intuition is that there are information arbitrage opportunities in both scope and scale of information, and this implies that multiple financial intermediaries (financial analysts, mutual fund designers, and so forth) can operate simultaneously and can derive positive rents (see footnote 6).

We now discuss the commonly observed phenomena in real economies which provide the intuitive basis for the segmentation model here and also the contexts in which to test the predictions from the model. Consider the global economy. Individual country stock exchanges are segmented from each other. Since the NYSE accounts for a large part of the world's asset capitalization and is widely followed, we may regard it as a central market.

Alexander et al. (1987) document the global segmentation.[7] Clearly, the Mexican, Indian, Hong Kong, Japanese, German, etc. stock markets are not spanned by U.S. stocks and vice versa. While there has been a movement towards global integration,[8] political as well as national self-interest makes full scale integration infeasible in the foreseeable future. Global segmentation is the result of institutional and political restrictions as well as information limitations.

An example of a purely institutional constraint producing segmentation is the *totally local* municipal bond market of small municipalities (see, e.g., Kidwell and Koch (1983), and Feroz and Wilson (1991)). Another similar example is the U.S. banking and savings and loan industry. Unlike Canada, by law U.S. banks are regional in scope. This is particularly true of the savings and loan industry.[9] There are some that are called "super regionals," and may someday become national, as the laws may change.

The real estate industry, which is concerned with the purchase of sale of the largest (in dollar value) collection of assets in the economy is segmented. This is our third

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[7]Indeed, while revising this paper in June 1991, we came across the following story in the *Wall Street Journal, June 20, 1991*, "Heard on the Street" column that exemplifies global segmentation:

European Managers Prefer Homegrown Stocks to U.S. Shares (by Michael R. Sesit), Zurich:
"At the start of the year, European managers didn't much care for U.S. stocks.
Many of them missed the year's U.S. stock rally.
To make matters worse, they didn't ride the dollar's explosive rise.
Guess what? They are still not crazy about U.S. stocks...For the most part their favorites are *right at home* in Europe" (emphasis added).

[8]Several European and Japanese stocks are listed on the U.S. stock exchanges as ADR's, and many U.S. internationals have their subsidiaries listed in the host countries' exchanges as independent companies.

[9]A small bank in a small community acts as the "regional market" in many respects in the sense we describe regional markets here. Most people in the community would have their portfolios made up of local assets (home, family businesses, and cash deposits). A few may own stock in national companies like IBM. The bank acts as the intermediary between borrower and lenders in the local community. Indeed, most small municipality financing is done by local banks.

example. The segmentation is obvious and literally hundreds of examples of typical real estate transactions can be cited. Here we limit the argument to two of the most commonly observed practices - family real estate purchases (which probably account for 30%-40% of consumer spending in the economy which in turn accounts for nearly two-thirds of the total economic activity), and real investment trusts (REITS).

Diamond (1984) points out that most transactions are consummated with the help of financial intermediaries, and the purchase and sale of family homes is a prominent example. There are over 500,000 real estate brokers in the U.S. alone. The question arises as to why? The sheer scale of information is so vast that information processing costs would be prohibitive for most families.[10] Let us examine for the moment trade among holders of real estate in Minneapolis. It is obvious that this trading activity in the Minneapolis regional market does not directly affect the prices in San Francisco. Indeed people in one suburb of Minneapolis-St. Paul rarely know the complete characteristics of a house in another suburb, let along houses in San Francisco. The indirect effects on prices in both areas are transmitted through the central capital markets in the sense that capital is used for local assets and not assets in the central or different regional markets. In short, real estate markets behave very much along the lines of our model here.

In addition to personal home real estate, real estate investment trusts (REITS) are another example. REITS, in purely economic terms, are simply mutual funds, narrowly based on commercial (and sometimes personal) real estate property. There are a few

[10]Most families investigate only a few properties before purchase from the thousands listed on brokerage listings. It would be rare to find a family that bought a house by just looking at real estate listings, photographs and information without visiting the place. This activity confirms Diamond's (1984) search model and it implies huge information gathering costs on the buyer.

national REITS, but by far the largest number of these syndicates are *local* REITS. For example, there could be a closely held REIT focused on, say the Dallas hospital market, and another such REIT made up of only Minneapolis shopping center real estate. Usually, there would be no cross trading between these REITS because a shareholder of the Dallas REIT may know the existence of REITS in Minneapolis, but not the precise characteristics of the assets in the Minneapolis REIT.

Technological innovation is a primary and significant cause of market incompleteness and segmentation. While the real estate market is segmented because information is extremely large and widely dispersed, technological innovation is a major cause of incompleteness and segmentation because the information about the innovation is usually extremely limited or totally absent (except among a set of economic agents with a measure of almost "zero" in regards to the rest of the economy) from the economy before the innovation becomes public. To take a concrete case, consider the invention of aircraft. When Wall Street opened in 1792, 200 years ago, it is doubtful that anyone would have imagined people flying in heavier than air machines. Therefore, it is impossible to imagine investors buying or building assets that would contribute to the various components of a modern aircraft. Indeed, even after the Wright brothers' historic flight, there is no evidence of the rich investors in the early 1900's positioning themselves in industries that now supply parts and material to Boeing, McDonnell Douglas, etc.

Significant technological innovations at large R&D departments of corporations such as AT&T, General Electric, Merck notwithstanding, most technological innovations emerge from the efforts of small teams of scientists at universities and small laboratories. These researchers usually first patent the inventions, and then form small companies, initially owned by a tightly knit group of friends, family, local banks and local venture capitalists. Geographical separation adds to the information limitations so that for some time, these groups trade among themselves or with other firms with the same geographical, technological or other characteristics. These are regional markets in our sense of the term. Then through initial public offerings (IPO's), these small companies seek larger national recognition when the scale of production or research activity cannot be financed only by local capital. Prime examples of such firms are most of the high tech companies in the Silicon Valley and elsewhere, including such household as Apple Computer, Microsoft, Hewlett-Packard, and others.

The final example we provide in the text is of the large privately held companies such as Cargill (revenues about $20 billion), Bechtel International (revenues $10-$15 billion), RJR Nabisco (revenues of about $20-$25 billion), and professional partnerships such as law, accounting and medical partnerships. A syndicate of owners and employees own these companies and trading is often restricted by corporate and partnership charters to other investors in the same company or those approved by the main investor. There is no active secondary market in "shares" of such firms' assets. They are regional markets in our sense because they are clearly segmented from each other, but many of the most wealthy owners also trade in the central market from stocks and bonds.[11]

The "central market" in our terminology is then the entire collection of assets in an economy about which there is *common knowledge* among all agents in the economy. Typical examples are widely held firms such as IBM, GE, AT&T, and so on.

Now that we have discussed the theoretical structure of a segmented market economy and the observed asset configurations in real economies that lend the model empirical support, the natural question is whether this provides opportunities for arbitrage. Indeed it does. Some discussion in this regard was provided in relation to point (6) above. Further insights will be provided in Section 4, and an extensive analysis is found in Amershi and Ramamurtie (1991). To conclude here, it is worth mentioning that there is substantial evidence for markets spanning activity, and this is discussed in the concluding section of this paper. The demand for spanning activity is a natural consequence of the almost universal *non-diversification* among investors. Substantial empirical evidence is found in the work of Feldstein (1979), King and Leape (1984), who show that most investors, including the most wealthy, hold *risk-undiversified portfolio* - a finding that is in sharp contrast to the prediction of the usual integrated CAPM models, especially the heavily used Sharpe-Lintner model.

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[11]These five examples constitute only a part of the range of economic asset transaction activity that we can recite to support the structure of our model. Other examples are the large collections of art and jewelry among the extremely rich. Their value is in the hundreds of billions of dollars, but there is no active public trade in them. This select group frequently engages in internal trade, exchange and transfers (through marriage, death, etc.). This is a "regional market" in our terminology. Another example of "regional markets" that is more colorful in large criminal organizations such as the Medellin drug cartel, the Mafia, and more recently (May 1991 onwards), the Bank of Commerce and Credit International (BCCI).

Allen and Gale (1991) cite a study by Mankiw and Zeldes (1990) that supports the findings in the earlier studies.

The paper is organized as follows. Section 2 develops the model. Section 3 provides the main existence and persistence results. Section 4 develops the metric for measuring the welfare effects incremental asset payoff and spanning information. Some insights are heuristically discussed here. Section 5 concludes the paper. The Appendix contains the details of the proofs of the results not provided in the text.

2. A MODEL OF A SEGMENTED MARKETS ECONOMY

In this section we present the structure of the model. The model is general and, in principle, the economy can consist of an arbitrary finite number of investor groups (regional asset markets), and a central market. However, for simplicity of exposition, the model is developed in its most basic form in which the economy consists of one central market, denoted 0, and two segmented regional markets, denoted 1 and 2. There are two groups of investors. Each group trades only in the assets of its own regional market and those in the common central market. Figure 1, depicts the structure of our economy and its underlying intuition as discussed in Section 1. The equilibrium is derived in the context of a large economy so that the idiosyncratic noise terms in the private signals of the individual investors are not reflected in the equilibrium price vectors. This lends legitimacy to the assumption of competitive behavior by investors. We also assume, purely for ease of computation, that each of these two groups has roughly the same number of individuals and that average risk tolerance in each group of investors is the same.[12]

I. Investors and Their Preference Orderings

Each investor is identified by a superscript and a subscript. The superscript denotes the regional market (and thereby the group to which he belongs) in which he and others in the same group trade in; and the subscript is his personal identification. All investors have preferences over money that exhibit constant absolute risk aversion and they seek to maximize expected utility of end of period (time 1) wealth. Each investor has an initial (time 0) endowment of wealth, which for ease of computation is assumed to be deterministic, implying an endowment of riskfree asset only.[13]

Formally, for investor j in market k,

$$u_j^k(\tilde{W}_{1j}^k) = -\exp(-\rho_j \tilde{W}_{1j}^k) \; \rho_j \in (0, \infty) \; \forall_j \; k = 1,2,$$

where $\tilde{W}_{1j}^k$ is investor j's end of period wealth.

Further, W_{0j}^k denotes the initial endowment of investor j in group k.

[12]We have also derived a more general result with groups of different sizes. The context is that of a sequence of economies increasing in size, leading to the limiting case of the large economy in which the relative size between the groups is kept constant. The assumption about average risk tolerance is also relaxed. However, the insights are not much different from those obtained in this paper.

[13]In a more general setup, we have endowments composed of both risky and riskfree assets. Again, the insights are almost identical.

II. Structure of the Economy and the Exogenously Specified Distribution of Payoffs, and Other Parameters

There is a single riskfree asset in zero net supply with an end of period payoff of R (in terms of the numeraire commodity) per unit. The price of the riskfree asset is normalized to be 1 per capita.

There are several risk assets, some belonging to the central market, and others to the regional markets. For concreteness, let there be K_0, K_1, and K_2 risky securities in each market respectively. The per capita payoff distributions are:

$$\begin{bmatrix} \tilde{F}_0 \\ \tilde{F}_1 \\ \tilde{F}_2 \end{bmatrix} \sim N \left[\begin{bmatrix} \bar{F}_0 \\ \bar{F}_1 \\ \bar{F}_2 \end{bmatrix}, \begin{bmatrix} \Sigma_{00} & \Sigma_{01} & \Sigma_{02} \\ \Sigma_{10} & \Sigma_{11} & \Sigma_{12} \\ \Sigma_{20} & \Sigma_{21} & \Sigma_{22} \end{bmatrix} \right]$$

where

$\bar{F}_0$: is per capita payoff vector of the assets traded in the central market 0,

and

$\bar{F}_k$: is the per capita payoff vector of the assets traded in the regional market $k = 1,2$.

The number of assets in each market is fixed but arbitrary. The variance-covariance matrix of asset payoffs is non-singular and positive definite. Hence, there are no redundant assets. The per capita supply vectors for each market are the constants $\bar{N}_0$, $\bar{N}_1$, and $\bar{N}_2$. This feature is a fundamental distinction between the model here and the extant standard integrated NREE (SINREE) models in which the supplies are assumed to be stochastic (Ramamurtie (1990) develops a model with stochastic supply.

It is of *fundamental* importance to our model to note well that the exogenously specified payoff distribution shown above is *not* common knowledge. This is the *technical* definition of *segmentation*. Also, our model, like all other models in this genre, is a single period model.

