

[EMERGING] ASSET MARKETS: A  
MODEL OF COMOVEMENT

by

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A thesis submitted in partial fulfillment of  
the requirements for the degree of

Master of Arts in Economics

National University of “Kyiv-Mohyla  
Academy” and Economic Education &  
Research Consortium

2003

Approved by \_\_\_\_\_  
Chairperson of Supervisory Committee

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Program Authorized  
to Offer Degree \_\_\_\_\_

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## **ABSTRACT.**

There is an extensive literature looking into the issue of contagious crises, whereby several markets may exhibit patterns of excessive co-movement. Part of the explanation involves fundamental linkages, in particular if markets have significant bilateral trade or some common sources of shocks, such as common destinations of imports or lenders. Other studies trace contagious propagation to some kind of similarities between markets as perceived by the investors. In particular, co-movement may be induced by patterns of holding such as ‘style investing,’ whereby agents may specialize in particular categories of assets and rebalance their portfolios based on the performance of the category at large. Although style investing has been practiced for years, Barberis & Shleifer (2003) is the first theoretical treatment of the subject. In the present paper, I propose a similar theory that suggests how style investing is effectively implied without prior design, and how it creates a channel of excessive comovement in adverse states. In particular, I apply microfoundations such as the duality theory, the modelling of elasticities of substitution, and the analysis of excess demands in a general equilibrium setting. I then test the model on a sample of stocks proxying emerging versus mature markets.

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## ACKNOWLEDGMENTS

The original acknowledgement note went on as follows. To the Lord God for all the incredible blessings I've enjoyed in my life. I also feel indebted to Tatyana I. for much emotive inspiration throughout.

## GLOSSARY

### **COMPLEMENTARITY**

Negative cross-price elasticity of demand for normal goods

### **COMOVEMENT (CONTAGION)**

According to the World Bank Economics Department, three definitions are those most uniformly used:

- *Broad Definition*: C. is cross-country transmission of shocks or the general cross-country spillover effects
- *Restrictive Definition*: C. beyond any fundamental links or common shocks (usually ascribed to herding behavior)
- *Very Restrictive Definition*: C. during “crisis times” in excess of that during “tranquil times”

### **INTRA-INDUSTRY TRADE (‘STYLE INVESTING’)**

“IIT in financial assets” is used in the sense of “intra-type holding patterns,” as opposed to the conventional, inter-type, diversification scheme (rather than competing, the two schemes complement one another within the same portfolio). As an example, a portfolio or direct investor may choose to participate in more than one business projects in the area of, say, consultancy where he perhaps commands an expertise. In the text, IIT refers to the *fact* that nations ‘trade’ in similar assets rather than to the very *process* of agents trading in assets.

### **HERDING**

Decision making pattern, whereby an investor will not make a decision when other investors do not, even though he or she might when others’ decisions are unobserved (unrevealed through their actions)

### **HOME BIAS**

A phenomenon observed in international trade and portfolio investment literature whereby national agents tend to have domestic sources over-represented in their portfolios

### **NETWORK**

Used in the text as any particular financial market established and maintained for trade in assets whose value depends on the (non-decreasing) number of participants (market makers).

### **NETWORK EXTERNALITIES**

Any economies (or diseconomies) of scale (size of the network), spillovers or different agents affecting each other’s decisions (in particular with

respect to their choice of whether to retain, enhance or reverse their holding status). See Herding.

**SUBSTITUTABILITY**

Refers to the phenomenon of positive cross-price elasticity of demand for normal goods

**SUBSTITUTION EFFECT**

Commonly used in the microeconomics literature as a component of decomposition of marginal change in demand as a reaction to relative price changes, in the direction consistent with the assumption of generally positive cross-price elasticity of demand for (normal) goods. (Income effect points in the direction consistent with the assumption of negative own price elasticity for normal goods). When applied to assets or networks used in the sense of withdrawal from some and increasing presence (holdings) in others.



## *Chapter 1*

### INTRODUCTION

A series of financial crises that occurred over the past decade have had major implications for national macroeconomic policies and global financial integration alike. One important phenomenon of the more recent times has been the apparently increased interdependence among international capital markets and financial systems, whereby a significant interlinkage has been noted even among seemingly unrelated markets. A local financial turmoil is therefore believed to have the potential to get transmitted globally, within a short period of time. Intuitively, it should be of no surprise that increased financial openness and interdependence creates a leverage vehicle of one kind or another which would act to aggravate the vulnerability of national systems to exogenous (including transmitted) shocks. Gradual propagation of turmoil seems natural when trade channels are plugged into the analysis. Indeed, countries connected by bilateral trade or common trading partners may propagate supply-type shocks which affect relative prices and, if large enough, cause significant substitution effect (imports re-orientation). However, theory has relatively little to say about cases in which the countries have very little if any bilateral trade or the shocks to relative prices are minor. This is the case in the “South-South” type trade (taking place between emerging markets), which is relatively less important than “South-North” type, and yet these less developed markets are in fact the fastest to get hooked by shocks coming from other regions, distant geographically and economically. Moreover, it would indeed be nice to have an analytical framework capable of accounting for large-scale volatility as propagated by even minor changes in relevant fundamentals.