Investor's Private Information

Each investor j, operating in the regional market k (and the central market 0), is in receipt of a private signal vector about end of period asset payoffs. Furthermore, all the investors belonging to a common group have homogenous beliefs (prior to receipt of private information) about the payoffs of the assets that they are informed about the trade in. The private signal of investor j operating in markets 0 and k is the random vector

$$\tilde{Y}_j^k = \begin{bmatrix} \tilde{Y}_{0j}^k \\ \tilde{Y}_{kj}^k \end{bmatrix} = \begin{bmatrix} \tilde{F}_0 \\ \tilde{F}_k \end{bmatrix} + \begin{bmatrix} \tilde{\epsilon}_{0j}^k \\ \tilde{\epsilon}_{kj}^k \end{bmatrix} \quad \forall j, \forall k = 1,2$$

where

$$\begin{bmatrix} \tilde{\epsilon}_{0j}^k \\ \tilde{\epsilon}_{kj}^k \end{bmatrix} \sim N\left[\begin{bmatrix} \underline{0} \\ \underline{0} \end{bmatrix}, \begin{bmatrix} S_{00j}^k & S_{0kj}^k \\ S_{k0j}^k & S_{kkj}^k \end{bmatrix} \right] \quad \forall j, \forall k = 1,2$$

The noise terms ϵ are independent of the payoffs F and other noise terms. That is,

$$E\left[\begin{pmatrix} \tilde{F}_0 \\ \tilde{F}_k \end{pmatrix} \cdot \begin{pmatrix} \tilde{\epsilon}_{0j}^k \\ \tilde{\epsilon}_{kj}^k \end{pmatrix}^T \right] = 0 \quad \forall j, \forall k$$

and

$$E\left[\begin{pmatrix} \epsilon_{0j}^k \\ \epsilon_{kj}^k \end{pmatrix} \cdot \begin{pmatrix} \tilde{\epsilon}_{0i}^L \\ \tilde{\epsilon}_{Li}^L \end{pmatrix}^T \right] = 0 \quad \forall j, \forall i, \forall k = 1,2 \; \forall \; L = 1,2.$$

Investor's Price Conjectures

We now describe the most critical component of our model, namely the investors' equilibrium price conjectures. Each investor in each regional market group is aware of the existence of other regional markets, large enough to directly affect prices in the central market, and in turn indirectly affect (because all prices are relative) prices of his own regional market securities. What he does not know are the location and other payoff characteristics of the securities in the other markets.[14] The effects of the other regional market's investors' trades are included in his price conjectures as *intermarket trading noise*. We assume, then, that investors in regional market k = 1,2 conjecture equilibrium prices of securities in the central market and the k^{th} market securities to be linear regional market participants L(L = 1,2, L ≠ k) as follows:

$$\begin{bmatrix} \tilde{P}_0 \\ \tilde{P}_k \end{bmatrix} = \begin{bmatrix} A_0^k \\ A_k^k \end{bmatrix} + \begin{bmatrix} A_{00}^k & A_{0k}^k \\ A_{k0}^k & A_{kk}^k \end{bmatrix} \begin{bmatrix} \tilde{F}_0 \\ \tilde{F}_k \end{bmatrix} + \begin{bmatrix} D_{0L}^k \\ D_{kL}^k \end{bmatrix} \left[\tilde{\Gamma}_L^k\right]$$
$$\forall k = 1,2, \ \forall L \neq k, \ L = 1,2,$$

where the term $[\tilde{\Gamma}_L^k]$ is the intermarket trading noise vector. We also assume that the noise term is distributed as

[14]Obviously, if the investor did not even suspect the existence of other regional markets, then the model is meaningless because the segmentation is so total, it amounts to isolation. Then we are back into the integrated markets framework for regional market k and central market 0 combined for an investor in market k. Since $\overline{N}_0$ and $\overline{N}_k$, the supply quantities are common knowledge, as well as $\tilde{F}_0$ and $\tilde{F}_k$, the investor should be able to determine the FREE for his regional market in a large economy. Then when the realized prices in central 0 and market k over the long run do not coincide with the FREE, the investor arrives at the rational conclusion that there is a systematic disturbance in the pricing. Consequently, he would induce from his observations that there must be some other large group of investors who are also trading in the central market.

The question that arises here is why, after becoming aware of the existence of other regional markets, the investor does not find out the structure of the securities in that other market. As intuitively explained at length in the Introduction, we assume that such search for information is prohibitively costly because of *information processing limitations* for most investors. Although this cost is not modeled here formally, it is the cause of the lack of common knowledge which is explicitly assumed here as a form of *bounded rationality*. In short, we have assumed that common knowledge occurs in small groups or in regards to widely known information (such as the price of IBM stock or the fact that the sun rises in the east). We find it silly to assume common knowledge about everything.

To be sure, there could be some investors who could derive arbitrage profits from spanning markets, and this is discussed in Section 4. However, for a more complete development in which these arbitragers create financial advisory services and spanning mutual funds under moral hazard and adverse relation, see Amershi and Ramamurtie (1991).

$$\left[\tilde{\Gamma}^k_L\right] \sim N\left[[0], \Sigma_{LL} - (\Sigma_{L0}\Sigma_{LK})\begin{bmatrix}\Sigma_{00} & \Sigma_0 k\\ \Sigma_{k0} & \Sigma_{kk}\end{bmatrix}^{-1}\begin{bmatrix}\Sigma_0 L\\ \Sigma_{kL}\end{bmatrix}\right]$$

$$\forall k = 1,2,\ \forall L \neq k,\ L = 1,2.$$

It will be shown that these equilibrium price conjectures are self-fulfilling; i.e., they precipitate a segmented market rational expectations equilibrium.

Information Structure of the Investors

The information structure of the investor j operating in regional market k and central market 0 is the random vector:

$$\begin{bmatrix}\begin{pmatrix}\tilde{F}_0\\ \tilde{F}_k\end{pmatrix}\\ \begin{pmatrix}\tilde{Y}^k_{0j}\\ \tilde{Y}^k_{kj}\end{pmatrix}\\ \begin{pmatrix}\tilde{P}_0\\ \tilde{P}_k\end{pmatrix}\end{bmatrix} \sim N$$

whose distribution is multivariate normal N with mean and variance-covariance matrices:

$$\left[\begin{bmatrix}\begin{pmatrix}\overline{F}_0\\ \overline{F}_k\end{pmatrix}\\ \begin{pmatrix}\overline{F}_0\\ \overline{F}_k\end{pmatrix}\\ \begin{pmatrix}\overline{F}_0\\ \overline{F}_k\end{pmatrix}\end{bmatrix}, \begin{bmatrix}\begin{pmatrix}\Sigma_{00}\Sigma_{0k}\\ \Sigma_{k0}\Sigma_{kk}\end{pmatrix} & \begin{pmatrix}\Sigma_{00}\Sigma_{0k}\\ \Sigma_{k0}\Sigma_{kk}\end{pmatrix} & \begin{pmatrix}\Sigma_{00}\Sigma_{0k}\\ \Sigma_{k0}\Sigma_{kk}\end{pmatrix}\begin{pmatrix}A^k_{00}A^k_{k0}\\ A^k_{k0}A^k_{kk}\end{pmatrix}^T\\ \begin{pmatrix}\Sigma_{00}\Sigma_{0k}\\ \Sigma_{k0}\Sigma_{kk}\end{pmatrix} & \begin{pmatrix}\Sigma_{00}\Sigma_{0k}\\ \Sigma_{k0}\Sigma_{kk}\end{pmatrix} + \begin{pmatrix}S^k_{00j}S^k_{0kj}\\ S^k_{0kj}S^k_{kk}\end{pmatrix} & \begin{pmatrix}\Sigma_{00}\Sigma_{0k}\\ \Sigma_{k0}\Sigma_{kk}\end{pmatrix}\begin{pmatrix}\Sigma_{00}\Sigma_{0k}\\ \Sigma_{k0}\Sigma_{kk}\end{pmatrix}^T\\ \begin{pmatrix}\Sigma_{00}\Sigma_{0k}\\ \Sigma_{0k}\Sigma_{kk}\end{pmatrix}\begin{pmatrix}\Sigma_{00}\Sigma_{0k}\\ \Sigma_{k0}\Sigma_{kk}\end{pmatrix} & \begin{pmatrix}\Sigma_{00}\Sigma_{0k}\\ \Sigma_{k0}\Sigma_{kk}\end{pmatrix}\begin{pmatrix}\Sigma_{00}\Sigma_{0k}\\ \Sigma_{k0}\Sigma_{kk}\end{pmatrix} & \begin{pmatrix}\Sigma_{00}\Sigma_{0k}\\ \Sigma_{k0}\Sigma_{kk}\end{pmatrix}\end{bmatrix}\right]$$

where

$$\begin{bmatrix}\overline{P}_0\\ \overline{P}_k\end{bmatrix} = \begin{bmatrix}A^k_0\\ A^k_k\end{bmatrix} + \begin{bmatrix}A^k_{00} & A^k_{0k}\\ A^k_{k0} & A^k_{kk}\end{bmatrix}\begin{bmatrix}\overline{F}_0\\ \overline{F}_k\end{bmatrix} \quad \forall k = 1,2$$

and

$$\begin{bmatrix}\Sigma^{P}_{00} & \Sigma^{P}_{0k}\\ \Sigma^{P}_{k0} & \Sigma^{P}_{kk}\end{bmatrix} = \begin{bmatrix}A^{k}_{00} & A^{k}_{0k}\\ A^{k}_{k0} & A^{k}_{kk}\end{bmatrix}\begin{bmatrix}\Sigma_{00} & \Sigma_{0k}\\ \Sigma_{k0} & \Sigma_{kk}\end{bmatrix}\begin{bmatrix}A^{k}_{00} & A^{k}_{0k}\\ A^{k}_{k0} & A^{k}_{kk}\end{bmatrix}^{T} + \begin{bmatrix}D^{k}_{0L}\\ D^{k}_{kL}\end{bmatrix}\left[Var(\tilde{\Gamma}^{k}_{L})\right]\left[D^{k}_{L0}\ D^{k}_{Lk}\right]$$

where

$$Var\,[\bar{\Gamma}^{k}_{L}] = W^{k}_{L} = \left[\Sigma_{LL} - \left[\Sigma_{L0}\ \Sigma_{Lk}\right]\begin{bmatrix}\Sigma_{00} & \Sigma_{0k}\\ \Sigma_{k0} & \Sigma_{kk}\end{bmatrix}^{-1}\begin{bmatrix}\Sigma_{0L}\\ \Sigma_{kL}\end{bmatrix}\right]$$

$$\forall k = 1,2,\ \forall L \neq k,\ L = 1,2.$$

It will be shown that the information structure admits a rational expectations equilibrium pricing functional exactly as conjectured.

Payoff and Information Structure of the Economy

For the economy as a whole, if there are I investors in each market, the real payoff and information structure is the $K_0 + I(2K_0 + K_1 + K_2)$ dimensional multivariate normal random vector of asset payoff and information noise random variables.

$$[\bar{F},\ \tilde{\epsilon}^{2}_{1},\ \tilde{\epsilon}^{1}_{2},\dots,\tilde{\epsilon}^{1}_{I},\ \tilde{\epsilon}^{2}_{1},\ \tilde{\epsilon}^{2}_{2},\dots,\tilde{\epsilon}^{2}_{I}]^{T} \sim$$

$$N\sim\left[\begin{bmatrix}[F]\\ \begin{bmatrix}\underline{0}\\ \cdot\\ \cdot\\ \underline{0}\end{bmatrix}\\ \begin{bmatrix}\underline{0}\\ \cdot\\ \cdot\\ \underline{0}\end{bmatrix}\end{bmatrix}\ \begin{bmatrix}[\Sigma] & [\underline{0}\ \cdots\ \cdots\ \underline{0}] & [\underline{0}\ \cdots\ \cdots\ \underline{0}]\\ \begin{bmatrix}\underline{0}\\ \cdot\\ \cdot\\ \cdot\\ \underline{0}\end{bmatrix} & \begin{bmatrix}S^{1}_{1} & 0 & \cdot & \cdot & 0\\ 0 & S^{1}_{2} & \cdot & \cdot & 0\\ \cdot & \cdot & S^{1}_{j} & \cdot & \cdot\\ \cdot & \cdot & \cdot & \cdot & \cdot\\ 0 & \cdot & \cdot & \cdot & S^{1}_{I}\end{bmatrix} & \begin{bmatrix}0 & 0 & \cdot & \cdot & \cdot & 0\\ 0 & \cdot & \cdot & \cdot & \cdot & \cdot\\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot\\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot\\ 0 & \cdot & \cdot & \cdot & \cdot & 0\end{bmatrix}\\ \begin{bmatrix}0\\ \cdot\\ \cdot\\ \cdot\\ 0\end{bmatrix} & \begin{bmatrix}0 & 0 & \cdot & \cdot & \cdot & 0\\ 0 & \cdot & \cdot & \cdot & \cdot & \cdot\\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot\\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot\\ 0 & \cdot & \cdot & \cdot & \cdot & 0\end{bmatrix} & \begin{bmatrix}S^{2}_{1} & 0 & \cdot & \cdot & 0\\ 0 & S^{2}_{2} & \cdot & \cdot & \cdot\\ \cdot & \cdot & S^{2}_{j} & \cdot & \cdot\\ \cdot & \cdot & \cdot & \cdot & \cdot\\ 0 & \cdot & \cdot & \cdot & S^{2}_{I}\end{bmatrix}\end{bmatrix}\right]$$

where

$$\bar{F} = \begin{bmatrix} \bar{F}_0 \\ \bar{F}_1 \\ \bar{F}_2 \end{bmatrix} \sum = \begin{bmatrix} \Sigma_{00} & \Sigma_{01} & \Sigma_{02} \\ \Sigma_{10} & \Sigma_{11} & \Sigma_{12} \\ \Sigma_{20} & \Sigma_{21} & \Sigma_{22} \end{bmatrix}.$$

$$S_j^1 = \begin{bmatrix} S_{00j}^1 & S_{01j}^1 \\ S_{10j}^1 & S_{11j}^1 \end{bmatrix}, S_j^2 = \begin{bmatrix} S_{00j}^2 & S_{02j}^2 \\ S_{20j}^2 & S_{22j}^2 \end{bmatrix}.$$

This information structure is *not* common knowledge. It is simply the underlying reality in the economy as distinct from the conjectures of the investors.[15] The significant aspect of our results is that this reality interacts with the conjectures and limited information of investors in the segmented markets economy to precipitate a rational expectations equilibrium as the economy becomes "large" ($I \to \infty$) in which the conjectured prices are fulfilled in equilibrium. Although we will derive the results "as if" $I \to \infty$, we need the following assumption to avoid technical difficulties that are irrelevant to the issues under investigation here.

Assumption 1: Let P(I) be a well defined mathematical function of I with values in some Euclidean space R^q, q positive. Then

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[15]This point is subtle and care must be taken to understand what we mean by an underlying reality that is *not* common knowledge. Some may argue that this should be taken as the "big bang" common prior in the sense of Harsanyi (1967-68) and our model "ought to" precipitate, by some information dispersion process the initial segmentation. As we have argued at length in footnote 6, and in footnote 18, the notion of a *universal primordial* common prior from which all phenomena arise by appropriately dispersed information processes is a "doctrine" (in Kreps' (1990)) whose validity - empirically and logically (Mertens and Zamir (1985) notwithstanding) has not been established free of paradox to the best of our knowledge. Our position has been influenced both by theoretical physics and the diverse essays of Bertrand Russel on the topic.

This having been said, consider the following analogy to help out the intuition here. Consider the real estate configuration of Minneapolis, and consider two suburbs of the city, A and B. There is an underlying asset value - information structure characterizing the Minneapolis real estate configuration, but it is not necessarily the case that investors in suburbs A and B (considered as regional markets) would know this structure. However, for an external observer (such as us), to create a theory of the Minneapolis economy as a whole, it is necessary for *modeling purposes* to assume some form for Minneapolis economy as a whole.

$$\lim_{i\to\infty} P(I) - P^{*} \in R^{q}$$

This assumption is used in the proofs of the results.[16]

3. The Existence and Persistence Results

In this section we prove the main existence and persistence of a rational expectations equilibrium in a segmented markets economy. The results can be summarized as follows:

(a) A segmented markets economy is in a segmented markets rational expectations equilibrium with *endogenous* intermarket trading noise that prevents full revelation of investors private information even if there is no liquidity trade and noisy supply (that is, the Grossman-Stiglitz paradox does not occur even with fully rational investors who make no liquidity trades).

(b) An economy is in a segmented markets equilibrium after trade *if and only if* it had segmented markets before trade.

Theorem 1: There exists a Noisy Rational Expectations Equilibrium (NREE) in the segmented markets economy with the price vectors of the forms below:

For investors operating in the central market 0 and regional market 1:

$$(1)\qquad \begin{bmatrix} \tilde{P}_0 \\ \tilde{P}_1 \end{bmatrix} = \begin{bmatrix} A_0^1 \\ A_1^1 \end{bmatrix} + \begin{bmatrix} A_{00}^1 & A_{01}^1 \\ A_{10}^1 & A_{11}^1 \end{bmatrix} \begin{bmatrix} \tilde{F}_0 \\ \tilde{F}_1 \end{bmatrix} + \begin{bmatrix} D_{02}^1 \\ D_{12}^1 \end{bmatrix} \left[\tilde{\Gamma}_2^1\right]$$

For investors operating in the central market 0 and regional market 2:

[16] It should be noted that we use implicitly the strong law of large numbers as in the "measure space of agents" approach to equilibrium analysis in the large, as is done in most of the SINREE models. However, the argument is cast in terms of limit economies for its' intuitive clarity.

$$(2) \qquad \begin{bmatrix} \tilde{P}_0 \\ \tilde{P}_2 \end{bmatrix} = \begin{bmatrix} A_0^2 \\ A_2^2 \end{bmatrix} + \begin{bmatrix} A_{00}^2 & A_{02}^2 \\ A_{20}^2 & A_{22}^2 \end{bmatrix} \begin{bmatrix} \tilde{F}_0 \\ \tilde{F}_2 \end{bmatrix} + \begin{bmatrix} D_{01}^2 \\ D_{21}^2 \end{bmatrix} \left[\tilde{\Gamma}_1^2\right]$$

Proof of Theorem 1: See Appendix.■[17]

The form of the REE price functionals in Theorem 1 is of critical importance in relating our development here to the integrated market NREE (SINREE) models. From the SINREE literature we know that the integrated economy price functional has the form:

$$(3) \qquad \tilde{P} = A_0 + A_1 \bullet \tilde{F} - B \bullet \tilde{N}$$

where the term $B \bullet \tilde{N}$ is the *exogenous* noise which makes the equilibrium price a noisy predictor of future payoffs so that information rents can be maintained.

The equilibrium price functional in our model (ignoring the superscripts) has the form

$$(4) \qquad \tilde{P} = A_0 + A_1\tilde{F} - D \bullet \Gamma$$

Observe well that mathematically, the terms $B \bullet \tilde{N}$ and $D \bullet \tilde{\Gamma}$ are *identical* in form. Hence the term $D \bullet \tilde{\Gamma}$ plays the same role as the noisy supply terms in the integrated economy model (3). However, *and this is the fundamental distinction*, in our model this intermarket trading noise is *endogenous* and arises as a result of *fully rational* trading on the part of different groups of investors in the whole economy. The trades of each group of investors have a component which transmits a stochastic shock through the common central market

[17]We apologize to the reader for any inconvenience caused by the length of the proof of this result. We have tried to reduce as much as possible the even more onerous proof in Ramamurtie (1990) without losing the flow of the argument. Essentially, the proof's most difficult steps are to derive the unknown parameters in the price conjecture (1) and (2) of the Theorem in terms of the exogenous parameter structure. Once this is done, then the self-fulfilling nature of the prices is established.

to the price vector observed and employed by the other group(s) of traders. It is this endogenous noise rather than the exogenously specified shocks that allows our model to accommodate the extant SINREE models as partial equilibrium models of regional markets *without* recourse to the artifice of "liquidity trading" and the "supply noise." That is, instead of justifying the noise term $B \bullet \tilde{N}$ in (3) as arising from "irrational" or "liquidity trade," we can justify it without "sanitizing" irrationality by the assumption that it is really rational in terms of the asset trading noise $D \bullet \tilde{\Gamma}$ and the market under study is a segment of the economy, rather than the economy as a whole. In short, our model provides a *meta model* in which SINREE analysis is essentially a partial equilibrium analysis of a particular market segment (see Introduction).

As a check of the validity of the model, it can be seen that the equilibrium breaks down when the assets in the regional markets are specified to be identical in all their characteristics and in their joint behavior with the central market assets. This corresponds exactly with the results obtained by Grossman (1976) and Hellwig (1980, Proposition 4.3).

In fact, is has been shown elsewhere (Ramamurtie (1990)) that in a segmented economy with stochastic supplies, NREE exists, and investors derive rents from private information even as the random supply noise in each price conjecture P_I and P_{II} goes to zero because the intermarket trading noise still remains.[18]

We now state and prove the results that market segmentation is self-perpetuating in equilibrium. That is, once the economy begins with segmentation, then segmentation will persist in equilibrium. This result is interesting in the sense that in the existence result of

[18]This fact further reinforces the points discussed in footnote 6. Generic results of this type are found in Noe and Ramamurtie (1991).

Theorem 1, there is no mention as to how "big" the regional markets 1 and 2 ought to be *in relation* to the central markets in order for segmentation to persist. For example, even if, in capitalization amount, the central market consists of, say, 95% of the asset capitalization in the economy, the regional markets only 5%, segmentation and the accompanying indirect intermarket trading noise will result in equilibrium. To put it more concretely, we need a few large professional firms, privately held industrial companies such as Cargill, Bechtell, RJR Nabisco, etc., or an environment of continual technological improvements to guarantee that after trade, the economy will remain segmented exactly as before.

The converse question, also fundamental, is whether an integrated market economy can ever precipitate a segmented market in equilibrium. The result provides a negative answer to this question. That is, if we begin with standard integrated markets as in Hellwig (1980), Verrecchia (1987), Admati (1985), and Admati and Pfleiderer (1987), and take the liquidity trade noisy supply term in the equilibrium pricing functional to be stochastically independent of the random end-of-period security payoffs, as is done in these SINREE models, then regardless of how noisy the market is, the economy will *remain integrated* in equilibrium. That is, *all* investors will hold all assets in the economy. This latter assertion has a sound intuition that, in fact, can be considered as an intuitive but heuristic proof of the next result.[19]

Proposition 1: An economy has no segmentation of its capital markets in equilibrium after trade if and only if it had no segmentation before trade and the supply noise term in the equilibrium pricing functional is independent of the payoff vector $\tilde{F}$ of the assets in the economy.

Proof: See the Appendix. ■

4. A METRIC TO MEASURE INFORMATION EFFECTS ON INVESTOR WELFARE AND SOME HEURISTICS

We shall now derive a metric that measures the monetary value of the change in an investor's expected utility as a result of a change in his pre-trade private information.

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[19]Assume that Markets I, II and 0 are fully integrated. Then following Admati (1985), the price conjectures for the economy as a whole by *all* investors is

$$P = A_0 + A\tilde{F} - B\tilde{N} \qquad (\alpha)$$

Although this is the price that also emerges in equilibrium, there is a hypothesized tâtonnement process by which the Walrasian auctioneer announcing prices, and the agents recontracting, arrive at the equilibrium through a process of *belief adjustments* (and hence demand adjustments). It is merely the dynamics of a fixed point argument. Thus at fictitious Stage 1, individuals condition their homogeneous prior beliefs of $\tilde{F}$ on the realization of $\tilde{Y}_i$ they receive. The posterior beliefs, including the noise, will again be multivariate normal with a non-singular variance-covariance matrix. Then at this stage the investors behave as heterogeneous belief traders with exponential utility functions, and therefore their demand functions will not be such that they hold *zero* amounts of any asset (see Lintner (1969) or Cass and Stiglitz (1970)).

Once these demands are submitted to the Walrasian auctioneer, he computes a revised price to bring supply and demand into equilibrium. The revised price includes some information about the other investors' private information; investors then in Stage 2, revise the posterior of Stage 1 to the posteriors in Stage 2 with this additional information. Again, at this stage, they behave as heterogeneous belief traders with exponential utility and multi-variate normal distributions with non-singular variance-covariance matrices. Again, their new demand functions at Stage 2 will not show segmentation (i.e., no security will be held in *zero* quantity (see Lintner (1969), Cass and Stiglitz (1970))).

This dynamics goes on until the equilibrium price conjecture (α) is reached, at which point they behave as standard heterogenous belief exponential utility traders with non-singular variance-covariance matrices on $\tilde{F}$. Since at no stage in the process, segmentation results, and in equilibrium they behave as described above, then in the limit of this equilibrating process, segmentation will not result.

The welfare change metric measures the maximum information rent an information agent, whom we generically term the *financial intermediary*, can collect when the agent is a truthful machine - no moral hazard or adverse selection considerations serve to reduce the rent. If there exists *moral hazard* (i.e., the agent spends effort at discovering the information and incurs disutility) and *adverse selection* (i.e., the agent may sell useless information if it is advantageous to do so without the investor knowing it), then the maximum rent computed here is the first best amount and the second best amount would be less.[20]

Thus let δ_j^* denote the maximum among of rent the financial intermediary can collect from investor j upon sale of information. If $\tilde{W}_{1j}$ denotes investor j's random end-of-period wealth without the information, and $\tilde{W}_{1j}^*$ denotes the end-of-period wealth with the information *after* payment of δ_j^* at time 0, then we must have

(5) $$E[U(\tilde{W}_{1j})] = E[U(\tilde{W}_{1j}^*)]$$

where the equation is the *individual rationality* condition that the investor will pay rent up to the point of indifference.

Observe that j could be in regional market 1 or 2. For simplicity of notation, we will not use the double subscript "kj" where $k=1,2$, and to specify j, we shall only use the subscript j in the information vector $\tilde{Y}_j$. Thus, instead of $\tilde{F}_{kj} = [\tilde{F}_{0j}, \tilde{F}_{kj}]^T$, $\tilde{P}_{kj} = [\tilde{P}_{0j}, \tilde{P}_{kj}]^T$, we shall simply use $\tilde{F}$, $\tilde{P}$. No confusion will arise since at least one parameter will be

[20]This is a standard result in the theory of contracts (see e.g., Hart and Holmstrom (1987) for a nice survey). An initial attempt by Amershi (1984) to produce a theory of mutual funds and financial intermediation resulted in a performance evaluation metric for mutual fund managers that had the virtue of simplicity and intuitive appeal. However, the result was not derived in the context of a proper rational expectations equilibrium in segmented markets. In a related paper (Amershi and Ramamurtie (1991)), we introduce disutility for effort in the information producing agent (termed the financial intermediary in Section 4), an ability to reveal information strategically and capacity constraints on the information technology induced by an upper bound on the total search effort available.

subscripted j. Let $(\tilde{F}, \tilde{Y}_j, \tilde{P})$ denote the parameters for j before additional information, and let $(\tilde{F}^*, \tilde{Y}_j^*, \tilde{P}^*)$ denote the parameters after getting information $\tilde{Y}_j^*$. Observe that we assume $\tilde{Y}_j^*$ to be quite general and $\tilde{Y}_j^*$ may not have, in general, a simple additive relationship with $\tilde{Y}_j$. Similarly, $\tilde{F}^*$ allows for the possibility that the investor's opportunity sets expands from $\tilde{F}$ to $\tilde{F}^*$. Hence $\dim \tilde{F}^* \geq \dim \tilde{F}$ (where dim denotes the vector "dimension" of the payoff vector). Similarly $\tilde{P}^*$ may be different from $\tilde{P}$ depending on whether or not the information is sold to a positive measure set of agents of which j is a representative.

Other Notation

R: Payoff of the riskfree asset.

ρ_j: Absolute risk aversion coefficient of the investor j.

$\Phi_{jb} = [\mathrm{Var}[\tilde{F} \mid \tilde{Y}_j, \tilde{P}]]^{-1}$: The conditional precision matrix of the asset payoffs when investor j is in receipt of signal(s) $\tilde{Y}_j$ and also incorporates information from the equilibrium prices, $\tilde{P}$.

Ψ_j: $\mathrm{Var}[\tilde{F} - R\tilde{P}]$: The unconditional variance matrix of the excess asset payoffs corresponding the investor j's *a priori* information and the current market structure.

μ_j: $E[\tilde{F} - R\tilde{P}]$: The unconditional expected excess asset payoff vector, again corresponding to the investor j's *a priori* information and the current market structure.

Φ_j^*, Ψ_j^*, μ_j^* are then the corresponding conditional precision, unconditional variance and the unconditional expected excess payoff under the regime $(\tilde{F}^*, \tilde{Y}_j^*, \tilde{P}^*)$.