The ability to fully utilize the benefits of international financial markets therefore hinges critically on our understanding of these events. While an extensive literature has been developed that addresses many crucial issues, some questions of paramount importance remain open. In this study, we focus on a mechanism of downside comovement across markets and groups of markets. We approach this issue by attempting to apply some of the results and notions of the new trade theory that we find relevant for the analysis of international trade in assets as well as commodities. We describe how intra-industry trade in financial assets can be employed to studies of contagion<sup>1</sup>. The underlying idea is to view an investor holding financial assets in multiple homogeneous markets as the primary magnifying leverage which determines massive simultaneous substitution effect away from many associated markets, thus accounting for contagious link between them. We then elaborate a generalization of this ‘special theory’ to explain just how comovement might occur between markets exhibiting *any* fundamental relationships (elasticity of substitution) other than perfect substitutability.

One common weakness of the previous studies is that they have lacked a common and consistent theoretic framework based on a clear conceptualization. Empirical studies will not likely come of high analytic value until after an adequate theoretical interpretation has been introduced, delineating the criteria and identifying the objectives of a test. The present work is aimed at bridging this gap and providing a uniform framework that captures most stylized facts and moreover makes perfectly compatible the results from previous studies. This generalization is made possible if we are willing to trade off some sophistication of the past individual formal models and integrate them by a core principle they have overlooked to this day.

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<sup>1</sup> Please refer to our definition in the Glossary.

Some recent studies (notably Barberis and Shleifer, 2003) attempted a similar approach, in that they focus on patterns of ‘style investing,’ i.e. large institutional investors specializing within particular types of assets. This analysis, however, clearly stems from very different prior theory and does not explicitly integrate the microeconomic tools such as elasticities of substitution. My framework traces back to a parent theory looking into intra-industry trade in information inputs, i.e. *implicit* trade in information a-la Heckscher-Ohlin-Samuelson, via similar products for which [similar] information is used as an input. (Please refer to Appendix for a detailed exposition). Moreover, our model suggests and builds on a more complete notion or structure of value, thus generating a number of additional important implications as to the relevance of diversification, CAPM strong form of efficiency, and behavioral facets of investor choice. The key add-on is the strategic or interactive component of value which I found can most productively be proxied by the network notion.

It is important to qualify our intended scope from the outset. A huge literature has evolved recently on issues such as crises. We do not study *crises* as to what possibly causes them and when. Nor do we restrict our analysis to the *currency* crises convention. Instead, ours is a theory applying to pretty much *all* asset types (much in line with Krugman’s (2001) reflections on the ‘next generation’ of crises), particularly in so much as they have a significant interactive value component. In a sense, then, this is a ‘pure ordinality’ theory, in that we learn about the *relationships* between properties without necessarily knowing much about the *properties* per se. Finally, this proves to be a surprisingly minimalist and elegant framework in that it maps a small set of weakest possible assumption into a large set of implications spanning the observed stylized facts.

## *Chapter 2*

### SURVEY OF LITERATURE

Traditional, or “first-generation,” models of currency and financial markets crises stress weak or unsustainable macroeconomic policies or fundamental imbalances as one explanation of currency crises a la South-East Asia. Krugman (1979) provides a simple yet insightful framework predicting the probability of initial and successive speculative attacks on the domestic currency subject to the central bank’s commitment to maintain threshold levels of official reserves (against their level of credibility as backed up by the “fundamentals.”)

More recent and more comprehensive models have had better success in explaining the severity of financial crises by incorporating into analysis the interaction of policies and institutions (in particular, volatile capital markets). The models of so-called “self-fulfilling prophecies” hold it that a sudden change in investors’ expectations (say, with respect to a harder budget constraint in the near future due to excessive current government spending) may force a policy response which will lead to exactly the consequence predicted, which further undermines investors’ confidence. (See Pesenti and Tille[2000] for a recent survey of these two early generations of models). More recently, two additional factors have been integrated into modeling, which identify inadequate supervision of financial system and the mechanism of rapid transmission of crisis through structural links and spillovers. The present study focuses on the latter aspect of the so-called financial contagion among many markets globally. The latter is defined in the literature as increased probability of assets prices co-movement or of simultaneous speculative attack on currencies (Claessens [1999]). Alternatively, it can be referred to as simply a reduction by an investor of investment in many risky assets when an adverse

shock impacts one of them (see Schinasi and Smith [2000] who approach contagion from the textbook portfolio theory perspective). The World Bank economics department staff have developed several definitions each being a narrow version of the previous one (please refer to the Glossary). In our analysis, we opted to stick with the more restrictive definition, as it exactly captures the scope of our interest. We will therefore define the “pure” contagion as cross-market linkage beyond the fundamentals or common shocks during crisis times in excess of those during “tranquil” times. Although no common decision has been developed or agreed upon in the literature as to whether it is the existing transmission channels (yet possibly changed) or some new ones that account for the effects studied, we will try to develop a parsimonious conceptual and analytic framework aimed at providing a better insight into how the “embedded” mechanisms could best be utilized to study and possibly anticipate similar phenomena occurring. This would also address the challenges facing the existing literature on the subject. The phenomena following the emerging markets’ birth were relatively new, and the conceptual and modeling apparatus could not reasonably be expected to successfully address issues before they evolved. Far from proactive, its development has lagged even in the hindsight. On the one hand, this may largely be due to the tendency to separate the global-scale issues (ascribing macroeconomic to them) from those presumably arising even within small networks. One other trend shining through theoretic literature on crises is its largely descriptive (mainly with respect to symptoms) nature with potentially compatible models failing to trace through common origins. In particular, “symptomatic” description naturally fails to distinguish between outcomes common to both poor fundamentals or market failures which are region-specific and those stemming from the use of leverage which is an inherent characteristic of (overly) efficient markets.<sup>2</sup> In our analysis, we hope to avoid such limitations yet probably at the

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<sup>2</sup> That the higher potential benefits are associated with higher risk in bad states of nature should not be surprising; what is astonishing is how it can be confused with inefficiency of any sort.

cost of broadening the proposed analytic scope of the seemingly narrow subject. We believe, however, that it represents the rare field of issues whose importance shows promise for growth, if only due to lending itself well with other fields routinely viewed as standalones.

### ***Herding***

Policymakers and supranational bodies alike have often voiced the sentiment that herding behavior of financial market participants has largely aggravated the fragility of international financial system. In their paper, Bikhchandani and Sharma (2000) provide a survey of the literature on herding and make an attempt at clarifying possible causes as well as the actual role of ‘rational’ herd behavior in financial markets. In particular, they identify several types of herding, namely that *information-*, *reputation-* and *compensation-based*.

Herding can be defined as a *decision making pattern, whereby an investor will not make a decision when other investors do not, even though he or she might when others’ decisions are unobserved (unrevealed through their actions)*.

Alternatively, an investor is said to herd whenever additional knowledge about others’ action (without necessarily additional information) can alter her decision. One reason she might act so is a consequence of asymmetric information (which “information-based” herding seems much along the lines of an insider-outsider perspective, whereby a foreigner as an “outsider” party to IIT heeds the actions of the national as a presumably better-informed “insider,” even though risk and otherwise own preferences might actually differ). Some other explanations of ‘rational’ herding include “compensation-” or “reputation-based” herding, according to which, say, a fund manager is rewarded for mimicking the average portfolio structure, or is otherwise forced to keep a safe portfolio (which translates into fairly consistent market whims when the share of institutional holding is large, more so in international IIT). However, there may well exist the so-called “*spurious herding*,” whereby different investors may display similar preferences and information sets, in

which case they cannot be thought of as merely herding. To conclude this part of the survey, one other herding-related notion could come in handy, what I dub “*strategic rationality*.” By this I mean a situation when an investor must follow the herd to maximize his utility based on conjectured direction of substitution effect *en masse*, even though his own (independent) valuation of the assets fundamentals might be very different. In addition, this approach fully agrees with the taxonomy adopted in a model of network externalities that we will focus on shortly. Finally, this notion may help in explaining why and when choice (which has been treated as revealed preferences) may deviate from preferences.

Choe, Kho, Stulz (1998) study herding effects on the part of foreign investors in the Korean stock market in 1997. They find strong positive evidence of herding during the pre-crisis period (last quarter of 1997), which is in excess of 20% for large stocks as compared with the low 5% level for US mutual funds. However, the evidence of positive feedback trading weakens in subsequent periods and eventually disappears over a longer horizon (except for the largest stocks). One reason that many studies on contagious linkages and crisis were conducted for Korea is data availability. Daily data on trades allowed the authors to subdivide the agents into three groups: individual Korean investors, institutional Korean investors and foreigners. They find no evidence that foreign traders had significantly disturbed the performance of Korean stock market over the one-year sample period. The expectations of foreigners’ role (and internal contagion for that matter) are routinely grounded in the assumption of investors being *positive feedback traders*. The latter implies that the average investor follows the market in selling when it falls and buying when it gains momentum.

Compared with some opposite patterns of behavior (as attributed to, say, the so-called ‘*contrarians*’ who go opposite to herd), the assumption of herding does not seem unreasonable and is in fact observed. However, it is useful to

distinguish between positive feedback grounded in rational behavior versus that underlain by behavioral biases. Some models maintain that positive feedback trade leads to overheating bubbles when stock prices show abnormal returns compared with fundamentals, and to market crashes when returns underperform fundamentals. In Brannon and Cao (1997) emphasizing information asymmetries, foreign agents learn about quality of fundamentals from price levels and first order conditions and from behavior of nationals, so they buy or sell based on information available to the latter. This is, again, consistent with the “insider-outsider” framework we have referred to previously, which effectively eliminates asymmetry in information possessed by national versus foreign agents, inasmuch as *insider trading* (hidden activities based on private information) is controlled for. In measuring the effect of positive feedback trading or herding, however, one must distinguish between the threat of equity capital versus debt capital flights during contagion, which have very different explanations. While equity prices can and do adjust following news (so that equity need not suffer net substitution away), debt will have to be returned, or rollover may be far more costly or even impossible following unfavorable news (rollover terms will exhibit stickiness and not adjust to more information for a long period of time).

Thus, despite the long-popular belief that foreign investors are a major factor contributing to volatility in the local financial markets, it has been shown by Cho et al. (1998) that in Korea, national investors had a far greater impact on returns. In a sense, it is consistent with their estimates of foreign ownership, which on average constitutes 6.5% and has shown to grow with the stock size. Therefore, one need take these data into account as well when analyzing the role of external investors. In addition, it seems possible to somehow utilize relative sizes (or weights as different stocks’ relative market capitalizations) as proxy for foreign ownership, which may be unobservable or underreported.

Moreover, such analyses are capable of generating meaningful results chiefly for periods in which markets are active and evidently not for post-crisis periods. Equivalently, they may be less applicable for the so-called *frontier markets*, markets in transition displaying a very low liquidity or depth.