The metric δ_j^* is determined in the next result.

Proposition 2: The maximum rent δ_j^* is equal to

$$(6)\quad \delta_j^* = \frac{1}{2R\cdot\rho_j}\cdot \text{Log}_e \cdot \left[\frac{|\Psi_j^*|\,|\Phi_j^*|}{|\Psi_j|\,|\Phi_j|}\right]$$

$$+\ \frac{1}{2R\cdot\rho_j} \bullet [\mu_j^{*T} \bullet \Psi_j^{*-1} \bullet \mu_j^* - \mu_j^T \bullet \Psi_j^{-1}\, \mu_j]$$

Proof: The conditional demand for the risky assets under regime $(\tilde{F}, \tilde{Y}_j, \tilde{P})$ is

$$(7)\quad D_j(\bullet\,|\,\tilde{Y}_j, \tilde{P}) = \frac{1}{\rho_j}\, [\text{Var}\, \tilde{F}\,|\,\tilde{Y}_j, \tilde{P}]^{-1} \bullet [E(\tilde{F}\,|\,\tilde{Y}_j, \tilde{P}) - R\tilde{P}]$$

$$= \frac{1}{\rho_j} \bullet [\Phi_j] \bullet [E(\tilde{F}\,|\,\tilde{Y}_j, \tilde{P}) - R\tilde{P}]$$

Similarly, the conditional demand under the regime $(\tilde{F}^*, \tilde{Y}_j^*, \tilde{P}^*)$ is $D_j^*(\bullet\,|\,\tilde{Y}_j^*, \tilde{P}^*)$ and is identical in form to (7) except that * is entered in the parameters.

Hence the end of period wealths $\tilde{W}_{1j}$, and $\tilde{W}_{1j}^*$ are

$$(8)\quad \tilde{W}_{1j} = W_{0j} \bullet R + \frac{1}{\rho_j}\, [\text{Var}(\tilde{F}\,|\,\tilde{Y}_j, \tilde{P})]^{-1} \bullet [E(\tilde{F}\,|\,\tilde{Y}_j, \tilde{P}) - R\tilde{P}]$$

$$(9)\quad W_{1j}^* = (W_{0j} - \delta_j^*)R + \frac{1}{\rho_1}\, [\text{Var}(\tilde{F}^*\,|\,\tilde{Y}_j^*, \tilde{P}^*)]^{-1} \bullet [E(\tilde{F}^*\,|\,\tilde{Y}_j^*, \tilde{P}^*) - R\tilde{P}^*]$$

$$(10)\quad E(U(\tilde{W}_{1j})) = E(-\exp(-\rho_j W_{1j}))$$

$$(11)\quad = \frac{-1}{|\Psi|^{\frac{1}{2}}|\Psi|^{\frac{1}{2}}} \bullet \exp[-\rho_j \bullet R \bullet W_{0j} - \frac{1}{2}\, E[\tilde{F} - R\tilde{P}]^T \bullet E[\tilde{F} - R\tilde{P}]]$$

This can be proved directly from substituting from (8) for $\tilde{W}_{1j}$ and noting that it is a moment generating function of a multivariate normal after appropriate linear transformation. (The details can be found in the Proof of Proposition 2 in Admati and Pfleiderer (1987). We shall not repeat them here).

Similarly, we can derive the expression (denoted by (11*)) for

$$(12)\quad E(U(\tilde{W}_{1j}^*)) = E(-\exp(-\rho \tilde{W}_{1j}^*))$$

from (9). Simply insert * in (11) for the expressions $\tilde{F}$, Φ, Ψ, $\tilde{P}$ and $(W_{0j} - \delta_j^*)$ for W_{0j} to obtain (11*).

From equation (5),

$$(13) \qquad \frac{E(U(\tilde{W}_{1j}^*))}{E(U(\tilde{W}_{1j}))} = 1$$

Taking log on both sides in (13) and substituting from (11) and (11*), by appropriate simplification we get equation (6) for δ_j^*. ■

Observe that δ_j^* differs from the value of information in an integrated market. In an integrated market (see Admati and Pfleiderer (1987)), we have the simpler expression

$$(14) \quad \delta_j^* = \frac{1}{2\rho} \log\left(\frac{|\Phi_j^*|}{|\Phi_j|}\right) = \frac{1}{2\rho} \left(\log|\Phi_j^*| - \log|\Phi_j|\right), \{\text{with } R = 1\}$$

because $\psi^* = \psi$. In the segmented market case $\psi^* \neq \psi$ (except in case (a) discussed below). Thus the comparative statics of the value δ^* are different. We now provide some derivations in this regard. Equation (6) shows that δ_j^* is made up of two components:

$$(i) \qquad \frac{1}{2R\rho_j} \log\left(\frac{|\Psi_j^*|\,|\Phi_j^*|}{|\Psi_j|\,|\Phi_j|}\right)$$

$$(ii) \qquad \frac{1}{2R\rho_j} [\mu_j^{*T} \bullet \psi_j^{*-1} \bullet \mu_j^* - \mu_j \bullet \psi_j^{-1} \bullet \mu_j] = \frac{1}{2R\rho_j} \Delta_j^*.$$

Observe that by properties of conditioning

$$(15) \quad \Phi_j^{-1} = \mathrm{Var}(\tilde{F}\,|\,\tilde{Y}, \tilde{P}) = \mathrm{Var}(\tilde{F} - R\tilde{P}\,|\,\tilde{Y}, \tilde{P})$$

and similarly for the precision matrix Φ^* with information.

Before we proceed further, it is necessary to spell out clearly how the information vector Y_j^* is acquired in segmented market economies.

In the segmented markets, there are several ways in which information can be collected by a financial intermediary and packaged and sold (or used by herself as in Amershi and Ramamurtie (1991)) to collect information rent. Some of these methods are identical to the SINREE case, extensively developed by Admati and Pfleiderer (1987) as "viable allocations" of information. On the other hand, by the very nature of segmented markets economics, there is a far greater scope for information production and sale activity in such economies. For example, a large part of this activity would be *search* activity by financial intermediaries to *span* regional markets. Thus, there would exist financial intermediaries, who have comparative advantage in asset search and location, who would inform investors in one market about investment opportunities in other markets. In addition, there would be financial intermediaries who have the comparative advantage over average investors to not only locate new assets, but also to acquire additional information of their payoff structure than what is commonly known about these assets.

Here we shall consider three cases of information arbitrage activity and provide some analysis and heuristics based on the information-value metric derived in Proposition 2. There are other possibilities, but address them elsewhere (Amershi and Ramamurtie (1991)). The three cases are:

Case (a): Investor j in market $k=1,2$ acquires additional information about his own market k's assets.

Case (b): The financial intermediary provides investor j in market $k=1,2$, the information *only* about the *location* and *payoff characteristic* information about some or all assets in market $L = 1,2$, $L \neq k$. The information provided is the *basic* payoff distribution information of L's assets that is common knowledge in the L market. (Note that in this case, investors in the L market may have private information about L's assets in addition to the basic information.) We call this type of information *spanning information*.

In this case $\bar{F}^* = (\bar{F}_0, \bar{F}_k, \bar{F}_j^L)$ where $\bar{F}_j^L$ may or may not equal the whole of $\bar{F}_L$, $\bar{Y}_j^* = \bar{Y}_j$ (as not additional information other than $\bar{F}_j^L$ is provided) and, $\bar{P}^* = (\bar{P}_0, \bar{P}_k, P_j^L)$, where we take P_j^L to be simply the price vector of the $\bar{F}_j^L$ assets taken as a *parameter* in j's budget constraint, where $(\bar{P}_0, \bar{P}_k)$ is price functional conjecture in the k market about the assets in the central and k market, $k \neq L$. The reason why we consider investor j in k takes P_j^L as a parameter rather than a conjecture is because he individually has measure zero and his trading activity in L assets will have no effect on P_j^L. Thus it is reasonable to assume he will take P_j^L as given and simply consider the additional assets as additional investment opportunities with fixed prices P_j^L.

Case (c): The financial intermediary provides investor j in market k information as in (b), and in addition also provides a private signal (just as investors in L have their private signals) about the payoff of the assets in market L about which she has provided location and basic structural information. In this paper, we shall not worry about packaging the totality of this information and how it will be allocated. Here we are concerned only with how the information-value metric would behave if all this information were procured by the investor j in market k about the assets in market L simultaneously.

In this case then we have that $\tilde{T}^*$ increases from $(\tilde{F}_0, \tilde{F}_k)$ to $(\tilde{F}_0, \tilde{F}_k, \tilde{F}_k^L)$, and $\tilde{Y}_j^* = (\tilde{Y}_k, \tilde{Y}_k^L)$. The composition of $\tilde{P}^*$ is again similar since j is measure zero.

Let us dispense with case (a) quickly. Given our discussion in Section 3 that the k^{th} regional-central market conglomerate (k = 1,2) pricing functional is identical in mathematical form to the SINREE model (except that the noise term arises endogenously from intermarket trading noise), the incremental information about the conglomerate has the same effects as in the SINREE model. Since the comparative statics of information in this milieu have been lucidly and extensively investigated by Admati and Pfleiderer (1987), we bypass this case here.

Cases (b) and (c) are somewhat more involved. To analyze them, we need the following lemma:

Lemma 1: Let G be the partitioned (m+n) x (m+n) matrix

$$G = \begin{bmatrix} H & H_{12} \\ G_{21} & G_{22} \end{bmatrix}$$

where H is some mxm matrix. If g and H are positive definite, then if $\hat{x} = \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$ is any partitioned vector of the vectors x_1 (whose dimension = m) and x_2 (dim x_2 = n), $\hat{x}^T G^{-1} x > x_1^T H^{-1} x$.

Proof: Straightforward linear algebra. ■

From the lemma we can prove that $\Delta_{j,s}^* > 0$.

Fact 1: $\Delta_{j,s}^* > 0$.

Proof: Suppose the additional information provided to agent j in market k = 1,2, about assets in market L is about some (or all) assets in L whose random vector of payoffs is $\tilde{F}_j^L$

of dimension n (less than equal to #L = number of assets in L). Then the total payoff vector knowledge available to j is $(\tilde{F}, \tilde{F}_j^L)$. Similarly,

$$\tilde{P}^* = (\tilde{P}, P_j^L).$$

Since

$$\psi = \mathrm{Var}(\tilde{F} - R\tilde{P})$$

$$\psi^* = \mathrm{Var}\left(\begin{bmatrix}\tilde{F}\\ \tilde{F}_j^L\end{bmatrix} - R\begin{bmatrix}\tilde{P}\\ P_j^L\end{bmatrix}\right)$$

then,

$$\psi^* = \begin{bmatrix}\Psi & B\\ C & D\end{bmatrix}, \text{ D positive definite matrix}$$

for appropriate matrices B, C, D. Both ψ^* and ψ are positive definite.

It follows from the Lemma 1 and the fact that

$$\mu = E[\tilde{F} - R\tilde{P}]$$

and

$$\mu^* = E\left(\begin{bmatrix}\tilde{F}\\ F_j^L\end{bmatrix} - R\begin{bmatrix}\tilde{P}\\ P_j^L\end{bmatrix}\right),$$

that

$$\mu^{*T}\psi^{*-1}\mu^* > \mu^T\psi^{-1}\mu$$

or $\Delta_{j*}^* > 0$. ■

This shows that the second component (ii) of δ_j^*, namely $\frac{1}{2R\rho_j}\Delta_{j*}^* > 0$ regardless of what the additional information is.

Unfortunately, component (i) is *indeterminate*.

To prove the indeterminacy, observe that since for any matrix D, $|D^{-1}| = |D|^{-1}$,

$$\log\left(\frac{|\Psi^*|\cdot|\Phi^*|}{|\Psi|\cdot|\Phi|}\right) = \log\left(\frac{|\Psi^*|}{|\bar{\Psi}^*|}\right) + \log\left(\frac{|\bar{\Psi}|}{|\Psi|}\right)$$

where from (15) $\bar{\psi} = \Phi^{-1} = \mathrm{Var}(\mathbf{F} - \mathbf{RP}\,|\,\mathbf{Y}, \mathbf{P})$ and

$$\bar{\psi}^* = \Phi^{*-1} = \mathrm{Var}\left(\begin{bmatrix}\tilde{\mathbf{F}}\\ \tilde{\mathbf{F}}_j^{L}\end{bmatrix} - \mathbf{R}\begin{bmatrix}\tilde{\mathbf{P}}\\ \mathbf{P}_j^{L}\end{bmatrix}\,|\,\tilde{\mathbf{Y}}, \mathbf{P}^*\right).$$

We next access the following result:

Lemma 2: $|\psi^*|$ is strictly greater than $|\psi|$ is strictly greater than $|\bar{\psi}|$.

Proof: This follows from the properties of unconditional and conditional variance-covariance matrices obtained from normally distributed random vectors, and the properties of positive definite matrices (Beckenbach and Bellman (1961). ■

We have therefore,

(16) $\log\left(\frac{|\Psi^*|}{|\bar{\Psi}^*|}\right) > 0$ as $|\psi^*| > |\bar{\psi}^*|$

and

(17) $\log\left(\frac{|\bar{\Psi}|}{|\Psi|}\right) < 0$ as $|\bar{\psi}| < |\psi|$.

Thus

(18) $\log\left(\frac{|\Psi^*|\cdot|\Phi^*|}{|\Psi|\cdot|\Phi|}\right)$ is indeterminate.

$\Delta_{j\mathrm{s}}^*$ is the component in δ_j^* that is due to purely an increase in the number of asset from market L that the financial intermediary provides to investor j in market k ≠ L. Thus we define:

Definition 1: $\Delta_{j\mathrm{s}}^*$ = value of market spanning information.