One common deficiency to the many techniques of assessing herding is the tradeoff between nonexistence of requisite data for the more advanced ones versus the rather general nature of results from the more ‘naive’ measures that oftentimes are undistinguishable from mere detecting of common trading direction among investors. Therefore, we feel that our focus on IIT will prove a significant improvement over the conventional herding studies. For one thing, we are talking about a possibility of one agent holding in many similar markets, which preserves all the symmetry of incentives for IIT (whereby a same investor is willing to hold similar domestic and foreign securities embodying a complete set of investment opportunities). The larger the holding network of this investor, the larger the potential scale of simultaneous substitution effect. The latter in fact amounts to many “identical investors” each holding in these similar markets (of course, identical investors will exhibit perfect correlation of substitution directions and possibly velocities.) Furthermore, we do distinguish between IIT and pseudo-activity during the contagion upsurge.

### ***Style Investing Literature***

Classification has long been observed to be one of the more efficient heuristic mechanisms of reasoning (Rosch and Lloyd 1978, Wilson and Keil 1999). The grouping of objects into natural categories or classes pertains, on the one hand, to spotting similarities between them (thus allowing a richer insight into the structure of the problem-solving setting). On the other, it suggests some practical hints as to how the neoclassical notion of rationality can be made more operational and moreover consistent with the inherently limited

deliberating ability, by allowing for ways and means of augmenting the reasoning faculty and facilitating decision making.

That, for the most part, applies to complex choices involving more than two alternatives, or where the choice cannot be reduced to pairwise comparison. For that matter, one should note well that comparison and choice grows all the more complex, when nonlinear relationships of imperfect substitutability are involved. In fact, much of the emphasis in the present paper is placed on this dimension of relationships between objects, more than to their proper qualities as such. In particular, I will seek to come up with a coherent framework that could take full account of structural linkages within an arbitrary set or sample of objects, whether it be commodities or financial assets (markets).

In financial markets, classification of assets into categories has played a vital part too (Bernstein 1995, Swensen 2000). On the one hand, given the overwhelming variety and heterogeneity of qualities (horizontal differentiation is implied here), grouping assets into broad classes—such as large-capitalization versus small-cap stocks, AAA rated corporate debentures, or for that matter emerging markets funds—could be an instrumental first iteration. Categorizing could then loop on in successive iterations, by zooming in on the finer aspects possibly underpinning the conjectured relationships between assets: growth stocks within large caps, value stocks within small caps, tech securities within the S&P 500 or Hang Seng indices, etc.

In a very definite sense, the appearance of a new style could be studied as a facet of financial innovation. On second thought, since unique categories allowing for no overlaps or alternate grouping is a rare if plausible possibility, shaping objects (assets in particular) into classes is largely a matter of

idiosyncratic hunch<sup>3</sup>. Having said that, I will show how this mechanism can be modeled formally by deploying tools such as the elasticity of substitution utility functions. For the most part, my analysis will be centered around the *constant* elasticity of substitution (CES), which proves sufficient for capturing key stylized facts and moreover can be rationalized conceptually. To my knowledge, this is the first attempt at capturing the relationships between assets by invoking the ES modeling for the purpose of studying comovement. The more popular approach has been to employ covariances and correlation coefficients, with an eye toward spotting some regular (symmetric across states) or excessive patterns (e.g. showing an increased correlation in adverse states). I will demonstrate, however, that the conventional covariances overlook some crucial insights pertaining to the analysis of large groups of objects. For one thing, covariances routinely apply to an  $n=2$  case only. For another, there is little prior conceptual underpinning behind expecting any two objects to be correlated probabilistically. In this light, some of the now-standard results such as the celebrated Capital Asset Pricing Model (CAPM) and its varieties could be questioned on grounds of conceptual depth, over and above the empirical criticisms it has been subjected over the past few decades. These issues will be treated at length in the section featuring implications.

Literature suggests several reasons why individual and institutional investors alike might pursue style investing<sup>4</sup>. Mullainathan (2000) demonstrates how

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<sup>3</sup> On reflection, it would appear that the very notion of utility function suggests that preferences and relationships between inputs are largely subjective. Granted, subjective relationships between values might well pose more of a challenge than do subjective probabilities to rationality assertions and tests.

<sup>4</sup> Two alternate denotations can be used when referring to “style investors.” First, these could be pension plan sponsors, or *principal* type investors, allocating their funds at a style level. Alternatively, we could keep in mind the money managers or indeed agent type players acting on behalf of actual investors. Incentives could vary dramatically across these types of players. In particular, the moral hazard implied in the effectively monitored agency scheme

behavioral modeling could account for the bulk of systematic errors on the one hand, and rationalize the use of heuristics like categorizing, on the other. Moreover, as Sharpe (1992) shows, the creation of classes assists the investors in monitoring the performance of fund managers. One other reason style is popular pertains to the finding that, groups of securities with common characteristics have frequently exhibited superior performance relative to naïve index holding (see, e.g. Banz 1979 for an early detection of the small-cap effect<sup>5</sup>, or to Barberis & Shleifer 2003 who find that style funds have consistently outperformed index). Finally, styling could simplify diversification, in that the investor is in a better position to identify risks specific to a style, or for that matter to any category of investments at large. Shocks and uncertainties could then be studied in a rather structured and detailed fashion, thus making possible the construction of accurate APT-type models (arbitrage pricing theory) that incorporate the betas as per each relevant direction of covariance<sup>6</sup>.

Although style investing has been around as an established practice for about two decades now, the Barberis & Shleifer (2003) study claims to be the first theoretical treatment and a survey of the literature that could be of relevance to comovement issues. Since my framework evolved independently and

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would seem a natural rationale behind stories such as herding or indeed margin call-based rebalancing. Studying the behavior of principals could yield some more interesting findings, and this will be the focus of our modelling.