On the other hand, Φ^* and Φ are precisions of the *total* (initial plus incremental information) information conditioned *precision* matrix and the initial information *precision* matrix. The ratios $|\psi^*|/|\overline{\psi}^*|$ and $|\psi|/|\overline{\psi}|$ define the ratio of the *ex ante* (before information) and *ex post* (conditional on information) variance-covariance matrix determinants.

Observe that if the financial intermediary provides only location information about assets in market L = 1,2, to investor j in market k, it does *not* mean that $\psi^* = \overline{\psi}^*$. The reason is that the private information of j in k, $\bar{Y}_j$ may have an effect on the conditional precision of the additional assets $\bar{F}_j^L$ from L. Consequently, we cannot assume $\overline{\psi}^* = \psi^*$ when only spanning information is provided. In view of this, we define:

Definition 2: If the information provided to investor j in market k = 1,2, about assets in market L ≠ k, L = 1,2 is such that

$$(19) \quad \delta^*_{j\rho} = \log\left(\frac{|\Psi^*|}{|\bar{\Psi}^*|}\right) - \log\left(\frac{|\Psi|}{|\bar{\Psi}|}\right),$$

is ≥ 0, then the information is called *precision improving*, and if it is < 0, then it is called *precision reducing*.

With these in hand, we now analyze cases (b) and (c).

First observe that in the case of SINREE models, from (14), $\overline{\delta}^*_j \geq 0$ because additional information is always precision-improving. There are no cross market effects. Hence, in the SINREE models, one can say that an increase in risk-tolerance ρ increases the demand for precision since the investor is willing to pay more (see Admati and Pfleiderer (1987)).

In the segmented market case, we cannot say this, because if $\delta^*_{j\rho} + \Delta^*_{j*} < 0$, then an increase in risk-tolerance would reduce the demand for precision and increase the demand for spanning information and also decrease demand for total information. On the other hand, if $\delta^*_{j\rho} > 0$, then demand for both precision and spanning information increase.

It should be noted, however, that since by Fact 1, $\Delta^*_{j\bullet} > 0$, then an increase in risk-tolerance always increases demand for spanning information. That is, a risk-tolerant investor would like to increase the size of his portfolio of assets with assets in L.

In general, then we have the following situations:

(I) $\delta^*_{j\rho} > 0$

(II) $\delta^*_{j\rho} < 0$ and $\delta^*_{j\rho} + \Delta^*_{j\bullet} > 0$

(III) $\delta^*_{j\rho} < 0$, and $\delta^*_{j\rho} + \Delta^*_{j\bullet} < 0$.

Clearly, the financial intermediary would never put out for sale to j in k information about assets in market L $\neq$ k, such that situation (III) obtains. Thus situation (III) can be ignored because this can never occur in equilibrium. This leaves situations (I) and (II).

We conjecture (though this needs to be proven) that situation (I) is more likely than situation (II) under case (c) when the financial intermediary provides both location and private information about assets in the other market. In the same vein, we conjecture that case (II) is more likely under case (b) than case (c).

Situation (II) requires care. Consider for example, case (b). The financial intermediary has to find out whether increasing the number of assets in L searched for j in k $\neq$ L decreases or increases $|\delta^*_{j\rho}|$. If it is decreased, then depending on his information technology and capacity constraints, the financial intermediary should sell a larger "*mutual fund*" (see Amershi and Ramamurtie (1991)). The opposite is the case when $|\delta^*_{j\rho}|$ increases.

In case (c), the financial intermediary has to determine the marginal change in $|\delta^*_{j\rho}|$ with an increase in asset location information, holding additional information about these assets fixed, or the marginal change in $|\delta^*_{j\rho}|$ with an increase in asset specific information, keeping the number of assets in L searched fixed, or both. Again an increasing or decreasing marginal rate would require an appropriate information. If the rate of $|\delta^*_{j\rho}|$ increases with span, but decreases with precision improvement information, span fixed, then the financial intermediary makes the appropriate substitutions.

In general then, there are a variety of possible scenarios, and this should provide different financial intermediaries with different information technology and capacity constraints to choose their level of effort and co-exist in competitive equilibrium. That is, we would see all sorts of mutual funds spanning markets, from narrowly based to widely diversified (see Amershi and Ramamurtie (1991)). There is no *a priori* reason why narrowly based mutual funds cannot exist in the presence of diversified mutual funds, and this is precisely what the analysis above suggests. There is considerable empirical evidence to support the prediction that a wide variety of mutual funds would exist in equilibrium (see also Section 5 for further remarks on this point).

Finally, if a positive measure of agents in case (c) receive identical information from the financial intermediary, then we can no longer take the prices of the assets in L, P^L_j as parameters. Our needs to recompute the equilibrium prices. This case is rather complex, and we leave it to future research (see Amershi and Ramamurtie (1991)).

5. SUMMARY AND CONCLUDING REMARKS ON POTENTIAL APPLICATIONS

In this paper, we have developed a model of a segmented markets economy in which investors are grouped into regional markets that do not cross-trade and a central market in which everybody trades. It was shown that there exists a rational expectations equilibrium (REE) in which the pricing functional for each regional market exhibits a structure that is identical to the REE pricing functional in an integrated market with exogenous supply noise created by liquidity trading. In our model, the noise term arises out of intermarket trading noise even if there is no exogenous supply noise. Hence, the model here can be viewed as a meta-model in which the integrated market models can be considered partial equilibrium equilibria, and we may replace exogenous noise by endogenous noise.

We showed that in the REE equilibrium, segmentation persists and investors can derive rents from private information because of the endogenous noise. Furthermore, the economy can be in segmented markets equilibrium if and only if it was segmented prior to trade. Thus, parametric integrated market models (Hellwig (1980), Verrecchia (1982), Admati (1985), and Admati and Pfleiderer (1987)) which start out with independent exogenous noise cannot precipitate a segmented markets equilibrium.

We also derived a metric to determine the value of additional information in segmented markets. This metric has a different form compared to the integrated market case discussed in Admati and Pfleiderer (1987). In particular, the metric showed that intermarket spanning information always has value, but precision information may not. This led to interesting comparative statics.

We do not provide a more detailed summary here, as it has been provided in Section 1. Here we consider observed phenomena and show how the model here can be adapted to those contexts to provide explanation and prediction. While we do not formally pursue the analysis here for lack of space, each potential application can be resolved in principle, and future research is intended on analyzing their phenomena within our model.

The first is the concept of "intrinsic value" of an asset that traces its origins to Graham and Dodd's work (see Cottle, Murray, and Block (1988)). This is closely linked to the notion of "hidden value." The popular press is replete with stories of investors, financial analysts and arbitrageurs engaged in widespread search of "mispriced" assets to capture hidden value. Rents to such private search activity often reach into billions of dollars, and are far in excess of eliminating standard round trip transactions costs. Arguments about such costs to explain the existence of these investors and financial intermediaries are obviously not plausible. We believe that the metric for welfare effects developed in Section 4 to determine the "value" created by arbitrage through the combination of assets in different markets can be used to determine "intrinsic value."

In particular, a commonly observed empirical fact which supports such "intrinsic value" information arbitrage is mergers and acquisitions. In almost every takeover, merger or acquisition (of which there are thousands), the acquiring firm or investor pays a large (typically 30% - 70%) premium over the current stock price of the target firm. The premium is for the "hidden value" discovered by the research departments of the acquiring investor's financial advisors and investment bankers. Similarly, certain mutual funds or portfolios (Fidelity Magellan, the Value Line portfolio) have, on average, *consistently* outperformed the generally accepted "market" proxy, namely the Standard and Poor's 500. Conversely, the very existence of a huge number of undiversified mutual funds, and an equally huge number of investors who hold *only* undiversified funds in their asset portfolios supports this claim, and we generated a heuristic analysis in this regard in Section 4.

A second phenomenon is the proliferation of narrow mutual funds generated by portfolio managers who created them from different regional markets between 1982 and 1989. Thus there exist *suppliers* of asset information who are able to acquire this information through skill and effort (see Section 4). Such effort and skill are prohibitively costly at the margin to acquire for the average investor, and, therefore, all investors do not engage in search for assets. (Amershi and Ramamurtie (1991) speaks to this issue.)

Both casual observation and empirical work (see, e.g., Diamond (1984), Pratt, Wise and Zeckhauser (1979), among others) provide empirical support to this observation. The current paper is a direct consequence of an earlier model by Amershi (1984) on compensation contracts of mutual fund managers.

In Nelson's Directory of "*Neglected Stocks*," there are about 13,000 "neglected" stocks in the public exchanges themselves not followed by an analyst. Given the fact that many stocks although listed on the major stock exchanges are nevertheless "neglected," it would be highly improbable that *all economic* agents in the economy are fully aware of the several million business enterprises, and the scores of millions of real estate, art and other assets. Thus segmentation exists, and hence the demand for mutual funds that combine assets by spanning markets.

Between 1982 and 1989 the number of mutual funds grew by a factor of 600% (from 300 to 1800) as revealed by the Lipper Index. Furthermore, most of these new funds are narrowly based, and a substantial number have survived 10 years or more despite the fact that over that period, they have consistently underperformed relative to the Standard and Poor 500. Indeed, funds like Fidelity Magellan which has approximately 5000 stocks in its portfolio (and thus is far more diversified than that Standard and Poor 500) has *consistently* outperformed the S&P 500. Yet, this fund has not grown into a mega fund. It contains only about $10 billion of the more than one trillion dollars in mutual funds. In fact, the so called "underperforming" mutual funds or group have 25 times more funds invested in them than the Magellan fund. This type of irrational investing is not possible unless these funds have private value to investors, which is what the analysis in Section 4 shows.

It may be argued that the S&P 500 span (in payoff terms), all these other assets, and thus most investors do not need to know the characteristics of these assets. This is an empirical issue, but the argument seems highly implausible. For one thing, this would imply that *every* technological innovation has a payoff characteristics spanned by the commonly traded assets, which makes no economic sense as argued in the introduction.

We have no taken up the issue of "price volatility" in our setting because we do not yet know how to model this phenomenon in our setting. Allen and Gale (1991) have developed a model of segmented markets (see footnote 5) that produces price volatility. Another well-known phenomenon is the "small firm" effect. We believe that this can be investigated within the framework of our model.

Appendix

Proof of Theorem 1:

First we will derive all the parameters of the conjectured price functionals (1) and (2) in terms of exogenous parameters. To this end we proceed.

The conditional demand function for investor j in market k = 1,2, is

$$\text{(A1)}\quad D_j^k(\bullet\,|\,\bar{Y}_j^k, \bar{P}_0, \bar{P}_k) = \frac{1}{\rho_j}\cdot\left[\mathrm{Var}\left(\begin{pmatrix}\tilde{F}_0\\ \tilde{F}_k\end{pmatrix}\Big|\begin{pmatrix}\tilde{Y}_{0j}^k\\ \tilde{Y}_{kj}^k\end{pmatrix},\begin{pmatrix}\tilde{P}_0\\ \tilde{P}_k\end{pmatrix}\right)\right]^{-1}\cdot$$

$$\cdot\left[E\left(\begin{matrix}\tilde{F}_0\\ \tilde{F}_k\end{matrix}\Big|\begin{pmatrix}\tilde{Y}_{0j}^k\\ \tilde{Y}_{kj}^k\end{pmatrix},\begin{pmatrix}\tilde{P}_0\\ \tilde{P}_k\end{pmatrix}\right) - R\begin{pmatrix}\tilde{P}_0\\ \tilde{P}_k\end{pmatrix}\right]$$

$$= \begin{pmatrix}\alpha_{0j}^k\\ \alpha_{kj}^k\end{pmatrix} + \begin{pmatrix}\alpha_{00j}^k & \alpha_{0kj}^k\\ \alpha_{k0j}^k & \alpha_{kj}k\end{pmatrix}\cdot\begin{pmatrix}\tilde{Y}_{0j}^k\\ \tilde{Y}_{kj}^k\end{pmatrix} + \begin{pmatrix}\beta_{00j}^k & \beta_{0kj}^k\\ \beta_{k0j}^k & \beta_{kkj}^k\end{pmatrix}\cdot\begin{pmatrix}\tilde{P}_0\\ \tilde{P}_k\end{pmatrix}$$

$$\forall j = 1,2,\ldots,I,\ I\to\infty,\ \forall k = 1,2.$$

From the market clearing conditions in equilibrium we get:

$$\text{(A2)}\quad \begin{pmatrix}\alpha_{0j}^k\\ \alpha_{kj}^k\end{pmatrix} = \frac{1}{\rho_j}\begin{bmatrix}\Sigma_{00} & \Sigma_{0k}\\ \Sigma_{k0} & \Sigma_{kk}\end{bmatrix}^{-1}\cdot\begin{bmatrix}\overline{F}_0\\ \overline{F}_k\end{bmatrix}$$

$$-\frac{1}{\rho_j}\begin{bmatrix}A_{00}^k & A_{0k}^k\\ A_{k0}^k & A_{kk}^k\end{bmatrix}^T\cdot\left[\begin{pmatrix}D_{0L}^k\\ D_{kL}^k\end{pmatrix}(W_L^k)i\begin{pmatrix}D_{L0}^k & D_{Lk}^k\end{pmatrix}\right]^{-1}\cdot\begin{bmatrix}A_0^k\\ A_k^k\end{bmatrix}$$

$$\text{(A3)}\quad \begin{pmatrix}\alpha_{00j}^k & \alpha_{0kj}^k\\ \alpha_{k0j}^k & \alpha_{kkj}^k\end{pmatrix} = \frac{1}{\rho_j}\begin{bmatrix}S_{00j}^k & S_{0kj}^k\\ S_{k0j}^k & S_{kkj}^k\end{bmatrix}^{-1}$$

$$\forall j = 1,2,\ldots,I,\ I\to\infty,\ \forall k = 1,2.$$

Hence from (A1), (A2), and (A3), we have

$$\text{(A4)} \quad \begin{bmatrix} \beta^k_{00j} & \beta^k_{0kj} \\ \beta^k_{k0j} & \beta^k_{kkj} \end{bmatrix} = \frac{1}{\rho_j} \begin{bmatrix} A^k_{00} & A^k_{0k} \\ A^k_{k0} & A^k_{kk} \end{bmatrix}^T \cdot \left[\begin{bmatrix} D^k_{0L} \\ D^k_{kL} \end{bmatrix} \left[W^k_L\right] \begin{bmatrix} D^k_{L0} & D^k_{Lk} \end{bmatrix} \right]^{-1} \cdot$$

$$\cdot \left[\begin{pmatrix} I_{00} & 0 \\ 0 & I_{kk} \end{pmatrix} - R \begin{pmatrix} A^k_{00} & A^k_{0k} \\ A^k_{k0} & A^k_{kk} \end{pmatrix} \right]$$

$$- \frac{R}{\rho_j} \cdot \left[\begin{bmatrix} \sum_{00} & \sum_{0k} \\ \sum_{k0} & \sum_{kk} \end{bmatrix}^{-1} + \begin{bmatrix} S^k_{00j} & S^k_{0kj} \\ S^k_{k0j} & S^k_{kkj} \end{bmatrix}^{-1} \right]$$

$$\forall j = 1,2,\ldots, I \to \infty, \ \forall k = 1,2 \ \forall L \neq k, \ L = 1,2.$$

Define

$$\text{(A5)} \quad \begin{bmatrix} \beta^k_{00} & \beta^k_{0k} \\ \beta^k_{k0} & \beta^k_{kk} \end{bmatrix} = \lim_{I \to \infty} \frac{1}{I} \sum_j \begin{bmatrix} \beta^k_{00j} & \beta^k_{0kj} \\ \beta^k_{k0j} & \beta^k_{kkj} \end{bmatrix}$$

$$\forall j = 1,2,\ldots, I \to \infty, \ \forall k = 1,2$$

and define the relationship

$$\text{(A6)} \quad \begin{bmatrix} \hat{\alpha}_{00} & \hat{\alpha}_{01} & \hat{\alpha}_{02} \\ \hat{\alpha}_{10} & \hat{\alpha}_{11} & \hat{\alpha}_{12} \\ \hat{\alpha}_{20} & \hat{\alpha}_{21} & \hat{\alpha}_{22} \end{bmatrix} = \begin{bmatrix} \beta^1_{00}+\beta^2_{00} & \beta^1_{01} & \beta^2_{02} \\ \beta^1_{10} & \beta^1_{11} & 0 \\ \beta^2_{20} & 0 & \beta^2_{22} \end{bmatrix}^{-1}.$$

Define as well,

$$\text{(A7)} \quad \begin{pmatrix} \alpha^k_{00} & \alpha^k_{0k} \\ \alpha^k_{k0} & \alpha^k_{kk} \end{pmatrix} = \lim_{I \to \infty} \frac{1}{I} \sum_j \begin{pmatrix} \alpha^k_{00j} & \alpha^k_{0kj} \\ \alpha^k_{k0j} & \alpha^k_{kkj} \end{pmatrix} < \infty \ \text{(By Assumption)}$$

$$\forall j = 1,2,\ldots, I \to \infty, \ \forall k = 1,2$$

Then we have

$$\begin{bmatrix} A_0^k \\ A_k^k \end{bmatrix} = - \left[\begin{pmatrix} \hat{a}_{00}\hat{a}_{00} \\ \hat{a}_{k0}\hat{a}_k^{k_k} \end{pmatrix} \begin{pmatrix} \alpha_0^k \\ \alpha_k^k \end{pmatrix} + \begin{pmatrix} \hat{\alpha}_{00}\hat{\alpha}_{0L} \\ \hat{\alpha}_{00}\hat{\alpha}_{kL} \end{pmatrix} \begin{pmatrix} \alpha_0^L \\ \alpha_L^L \end{pmatrix} + \begin{pmatrix} \hat{\alpha}_{00}\hat{\alpha}_{0L} \\ \hat{\alpha}_{k0}\hat{\alpha}_{kL} \end{pmatrix} \begin{pmatrix} \alpha_0^{L_*} \\ \alpha_{L0}^L \end{pmatrix} \cdot \left[F_L - (\Sigma_{L0}\Sigma_{Lk}) \begin{pmatrix} \Sigma_{00}\Sigma_{0k} \\ \Sigma_{k0}\Sigma_{kk} \end{pmatrix}^{-1} \begin{pmatrix} F_0 \\ F_k \end{pmatrix} \right] - \begin{pmatrix} \hat{a}_{0L} \\ \hat{a}_{kL} \end{pmatrix} (\overline{N}_L) - \begin{pmatrix} \hat{a}_{00}\hat{a}_{0k} \\ \hat{a}_{k0}\hat{a}_{kk} \end{pmatrix} \begin{pmatrix} \overline{N}_0 \\ \overline{N}_k \end{pmatrix} \right]$$

(A8) $\quad$ vk = 1,2, ∀L ≠ k, L = 1,2

where

(A9) $$\begin{pmatrix} \alpha_0^k \\ \alpha_k^k \end{pmatrix} = \lim_{I \to \infty} \frac{1}{I} \sum_j \begin{pmatrix} \alpha_{0j}^k \\ \alpha_{kj}^k \end{pmatrix} \quad \forall j = 1,2,\ldots I \to \infty, \ \forall k = 1,2$$

and

$$\begin{bmatrix} A_{00}^k & A_{0k}^k \\ A_{k0}^k & A_{kk}^k \end{bmatrix} \cdot \left[\begin{pmatrix} \hat{a}_{00}\hat{a}_{0k} \\ \hat{a}_{k0}\hat{a}_{kk}^k \end{pmatrix} \begin{pmatrix} a_{00}^k a_{0k}^k \\ a_{k0}^k a_{kk}^k \end{pmatrix} + \begin{pmatrix} \hat{a}_{00}\hat{a}_{0L} \\ \hat{a}_{k0}\hat{a}_{kL} \end{pmatrix} \begin{pmatrix} a_{00}^L a_{0L}^L \\ a_{L0}^L a_{LL}^L \end{pmatrix} \begin{pmatrix} \Sigma_{00} \Sigma_{0k} \\ \Sigma_{L0} \Sigma_{Lk} \end{pmatrix} \begin{pmatrix} \Sigma_{00} \Sigma_{0k} \\ \Sigma_{k0} \Sigma_{kk} \end{pmatrix}^{-1} \right]$$

(A10) ∀k = 1,2, ∀L ≠ k, L = 1,2.

Finally,

$$\begin{pmatrix} D_{0L}^k \\ D_{kL}^k \end{pmatrix} = - \left[\begin{pmatrix} \hat{\alpha}_{00} & \hat{\alpha}_{0L} \\ \hat{\alpha}_{k0} & \hat{\alpha}_{kL} \end{pmatrix} \begin{pmatrix} \alpha_{00}^L & \alpha_{0L}^L \\ \alpha_{L0} & \alpha_{LL}^L \end{pmatrix} \begin{pmatrix} 0_{Lk} \\ I_{kk} \end{pmatrix} \right]$$

∀k = 1,2, ∀L ≠ K, L = 1,2.

From (A3), we have that the coefficients

$$\begin{pmatrix} \alpha_{00j}^k & \alpha_{0kj}^k \\ \alpha_{k0j}^k & \alpha_{kkj}^k \end{pmatrix}$$

are independent of all endogenous mathematical constructs.

Define

$$\lim_{I\to\infty} \frac{1}{I} \sum_j \frac{1}{\rho_j} \begin{bmatrix} S^k_{00j} & S^k_{0kj} \\ S^k_{k0j} & S^k_{kkj} \end{bmatrix}^{-1}$$

as

$$(A11) = \frac{1}{\rho} \cdot \begin{bmatrix} S^k_{00} & S^k_{0k} \\ S^k_{k0} & S^k_{kk} \end{bmatrix}^{-1} < \infty \ \forall k = 1,2$$

where ρ is some constant.

We have therefore from the relationship (6)

$$\begin{bmatrix} \hat{\alpha}_{00} & \hat{\alpha}_{01} & \alpha_{02} \\ \hat{\alpha}_{10} & \hat{\alpha}_{11} & \hat{\alpha}_{12} \\ \hat{\alpha}_{20} & \hat{\alpha}_{21} & \hat{\alpha}_{22} \end{bmatrix} = \begin{bmatrix} \beta^1_{00}+\beta^2_{00} & \beta^1_{01} & \beta^2_{02} \\ \beta^1_{10} & \beta^1_{11} & 0 \\ \beta^2_{20} & 0 & \beta^2_{22} \end{bmatrix}^{-1}$$

the following equations that we need to solve:

$$(A12)\ \beta^k_{0k} = -R[\hat{\alpha}^k_{0k} + [\rho I_{00} + \hat{\alpha}^{kT}_{00}\delta^k_{00}]^{-1} \bullet [V^k_{0k} + \rho(\alpha^k_{0k} - \hat{\alpha}^k_{0k})]$$

$$\forall k = 1,2$$

and

$$(A13)\ \beta^k_{kk} = \rho^{-1}.$$

$$R[(\hat{\alpha}^k_{k0} \bullet \delta^k_{00})\ (\rho I_{00} + \hat{\alpha}^{k\theta}_{00}\delta^k_{00})^{-1} \bullet (V^k_{0k} + \rho(\alpha^k_{0k} - \hat{\alpha}^k_{0k})) - (V^k_{kk} + \rho\alpha^k_{kk})]$$

$$\forall k = 1,2$$

where

$$\hat{\alpha}^{kT}_{00} = \alpha^k_0 + \alpha^L_{00} - \alpha^L_0(\alpha^L_{LL})^{-1}\alpha^L_{L0} + [\alpha^L_{0L}(\alpha^L_{LL})^{-1} + \hat{\Sigma}^T_{L0}] \bullet [\alpha^L_{L0} - \alpha^L_{LL}m^L_{L0}]$$

$$\forall k = 1,2,\ \forall L \neq k,\ L = 1,2$$

where

$$(A14)\ m^L_{L0} = (\beta^L_{LL})^{-1}\ \forall L \neq k,\ L = 1,2.$$

$$\hat{\alpha}^k_{k0} = \alpha^k_{k0} + \hat{\Sigma}^T_{1k}(\alpha^L_{L0} - \alpha^L_{LL}m^L_{L0})\ \forall k = 1,2\ \forall L \neq k,\ L = 1,2.$$

$$\hat{\alpha}^k_{0k} = \alpha^k_{0k} + (\alpha^L_{0L} - m^L_{0L}\alpha_{LL})^T \bullet \hat{\Sigma}_{LK}\ \forall k = 1,2,\ \forall L \neq K,\ L = 1,2.$$

$$m^L_{0L} = \beta^L_{0L}(\beta^L_{LL})^{-1}\ \forall L \neq k,\ L = 1,2.$$

$$\delta^k_{00} = [(\alpha^L_{0L} - m^L_{0L} \bullet \alpha^L_{LL})\ \hat{\Sigma}(\alpha^L_{L0} - \alpha^L_{LL}m^L_{L0})]^{-1}\ \forall L \neq k,\ L = 1,2.$$

$$\hat{\Sigma}_{LL} = \Sigma_{LL} - \hat{\Sigma}_{L0}\Sigma_{0L} - \hat{\Sigma}_{Lk}\Sigma_{kL}\ \forall L \neq k,\ L = 1,2,\ k = 1,2.$$

$$\hat{\Sigma}_{L0} = (\Sigma_{L0} - \Sigma_{Lk}\Sigma^{-1}_{kk}\Sigma_{k0}) \bullet (\Sigma_{00} - \Sigma_{0k}\Sigma^{-1}_{kk}\Sigma_{k0})^{-1}$$

$$\forall L \neq k,\ L = 1,2,\ k = 1,2.$$

$$\hat{\Sigma}_{Lk} = (\Sigma_{Lk} - \Sigma_{L0}\Sigma^{-1}_{00}\Sigma_{0k}) \bullet (\Sigma_{kk} - \Sigma_{k0}\Sigma^{-1}_{00}\Sigma_{0k})^{-1}$$

$$\forall L \neq k,\ L = 1,2,\ k = 1,2.$$

$$\begin{pmatrix} V^k_{00} & V^k_{0k} \\ V^k_{k0} & V^k_{kk} \end{pmatrix} = \begin{pmatrix} \Sigma_{00} & \Sigma_{0k} \\ \Sigma_{k0} & \Sigma_{kk} \end{pmatrix}^{-1}\ \forall k = 1,2.$$

But

$$m^k_{0k} \equiv \beta^k_{0k}(\beta^k_{kk})^{-1}$$

$$\text{(A15)} = -\rho[\hat{\alpha}^k_{0k} + (\rho I_{00} + \hat{\alpha}^{kT}_{00}\delta^k_{00})^{-1} \bullet (V^k_{0k} + \rho(\alpha^k_{0k} - \hat{\alpha}^k_{0k}))].$$

$$\bullet\ [\hat{\alpha}^k_{k0} \bullet \delta^k_{00})\ (\rho I_{00} + \hat{\alpha}^{kT}_{00}\delta^k_{00})^{-1}\ (V^k_{0k} + \rho(\alpha^k_{0k} - \hat{\alpha}^k_{0k})) - (V^k_{kk} + \rho\alpha^k_{kk})]^{-1}$$

$$\forall k = 1,2.$$

Thus $\beta^1_{01}(\beta^1_{11})^{-1}$ is a function of $\beta^2_{22}(\beta^2_{22})^{-1}$ and conversely.