<sup>5</sup> Yet, the Fama & French (1995) critique of CAPM is far and away the more celebrated study highlighting such results. On second thought, as Barberis & Shleifer (2003) observe, styles tend to emerge and fade, as their excessive performance dies off. This is ‘consistent’ with the scepticism about the results suggesting superior performance of select styles or criteria, such as ‘size’ or book-to-market value, or for that matter any other category, which effects do not prove permanent.

<sup>6</sup> The classic CAPM stresses one such item, or for that matter aggregates all individual sources into a measure representative of swings in the market or the economy at large.

concurrently with their model, I will refer to it for comparative purposes (in particular to suggest what my work contributes above and beyond their findings).

To conclude, this literature survey does not claim to be exhaustive. In particular, the present study does not aim at integrating just about every tool or story featured in the crisis literature. I seek to develop a minimalist framework sufficient to capture the key stylized facts on excessive comovement that occurs in adverse states. Endogenizing these adverse states or indeed studying the driving forces behind the individual markets own behavior is beyond the intended scope. In so far as my emphasis is largely structural rather than dynamic, I manage to come up with a story that sheds light on the relationships within samples of markets or assets, without necessarily understanding their individual behaviors. In so doing, I build on the standard microfoundations, in particular the duality theory, the analysis of excess demands in general equilibrium, and the elasticities of substitution.

### ***Stylized Facts***

The following are some key stylized facts about contagion that our theoretical framework will address:

- (1) Contagion pertains to co-movement of assets/networks performances (traced largely to the joint dynamics of demand), strengthening on the downside
- (2) Contagion is not the same as crisis per se: contagion has to do with the relationship between values, while crisis is related to some factors driving the value's own dynamics
- (3) Contagion need not necessarily imply crisis (Kaminski), although it has mostly been detected on the downside

(4) Large players such as mutual and hedge funds are reported to have played a major part in recent crises/contagious episodes, in particular when it comes to style investing (Shleifer 2003)

(5) Herding has been the single most important driving force of contagion

(6) Margin calls have played an important role in withdrawal of funds by institutional investors.

### ***Scope of the Study***<sup>7</sup>

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<sup>7</sup> The present co-movement theme traces its origin all the way back to my earlier conjecture looking into intra-industry trade in information. Information is viewed as an *input* underlying the production of some ultimate value—which could indeed span a variety of information-intensive products. Thus, the original theory emerged as a largely abstract hypothesis building on modern trade theory. There are two important results in trade theory that I looked at. First, according to the celebrated Heckscher-Ohlin finding, trade could be explained in terms of relative resource endowments or scarcities, which distribution could be effectively smoothed via spatial trade. Economies will specialize in products that are intensive in inputs which are in relative abundance, and will import the rest of products—ones whose underlying inputs are relatively scarce. Moreover, even though it might not be possible to literally eliminate or smoothen *resource* scarcity across economies (resources might easily be nontradable—like climate, territory, etc.), still trade in *products* will increase the supply of each and every product in each country. As the Heckscher-Ohlin-Samuelson theorem (HOS) predicts, relative prices will converge materially as a result of trade. That pertains to product prices. However, since the initial scarcity of resources is no longer as relevant, *input* prices will converge too. The HOS result thus maintains trade to be a vehicle of effective convergence across the endowments or opportunity sets.

Moreover, the ‘new’ trade literature pays a close attention to *intra*-industry trade, i.e. trade in similar products.

I applied these results to information as an input. All players have some information, and together they hold all the information available. Similar ‘vintages’ of information might be used to produce similar products. Implications of trade in these similar products (implied intra-industry trade in the underlying information) could then be studied.

I was then challenged to come up with an example of a specific industry where information could be used as an input. A natural candidate was markets for financial assets. Moreover, since I was interested in *intra*-industry trade, it was natural to consider some pattern of holding many

I look at a [somewhat latent] vehicle of contagious co-movement, i.e. pure co-movement between assets/markets as well as groups of markets (or “styles”), in excess of their normal or fundamental correlation, if any. Explaining the nature and origin of *crisis* per se extends beyond the intended scope, and has been addressed extensively in the literature. Nor do I look at *normal* correlations or covariances, i.e. those likely to be symmetric across states of nature. The Barberis & Shleifer (forthcoming 2003) paper does a fair job along these lines. Finally, the crisis literature normally looks at currency crises. My framework applies to just about any asset types, currencies included, that have a significant interactive or network component to their value. This perspective is consistent with Krugman (2001) suggesting that new models of crises should focus on assets at large, while currencies might not play nearly as important a part as conventionally maintained.

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similar assets—which I initially dubbed ‘intra-type investing’ and later learned to be referred to as ‘style investing’ in the literature. Studying the implications of holding a full-blown portfolio capturing intra-style holding (over and above the conventional diversification) naturally led me to focus on contagion, or comovement across markets during episodes of crisis. To qualify my scope, it is important to stress that I did not intend to explain crisis per se—its stems, causes, or timing. What I did look into was contagion, or a strong vehicle of excess comovement, given that we have crisis. I therefore study contagion as a variable conditioned on crisis, without endogenizing the latter condition.