To summarize the above derivations, (A12), (A13) and (A15) result from the demand equation analysis and are repeated below:

$$\text{(A12)}\ \beta^k_{0k} = -R[\hat{\alpha}^k_{0k} + (\rho I_{00} + \hat{\alpha}^{kT}_{00}\delta^k_{00})^{-1} \bullet (V^k_{0k} + \rho(\alpha^k_{0k} - \hat{\alpha}^k_{0k}))]$$

$$\text{(A13)}\ \beta^k_{kk} = \rho^{-1}R[(\hat{\alpha}^k_{k0}\delta^k_{00}) \bullet (\rho I_{00} + \hat{\alpha}^{kT}_{00}\delta^k_{00})^{-1} \bullet (V^k_{0k} + \rho(\alpha^k_{0k} - \hat{\alpha}^k_{0k})) - (V^k_{kk} + \rho\alpha^k_{kk})]$$

$$(A15)\quad m^k_{0k} = \beta^k_{0k}(\beta^k_{kk})^{-1}$$

$$= -\rho[\hat{\alpha}^k_{0k} + (\rho I_{00} + \hat{\alpha}^{kT}_{00}\hat{\delta}^k_{00})^{-1}(V^k_{0k} + \rho(\alpha^k_{0k} - \hat{\alpha}^k_{0k}))].$$

$$\bullet\ [(\hat{\alpha}^k_{k0}\delta^k_{00})(\rho I_{00} + \hat{\alpha}^{kT}_{00}\hat{\delta}^k_{00})^{-1}(V^k_{0k} + \rho(\alpha^k_{0k} - \hat{\alpha}^k_{0k})) - (V^k_{kk} + \rho\alpha^k_{kk})]^{-1}$$

$$\forall k = 1,2.$$

Now define

$$[\alpha^1_{01} - m^1_{01}\alpha^1_{11}] = \theta^1_{01},$$

$$[\alpha^1_{10} - \alpha^1_{11}m^1_{10}] = \theta^1_{10},$$

$$[\alpha^2_{02} - m^2_{02}\alpha^2_{22}] = \theta^2_{02},$$

$$[\alpha^2_{20} - \alpha^2_{22}m^2_{20}] = \theta^2_{20},$$

where

$$m^1_{01} = \beta^1_{01}(\beta(^1_{11})^{-1},$$

$$m^2_{02} = \beta^2_{02}(\beta^2_{22})^{-1}$$

$m^1_{10} = (\beta^1_{11})^{-1}\beta^1_{10}$, and

$m^2_{20} = (\beta^2_{22})^{-1}\beta^2_{20}$ as before.

Then, by a suitable rearrangement of terms and simplifications, we have

$$(A16)\quad \theta^1_{01} = \begin{bmatrix} \alpha^1_{01}(\alpha^1_{11})^{-1}V^1_{11} - V^1_{01} \\ + [\overline{\alpha}_{00} + (\hat{\Sigma}^T_{20} + \alpha^2_{02}(\alpha^2_{22})^{-1} - \alpha^1_{01}(\alpha^1_{11})^{-1}\hat{\Sigma}^T_{21})\theta^2_{20}] \\ \cdot[\overline{\alpha}_{00} + \alpha^1_{01}(\alpha^1_{11})^{-1}\alpha^1_{10} + (\hat{\Sigma}^T_{20} + \alpha^2_{02}(\alpha^2_{22})^{-1} + \rho\theta^2_{02}\hat{\Sigma}_{22})\theta^2_{20}]^{-1} \\ \cdot[V^1_{01} - \rho\theta^2_{02}\hat{\Sigma}_{21}] \end{bmatrix} \cdot$$

$$\cdot \begin{bmatrix} (V^1_{11} + \rho\alpha^1_{11}) - [\alpha^1_{10} + \hat{\Sigma}^T_{21}\theta^2_{20}]^{-1}\cdot \\ \cdot[\overline{\alpha}_{00} + \alpha^1_{01}(\alpha^1_{11})^{-1}\alpha^1_{10} + (\hat{\Sigma}^T_{20} + \alpha^2_{02}(\alpha^2_{22})^{-1} + \rho\theta^2_{02}\hat{\Sigma}_{22})\theta^2_{20}]^{-1} \\ \cdot[V^1_{01} - \rho\theta^2_{02}\hat{\Sigma}_{21}] \end{bmatrix}^{-1} \cdot \alpha^1_{11}$$

and:

$$\text{(A17)}\quad \theta^2_{02} = \begin{bmatrix} \alpha^2_{02}(\alpha^2_{22})^{-1}V^2_{22} - V^2_{02} \\ + [\overline{\alpha}_{00} + (\hat{\Sigma}^T_{10} + \alpha^1_{01}(\alpha^1_{11})^{-1} - \alpha^2_{02}(\alpha^2_{22})^{-1}\hat{\Sigma}^T_{12})\theta^1_{10}] \\ \cdot[\overline{\alpha}_{00} + \alpha^2_{02}(\alpha^2_{22})^{-1}\alpha^2_{20} + (\hat{\Sigma}^T_{10} + \alpha^1_{01}(\alpha^1_{11})^{-1} + \rho\theta^1_{01}\hat{\Sigma}_{11})\theta^1_{10}]^{-1} \\ \cdot[V^2_{02} - \rho\theta^1_{01}\hat{\Sigma}_{12}] \end{bmatrix} \cdot$$

$$\cdot \begin{bmatrix} (V^2_{22} + \rho\alpha^2_{22}) - [\alpha^2_{20} + \hat{\Sigma}^T_{12}\theta^1_{10}]^{-1}\cdot \\ \cdot[\overline{\alpha}_{00} + \alpha^2_{02}(\alpha^2_{22})^{-1}\alpha^2_{20} + (\hat{\Sigma}^T_{10} + \alpha^1_{01}(\alpha^1_{11})^{-1} + \rho\theta^1_{01}\hat{\Sigma}_{11})\theta^1_{10}]^{-1} \\ \cdot[V^2_{02} - \rho\theta^1_{01}\hat{\Sigma}_{12}] \end{bmatrix}^{-1} \cdot \alpha^1_{11}$$

where, from equations (A14)

$$\begin{bmatrix} V^1_{00} & V^1_{01} \\ V^1_{10} & V^1_{11} \end{bmatrix} = \begin{bmatrix} \Sigma_{00} & \Sigma_{01} \\ \Sigma_{10} & \Sigma_{11} \end{bmatrix}^{-1}$$

$$\begin{bmatrix} V^2_{00} & V^2_{02} \\ V^2_{20} & V^2_{22} \end{bmatrix} = \begin{bmatrix} \Sigma_{00} & \Sigma_{02} \\ \Sigma_{20} & \Sigma_{22} \end{bmatrix}^{-1}$$

$$\overline{\alpha}_{00} = \alpha^1_{00} + \alpha^2_{00} - \alpha^1_{01}(\alpha^1_{11})^{-1}\,\alpha^1_{10} - \alpha^2_{02}(\alpha^2_{22})^{-1}\,\alpha^2_{20}$$

$$\hat{\Sigma}_{11} = \Sigma_{11} - \hat{\Sigma}_{10} \bullet \Sigma_{01} - \hat{\Sigma}_{12} \bullet \Sigma_{21} = \Sigma_{11} - \Sigma_{10} \bullet \hat{\Sigma}^T_{10} - \Sigma_{12} \bullet \hat{\Sigma}^T_{12}$$

$$\hat{\Sigma}_{10} = (\Sigma_{10} - \Sigma_{12}\Sigma^{-1}_{22}\Sigma_{20}) \bullet (\Sigma_{00} - \Sigma_{02}\Sigma^{-1}_{22}\Sigma_{20})^{-1}$$

$$\hat{\Sigma}^T_{10} = (\Sigma_{00} - \Sigma_{02}\Sigma^{-1}_{22}\Sigma_{20})^{-1} \bullet (\Sigma_{01} - \Sigma_{02}\Sigma^{-1}_{22}\Sigma_{21})$$

$$\hat{\Sigma}^T_{12} = (\Sigma_{22} - \Sigma_{20}\Sigma^{-1}_{00}\Sigma_{02})^{-1} \bullet (\Sigma_{21} - \Sigma_{20}\Sigma^{-1}_{02}\Sigma_{01})$$

$$\hat{\Sigma}_{12} = (\Sigma_{12} - \Sigma_{10}\Sigma^{-1}_{00}\Sigma_{02}) \bullet (\Sigma_{22} - \Sigma_{20}\Sigma^{-1}_{00}\Sigma_{02})^{-1}$$

$$\hat{\Sigma}_{20} = (\Sigma_{20} - \Sigma_{21}\Sigma^{-1}_{11}\Sigma_{10}) \bullet (\Sigma_{00} - \Sigma_{02}\Sigma^{1}_{11}\Sigma_{10})^{-1}$$

$$\hat{\Sigma}^T_{20} = (\Sigma_{00} - \Sigma_{01}\Sigma^{-1}_{11}\Sigma_{10})^{-1} \bullet (\Sigma_{02} - \Sigma_{01}\Sigma^{-1\prime}_{11}{}_{12})$$

$$\hat{\Sigma}_{21} = (\Sigma_{21} - \Sigma_{20}\Sigma^{-1}_{00}\Sigma_{01}) \bullet (\Sigma_{11} - \Sigma_{10}\Sigma^{-1}_{00}\Sigma_{01})^{-1}$$

$$\hat{\Sigma}^T_{21} = (\Sigma_{11} - \Sigma_{10}\Sigma^{-1}_{00})^{-1} \bullet (\Sigma_{12} - \Sigma_{10}\Sigma^{-1}_{00}\Sigma_{02})$$

$$\hat{\Sigma}_{22} = \Sigma_{22} - \hat{\Sigma}_{20} \bullet \Sigma_{02} - \hat{\Sigma}_{21} \bullet \Sigma_{12} = \Sigma_{22} - \Sigma_{20} \bullet \hat{\Sigma}^T_{20} - \Sigma_{21} \bullet \hat{\Sigma}^T_{21}.$$

As can be seen from above θ^1_{01} and its transpose θ^1_{10}, are functions of θ^2_{20} and θ^2_{02} and vice versa. Again by appropriate manipulation of terms and relationships, we obtain the values for β^1_{01}, β^1_{11}, β^2_{02}, β^2_{22}, β^1_{10} and β^2_{20} as below:

(A18) $\beta_{01} = \rho^{-1} \bullet \mathrm{R} \bullet [\eta^{1T}_{00}] \bullet [\overline{\alpha}_{00}]^{-1} \bullet [\alpha^1_{01}(\alpha^1_{11})^{-1}V^1_{11} - V^1_{01}]$.

(A19) $\beta^1_{10} = \rho^{-1} \bullet \mathrm{R} \bullet [V^1_{11}(\alpha^1_{11})^{-1}\alpha^1_{10} - V^1_{10}] \bullet [\overline{\alpha}_{00}]^{-1}[\eta^1_{00}]$.

(A20) $\beta^1_{11} = \rho^{-1} \bullet \mathrm{R} \bullet [V^1_{11}(\alpha^1_{11})^{-1}\alpha^1_{10}] \bullet [\overline{\alpha}_{00}]^{-1} \bullet [\kappa^1_{01}]$

$= \rho^{-1} \bullet \mathrm{R} \bullet [\kappa^1_{10}]\, [\overline{\alpha}_{00}]^{-1} \bullet [\alpha^1_{01}(\alpha_{11})^{-1} \bullet V^1_{11} - V^1_{01}]$.

and

(A21) $\beta^2_{02} = \rho^{-1} \bullet \mathrm{R} \bullet [\eta^{2T}_{00}][\overline{\alpha}_{00}]^{-1}[\alpha^2_{02}(\alpha^2_{22})^{-1}V^2_{22} - V^2_{02}]$.

(A22) $\beta^2_{20} = \rho^{-1} \bullet \mathrm{R} \bullet [V^2_{22}(\alpha^2_{22})^{-1}V^2_{20} - V^2_{20}] \bullet [\overline{\alpha}_{00}]^{-1}[\eta^2_{00}]$.

(A23) $\beta^2_{22} = \rho^{-1} \bullet \mathrm{R} \bullet [V^2_{22}(\alpha_{22})^{-1}\alpha^2_{20} - V^2_{20}] \bullet [\overline{\alpha^2_{00}}]^{-1}[\kappa^2_{02}]$

$= \rho^{-1} \bullet \mathrm{R} \bullet [\kappa^2_{20}][\overline{\alpha}_{00}]^{-1}\alpha^2_{20} - V^2_{20}] \bullet [\overline{\alpha^2_{00}}]^{-1}[\kappa^2_{02}]$.

where

(Equations) $\overline{\alpha}_{00} = \alpha^1_{00} + \alpha^2_{00} - \alpha^1_{01}(\alpha^1_{11})^{-1}\alpha^1_{10} - \alpha^2_{02}(\alpha^2_{22})^{-1}\alpha^2_{20}$

(A24) $\eta^1_{00} = \alpha^1_{00} + \alpha^2_{00} - \alpha^2_{02}(\alpha^2_{22})^{-1}\alpha^2_{20} + (\hat{\Sigma}^T_{10} - \alpha^2_{02}(\alpha^2_{22})^{-1} \bullet \hat{\Sigma}^T_{12})\alpha^1_{10}$

$\eta^{1T}_{00} = \alpha^1_{00} + \alpha^2_{00} - \alpha^2_{02}(\alpha^2_{22})^{-1}\alpha^2_{20} + \alpha^1_{01}(\hat{\Sigma}_{10} - \hat{\Sigma}_{12}(\alpha^2_{22})^{-1} \bullet \alpha^2_{20})$.

$\kappa^1_{01} = \alpha^1_{01} + \hat{\Sigma}^T_{10}\alpha^1_{11} - \alpha^2_{02}(\alpha^2_{22})^{-1} \bullet \hat{\Sigma}^T_{12}\alpha^1_{11}$.

$\kappa^1_{10} = \alpha^1_{10} + \alpha^1_{11}\hat{\Sigma}_{12}(\alpha^2_{22})^{-1}\alpha^2_{20}$.