THEORY SECTION

***Comovement***

The literature suggests several alternative stories or mechanisms of comovement. Some of them build on rather strong assumptions, like herding agents or fundamental linkages (e.g. trade) between the affected markets. However, there is very little trade “South-South” (i.e. between the LDCs or emerging markets), and still they are the first to get involved in a bandwagon. As far as herding is concerned, even a 10-player setting of *interactive* optimization suggests an unwieldy complexity, which only explodes for  $n > 10$  case<sup>8</sup>. Alternatively, *large* players like funds might herd, in so far as their managers face the moral hazard of finding themselves unemployed if they underperform the average or the market—so that mimicking might pay off. However, moral hazard applies to *agent* type large players only, while it would be interesting to draw more general implications (for *principal* type large investors). Otherwise, it is entirely reasonable that players each having incomplete information, might heed the perceived ‘insiders.’ But, it is exactly when we have the specialty type players (style investors) that such herding becomes irrelevant: supposedly, there are the insiders within their styles—whence, among other things, our focus on style investing. Finally, the literature conjectures comovement might be due to exposure to some common sources of shock. Again, such fundamental sources might or might not be there—my model does not hinge on an assumption like that. In a sense, models like CAPM do feature a ‘common source of shock’ (swings in the economy at large, as denoted by the market premium  $R_m - R_f$ ) and the varying sensitivities thereto (the individual betas). So, CAPM might do the job? But the most plausible

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<sup>8</sup> At any rate, it’s not been done in the quantum physics to date: there are no numerical, let alone analytical, solutions modeling the behaviors of better than 10 interacting particles.

candidate for ‘common source of shock’ is *information/news* applying to similar assets or markets—or indeed intra-industry information as an input!

### ***Perspective***

In my paper, I come up with a model that incorporates the notion of implied trade in information on the one hand, and the role of style investing on the other, in an attempt at capturing just about every stylized fact on contagion all within a minimalist yet powerful framework. Shleifer and Barberis (forthcoming 2003) is the more recent known theoretical treatment of the subject, even though style investing has been around as an established practice for a few decades now. However, I manage to avoid some of the overly strong assumptions they employ, such as discrete (or perfectly defined) styles. In fact, I show how style investing (intra-type holding, intra-industry trade) is *effectively implied* on a macro level, without there being any conscious or prior design. Put differently, investors need not knowingly engage in any style investing, for there to emerge the same consequences.

Apparently, then, my framework stems from an altogether distinct and different origin than Shleifer & Barberis (2003). For one thing, they do not seek to *rationalize* style investing per se (other than by showing it might prove profitable ex post), while I treat it at length from the standpoint of the intra-industry trade notion. As a consequence, I deploy a microeconomic analysis building on *elasticities of substitution* (constant ES, for the most part), which enables me to arrive at the results that cannot be captured by merely assuming perfectly defined styles. For one, as S&B themselves recognize, perfectly defined styles do not exist, because there will inevitably be some rich combinatorics of overlapping styles. By deploying elasticities of substitution, I arrive at a latent mechanism that holds for assets that may be related as closer substitutes, imperfect substitutes, or even neutrals (independent values); that is, my setting allows for a whole continuum of ‘styleness’—from distinct or unique styles to arbitrarily fuzzy or overlapping ones.

### ***Investors are Rational***

I impose no exotic behaviorist assumptions on rationality. Suppose individuals are rational, in that they mind their best self-interests and commit no systematic optimization errors. (Imperfect information per se being a standalone dimension over and above bounded rationality.) However, rationality does not amount to heeding/watching the ‘fundamentals’ *only*. Agents do observe fundamentals; suppose they in fact have perfect information on fundamentals, which arrives continually and is the same for the investors and the researcher that studies their behavior (so that there are no unobservables that serves as basis for some criticism of CAPM). However, if these rational players anticipate that the demand for the asset will deteriorate (because other players will likely be withdrawing), they will not hesitate to abandon this (otherwise fundamentally sound) asset. They will do so in an effort to minimize losses, which is a more binding direction of optimization for risk-averse individuals. (As the curvature of a nonlinear utility function suggests). Therefore, the players are rational so long as they maximize utility, rather than merely hold based on fundamentals only. In so far as there is a pure *interactive* component to value formation (i.e. in excess of information or news shaping the *fundamental* part of the value), externality and ‘strategic rationality’ cannot be ignored.

Now, moving with the trend is normally ascribed to *positive* feedback traders; negative feedback traders will be expected never to fail to tap into undervaluation. However, one has to distinguish between *minor* or short-run oscillations versus a major crash. Likewise, minor inflation or NAIRU unemployment rate cannot possibly suggest the same implications as *hyperinflation* or *mass* unemployment. A major crash could change the incentives and behavior (relative to routine undervaluation), in that the agents might perceive some kind of an *end* game horizon. For repeated games, it is reasonable that the final game involves very different strategies than the interior games did. A final game might pertain to a scenario whereby the network is perceived prone to decay in major ways. There is no way to cash in

on undervaluation, because the price might take just too long to recover (if ever). The market need not become so thin as to vanish for good, though; yet, the recovery horizon could be just too long compared to the investor's profile or liquidity preference (which defines how long-term or short-term a player she is). Therefore, investors will likely keep trading so long as an end game horizon (which is moving rather than fixed) is perceived to be long enough or uncertain. In a sense, what information or news players could be timing for is that relevant to end game horizon. Any major decisions on the part of larger players could be read by the rest as revealing some kind of 'insider' information as to a final game horizon.