$\eta^2_{00} = \alpha^1_{00} + \alpha^2_{00} - \alpha^1_{01}(\alpha^1_{11})^{-1}\alpha^1_{10} + (\hat{\Sigma}^T_{20} - \alpha^1_{01}(\alpha^1_{11})^{-1} \bullet \hat{\Sigma}^T_{21})\alpha^2_{20}$.

$\eta^{2T}_{00} = \alpha^1_{00} + \alpha^2_{00} - \alpha^1_{01}(\alpha^1_{11})^{-1}\alpha^1_{10} + \alpha^2_{02}(\hat{\Sigma}_{20} - \hat{\Sigma}_{21}(\alpha^1_{11})^{-1} \bullet \alpha^1_{10})$.

$\kappa^2_{02} = \alpha^2_{02} + (\hat{\Sigma}^T_{20} - \alpha^1_{01}(\alpha^1_{11})^{-1}\hat{\Sigma}^T_{21} \bullet \alpha^2_{22})$

$\kappa^2_{20} = \alpha^2_{20} + (\hat{\Sigma}_{20} - \alpha^2_{22}\hat{\Sigma}_{21}(\alpha^1_{11})^{-1} \bullet \alpha^1_{10})$.

We can then solve for β_{00}^1 and β_{00}^2 once we have the values for other β's: We have

(A25) $\beta_{00}^1 = \alpha_{01}^1(\alpha_{11}^1)^{-1}\beta_{10}^1 - \rho^{-1} \bullet R \bullet [V_{00}^1 + \rho(\alpha_{00}^1 - \alpha_{01}^1(\alpha_{11}^1)^{-1} \bullet \alpha_{10}^1) - \alpha_{01}^1(\alpha_{11}^1)^{-1} \bullet V_{10}^1]$.

and similarly

(A26) $\beta_{00}^2 = \alpha_{02}^2(\alpha_{22}^2)^{-1}\beta_{20}^2 - \rho^{-1} \bullet R \bullet [V_{00}^2 + \rho(\alpha_{00}^2 - \alpha_{02}^2(\alpha_{22}^2)^{-1} \bullet \alpha_{20}^2) - \alpha_{02}^2(\alpha_{22}^2)^{-1} \bullet V_{20}^2]$.

Thus, we obtain the values for all the beta coefficients in terms of the exogenously specified system parameters. We have therefore determined the parameters:

(Equations) $\hat{\alpha}_{00} = [\beta_{00}^1 + \beta_{00}^2 - \beta_{01}^1(\beta_{11}^1)^{-1} \bullet \beta_{10}^1 - \beta_{02}^2(\beta_{22}^2)^{-1}\beta_{20}^2)]^{-1}$.

$\hat{\alpha}_{01} = -\hat{\alpha}_{00} \bullet \beta_{01}^1 \bullet (\beta_{11}^1)^{-1}$.

$\hat{\alpha}_{02} = -\hat{\alpha}_{00} \bullet \beta_{02}^2 \bullet (\beta_{22}^2)^{-1}$.

$\hat{\alpha}_{10} = -(\beta_{11}^1)^{-1} \bullet \beta_{10}^1 \bullet \hat{\alpha}_{00}$.

$\hat{\alpha}_{11} = (\beta_{11}^1)^{-1} + (\beta_{11}^1)^{-1} \bullet \beta_{10}^1\hat{\alpha}_{00} \bullet \beta_{01}^1(\beta_{11}^1)^{-1}$.

$\hat{\alpha}_{20} = -(\beta_{22}^2)^{-1} \bullet \beta_{20}^2 \bullet \hat{\alpha}_{00}$.

$\hat{\alpha}_{12} = (\beta_{11}^1)^{-1} \bullet \beta_{10}\hat{\alpha}_{00} \bullet \beta_{02}^2 \bullet (\beta_{22}^2)^{-1}$.

$\hat{\alpha}_{22} = (\beta_{22}^2)^{-1} + (\beta_{22}^2)^{-1}\beta_{20}^2 \bullet \hat{\alpha}_{00} \bullet \beta_{02}^2 \bullet (\beta_{22}^2)^{-1}$.

Having expressed all the $\hat{\alpha}_{ij}$'s in terms of the exogenous parameters, we are now in a position to express the price vector coefficients

$$\begin{bmatrix} A_0^k \\ A_k^k \end{bmatrix}, \begin{bmatrix} A_{00}^k & A_{0k}^k \\ A_{k0}^k & A_{kk}^k \end{bmatrix}, \begin{bmatrix} D_{0L}^k \\ D_{kL}^k \end{bmatrix}, \quad \forall k = 1,2, \forall L \neq k, L = 1,2$$

also in terms of the exogenous parameters.

This proves the existence of a partially revealing rational expectations equilibrium in an economy with segmented markets and in which there is no exogenous supply noise as specified in Theorem 1. ■

Proof of Proposition 1:

In an SINREE model where all the investors have homogenous priors on all the assets, Admati (1985) derives a linear noisy rational expectations equilibrium price vector of the following form:

$$\tilde{P} = A_0 + A_1 \bullet \tilde{F} - A_2 \bullet \tilde{Z},\ A_2 \text{ non-singular}$$

where $\tilde{F}$ is the payoff vector for assets and $\tilde{Z}$ is the per capita supply vector. In Admati's model, investors receive private signals of the type $\tilde{Y}_a = \tilde{F} + \tilde{\epsilon}_a$ and for there to be an equilibrium an infinitely many number of them receive private signals which are of full dimension.

Each investor a, has a utility function over end of period (E.O.P.) wealth given by $U_a = -\exp\left(\frac{\tilde{W}}{\rho_a}\right)$ where ρ_a is the risk-tolerance $\rho_a \in (0, \infty)$.

Admati defines

$$\bar{\rho} = \int_0^1 \rho_a d_a \text{ and } Q = \int_0^1 \rho_a D_a^{-1} d_a \text{ where } S_a = \mathrm{Var}[\tilde{\epsilon}_a] \text{ for every a.}$$

The conjectured (and actual) joint distribution of payoff, supply and private signal vectors are as below:

$$[\tilde{F}, \tilde{Y}_a, \tilde{P}]^T \sim N\left[\begin{bmatrix}\bar{F}\\ \bar{F}\\ A_0+A_1\bar{F}-A_2\bar{N}\end{bmatrix}, \begin{bmatrix} V & V & VA_1^T \\ V & V+S_a & VA_1^T \\ A_1V & A_1V & A_1VA_1^T+A_2UA_2^T\end{bmatrix}\right] \forall a.$$

The a[th] investor's condition demand vector has the following form:

$$D_a(\bullet \mid \tilde{Y}_a, \tilde{P}) = \alpha_{0a}\tilde{Y}_a + \beta_a \bullet \tilde{P}_a = [\mathrm{Var}[\tilde{F} \mid \tilde{Y}_a, \tilde{P}]]^{-1}\,[E[\tilde{F} \mid \tilde{Y}_a, \tilde{P}] - R\tilde{P}]$$

where R is the E.O.P. payoff on the riskfree asset.

In equilibrium we have with the distribution of private signals such that Q is P $\bullet$ D.

$$A_0 = \frac{\bar{\rho}}{R} [\bar{\rho}V^{-1} + \bar{\rho}QU^{-1}Q+Q]^{-1} \bullet [V^{-1}\bar{F}+QU^{-1}\bar{Z}].$$

$$A_1 = \frac{1}{R} [\bar{\rho}V^{-1} + \bar{\rho}QU^{-1}Q+Q]^{-1} \bullet [Q+\bar{\rho}QU^{-1}Q].$$

$$A_2 = \frac{1}{R} [\bar{\rho}V^{-1} = \bar{\rho}QU^{-1}Q+Q]^{-1} \bullet [I+\bar{\rho}QU^{-1}].$$

Therefore, given that V, U and Q are all P $\bullet$ D, A_1 is in fact P $\bullet$ D and more importantly A_2 is non-singular. (Note that $\bar{\rho}V^{-1} + \bar{\rho}QU^{-1} + Q$ is P $\bullet$ D, and $I + \bar{\rho}QU^{-1}$ is non-singular.)

We have for an investor a who gets a full dimensional signal $\tilde{Y}_a = \tilde{F} + \tilde{\epsilon}_a$:

$$\beta_{1a} = \rho_a[A_1^T[A_2UA_2^T]^{-1} \bullet [I - RA_1]] - R \bullet \rho_a[V^{-1} + S_a^{-1}]$$

$$= -R \bullet \rho_a \bullet [[I + \bar{\rho}QU^{-1}]^{-1} \bullet V^{-1} + S_a^{-1}, \text{ and}$$

$$a_{1a} = \rho_a S_a^{-1} \text{ and therefore P} \bullet \text{D}.$$

This implies, since the investor's demand vector has the following form, that:

$D_a(\bullet \mid \tilde{Y}_a, \tilde{P})$ has a non-singular distribution for investor 'a' because $\tilde{F}$, $\tilde{\epsilon}_a$ and $\tilde{N}$ are all independent random variables and α_{1a} is of full rank.

We have for an investor who uses only price information:

$$D_a(\bullet \mid \tilde{P}) = \alpha_{0a} + \beta_a \bullet \tilde{P}.$$

$$\beta_a = -\rho_a R \bullet [I + \tilde{\rho}QU^{-1}]^{-1}V^{-1}, \text{ and therefore non-singular.}$$

This implies that his demand vector has the following form:

$$D_a(\bullet \mid \tilde{P}) = \alpha_{0a} + \beta_a \bullet \tilde{P}.$$

$$= (\alpha_{0a} + \beta_a A_0) + \alpha_{1a} \bullet A_1 F - \beta_a \bullet A_2 \tilde{N}.$$

Again $D_a(\bullet \mid \tilde{P})$ has a non-singular distribution because $\tilde{F}$ and $\tilde{N}$ are independent and $\beta_a \bullet A_2$ is non-singular and of full rank.

Therefore since the demand vectors for investors who get full dimension private signals and those who are privately uninformed are full dimensioned, we see that these investors will almost always hold all the assets in the market. Hence the condition that a positive measure set of investors do not hold the entire of assets, will never arise, i.e., the market will not precipitate segmentation endogenously.

Finally, even if all the investors observe signals of lower dimension, we find that there will not be segmentation *because the conditional variance-covariance matrices of each of the investor's conjectured asset payoff vectors are non-singular* (P • D). In fact the conditional asset payoff covariance matrix, for the investor is non-singular, whether or not he is in receipt of a private signal. This again leads to the conclusion that all investors will be full diversified.

Thus segmentation cannot be precipitated endogenously in equilibrium in SINREE models if the supply noise in the pricing functional is independent of the payoff vector $\bar{F}$ of assets in the economy as required. ■

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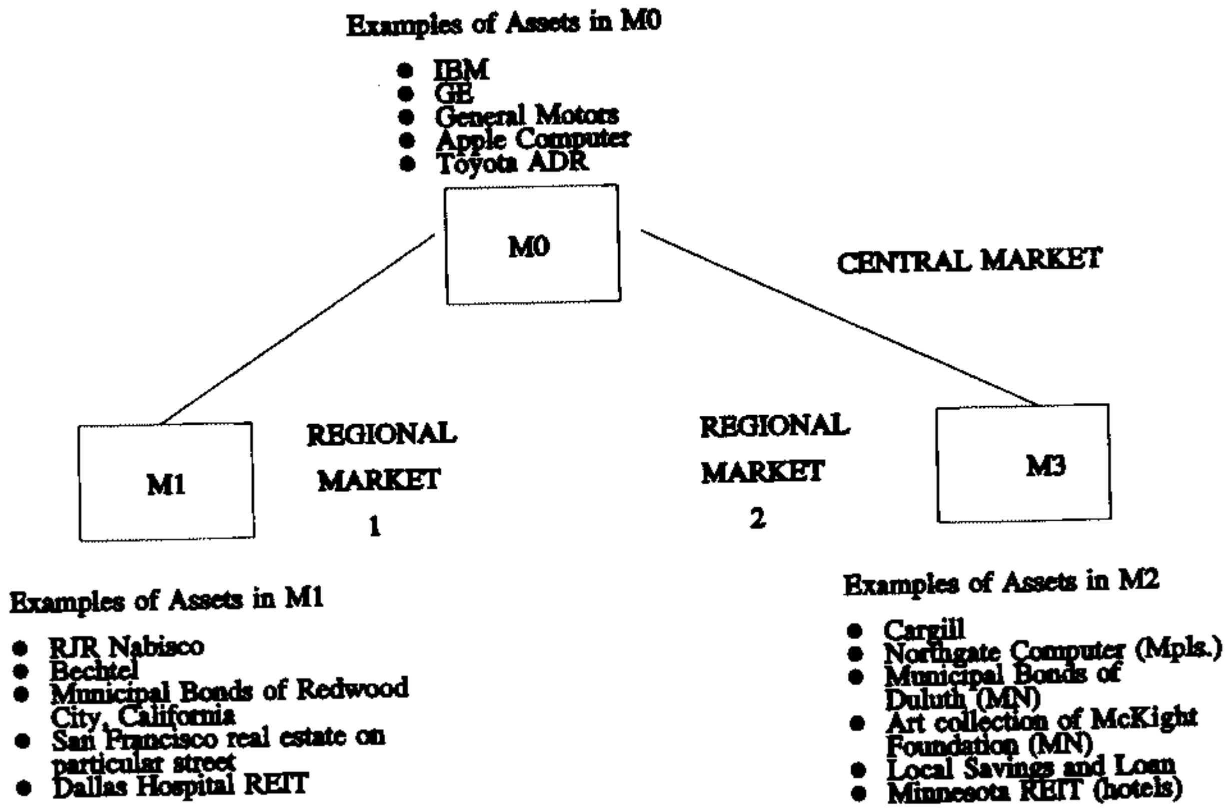

Figure 1
Structure of the Economy