### ***Value Structure***

I chose to model interactive or strategic value/price formation by deploying the notion of network. Dowd & Greenaway (1993) suggest an illuminating perspective on currency areas and dynamics thereof, by treating currencies as networks. Currency value will be higher, the larger the network; however, even if network decays, there is still some fundamental component left over not accounted for by interaction or externality:

$$U = (a + b \log N) \int_0^T \exp\{-r(t - T)\} dt = (a + bn)/r.$$

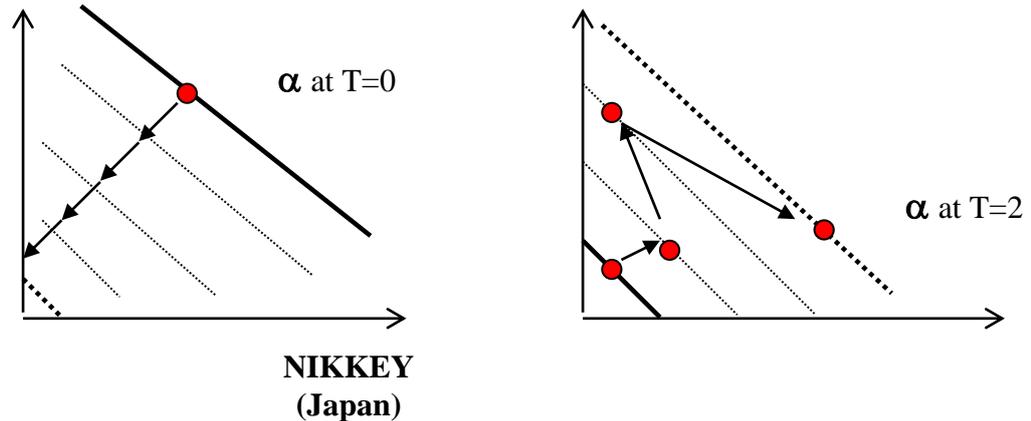
Our value function  $V = a_i + b_i \log(N_i + 1)$  features the fundamental value component (CAPM?) and the pure network component, respectively. I will get back to it after I outline the essential intuition behind our diagrammatic analysis building on elasticities of substitution.

### ***Contagion: Downside Comovement.***

On the one hand, contagious comovement would supposedly be due to some kind of complementarity—albeit spurious, but anyway occurring on the downside. For simplicity, consider a two-asset case first. Suppose they constitute a distinct style, or are *perfect* substitutes. The isoquant would in this

case be linear, and its curvature will increase for any departure from perfect substitutability.

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**Figure 1.a** Lower semi-complementarity in adverse states. **Figure 1.b** Mixed strategy equilibrium is not restored on recovery (no complementarity on the upside).

Reasonably, the lower threshold for assets is full neutrality: I do not perceive literal complementarity as very suggestive, necessary, or ‘interesting’ for the asset case, the way it applies to commodities. Or, if that were the case, the story could be over: We have complementarity, we have comovement.

Consider, for simplicity, a two-asset or two-market case (see Figure 8a above). For perfect complements, the budget line that kisses the isoquant everywhere could suggest multiple equilibria (indeed, an infinity of choices), unless the slopes are so different as to assure unique corner solutions. But, if *both* assets (or markets) are believed to be bound for mass withdrawal (as a style), *substitution* effect between them will be irrelevant and in fact will be nil. This is consistent with the convention in Shleifer & Barberis (2003) who suggest equal weights within styles. Admittedly, they maintain it for any state of nature, whereas I argue it will hold in crisis (end game) or under

deterioration only. Indeed, on the upside (normal times when news improve for a style), investors might not only increase their exposure to both assets, but do so unequally: we simply do not know how the agent will choose on the linear isoquant, and there is no reason to anticipate any particular choices as more likely than other mixes. Under a *minor* undervaluation or otherwise deterioration of price, the budget line does not reduce *all the way down to zero or minimum*, so substitution effect might be of some relevance. Not so in crisis (end game), though, when the budget line rapidly converges to zero level: we are going to abandon the markets (the style) anyway, so interim substitution effect is irrelevant and is nil.

Such asymmetry of substitution effect between the normal upside and end game downside suggests that in the latter case (and only then), assets will behave as perfect complements (commove in terms of network size and prices). Their fundamental relationship (substitutability) is irrelevant: affectively they behave as complements. To crystallize this intuition:

- (1) Irrelevance of substitution effect amounts to ‘fixed proportions.’
- (2) Fixed proportions (Leontief function) suffices for perfect complementarity, which in turn captures [weak] complementarity.
- (3) Irrelevance of substitution effect is assured within a style (i.e. for perfect substitutes).
- (4) Therefore, perfect substitutability amounts to a potential for comovement, which materializes in the end game (in crisis, whatever its causes), and on the downside (significant undervaluation, or growing book-to-market ratio, or huge deterioration of value) being close to end game setting asymptotically.

To draw a bottom line, style investing does account for much of contagion. However, unlike S&B, my setting implies there is significant excess comovement on the downside over and above whatever symmetric cross-correlation they maintain. Excessive or pure comovement during crisis is an observed phenomenon, and is the focus of my study. Granted, as will be shown,

mine is a latent mechanism building on effective relationships ex post, whereas theirs is a vehicle building on straightforward prior design. Importantly, I stress the relevant *relationships* between properties, without necessarily knowing these properties per se. In particular, my modelling enables me to study the effective relationships between markets (elasticities of substitution) without knowing much about their own behaviors or otherwise cardinal parameters that might be accountable for crises. My emphasis on *ordinal* properties while assuming away *cardinality*, proves quite in line with the modern microeconomics legacy.

### ***Formalizing the Intuition: Duality Theory***

In the previous section, I featured the basic intuition behind the relationships between assets (see Figure 8a). In fact, this same result could be shown formally, by employing the modern *duality theory* [e.g. Diewert 1982]. Microeconomic theory maintains a crucial duality between maximizing the utility or production function (direct or money-metric or its analogues like our value function) and minimizing the cost or expenditure function. In particular, it can be shown that the curvatures of their indifference curves are inversely related. Put differently, there is an inverse relationship between their elasticities of substitution. In particular, if the value function's ES (defined with respect to quantities) is closer to substitutability, then the expenditure or loss function's ES (defined with respect to prices or the loss Lagrange multipliers) will be closer to complementarity. As far as the dual elasticity of substitution is

concerned, it can be shown to be  $r = \frac{\rho}{\rho - 1}$ , if the primal ES was  $\rho$ :

**Primal:**  $\max V \equiv b_i N_i^\rho + b_j N_j^\rho$

s.t.  $p_i N_i + p_2 N_2 \leq e$

**Dual:**  $\min E \equiv A(\delta p_i^r + (1 - \delta) p_j^r)$

s.t.  $v \geq \bar{v}$

Now, if we define the value function in terms of value improvement and the loss function in terms of value deterioration, then perfect substitutability on the upside (value isoquants) implies perfect complementarity on the downside (loss isoquants). But that's exactly the point we maintained as a case for our asymmetry, or an irrelevance of substitution effect in crisis or on the downside! So long as the assets are perfect substitutes, they will remain that if their values are expected to improve, yet will act like perfect complements if their value is expected to deteriorate significantly.

By employing this duality-theoretic result, our intuition on the end game horizon becomes but supportive. We have suggested that crisis differs dramatically from routine, minor drops in value: reverting to mean which shapes the negative feedback trading incentives, does not hold near end game. However, the central result on asymmetry does not hinge upon this notion of end game horizon, anyway.

Technically, duality is perfectly defined for the less complex constraint sets. Remarkably, we have a single constraint (budget constraint). Incorporating another constraint, say, for an end game horizon criterion, might compromise duality to an extent. Which is one other reason to maintain the final game criterion as but a supportive pillar: there is a design to choosing not to formalize it.

There is no way duality (and/or the asymmetry) could possibly be obtained or even conjectured without explicitly employing a formal analysis of elasticities of substitution. No wonder, the S&B paper fails to build on these tools, as it fails to incorporate the elasticities-based modeling and instead defines styles as some kind of 'natural' categories. They implicitly maintain *perfect* substitutability within styles and perfect neutrality across styles, which strong assumption does not stand up to reality checks and, more importantly, overlooks some central results. Moreover, it is exactly that intra-industry trade intuition that motivated the use of elasticities of substitution in conceptualizing the story and in formal modeling. Our manner of motivating style investment to

be viewed at the crossroad of two fields could suggest some overlaps between these, as well as yield some implications relevant and applicable to both. It was made possible by looking at them through the underlying microeconomics common to both. To draw a bottom line, the Shleifer & Barberis study spots normal or symmetric correlations, without giving any account of contagious comovement in excess of these.

### ***From Perfect Substitutes to a General Case***

However, engaging in style investing is largely the prerogative of *large* investors like funds. It would be interesting to know just how the masses of *small* individual players (not herding via membership of the same fund) could account for comovement. Moreover, as I pointed out elsewhere, *perfect* substitutability (discrete styles) is a fiction anyway. (Which would call for some kind of behavioural assumptions of bounded rationality to make a model like S&B quite stand up). I now show that assets/markets could be imperfect substitutes or even independents (neutrals), and still be prone to contagious comovement. The key here is the value structure, or the importance of the interactive component (in excess of bare-bones fundamental value). I will demonstrate how perfect substitutability (ideal style) results effectively from a value structure, without there being any *a priori* or actual style designs at work.

### ***Value Structure***

The individual value function as per each asset or network is,  $V = a_i + b_i \log(N_i + 1)$ . Assuming additive separability, the total value function is,  $V^j = \sum_i^m V_i^j = \sum_i^m a_i + \sum_i^m b_i \log N_i$ . Indeed, this amounts to a CES function, with the [constant] elasticity of substitution equal to near zero (logs implying the neutrality case). I now deploy a modelling tool as in Hansen (1985), who suggested that a *representative* agent level accounts for higher elasticity of substitution (or sharp swings in labor supply not attributable to

tantamount shocks) that cannot be explained based on the *individual* utilities alone. That paper studied the labor market; I found the treatment could be adapted to our setting.

I will assume each investor holds the full-blown portfolio consisting of all assets out there—albeit some with a zero weight in the portfolio. So, assume there exists some allocation rule  $\alpha'$  which is a vector or matrix of asset weights. For simplicity, let's study the two-network case first<sup>9</sup>. The expected value of allocating between these would be as follows:

$$\begin{aligned} EV &= \alpha(a + b \log(N + 1)) + (1 - \alpha)(a + b \log(0 + 1)) = \\ &= \alpha a + \alpha b \log(N + 1) + a - \alpha a + b \log(0 + 1) - \alpha b \log(0 + 1) = \\ &= a + \alpha b \log(N + 1) \end{aligned}$$

However, since,

$$\begin{aligned} N_1 + N_2 &\equiv N \\ N_1 &\equiv \alpha N, \\ N_2 &\equiv N - N_1 = (1 - \alpha)N \end{aligned}$$

the resulting value is,

$$\begin{aligned} EV_1 &= a_1 + \alpha b_1 \log(N + 1) = a_1 + \frac{N_1}{N} b_1 \log(N + 1) \equiv a_1 + B_1 N_1, \\ B_1 &\equiv \frac{b_1 \log(N + 1)}{N} = \text{const} \end{aligned}$$

The total value CES is,

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<sup>9</sup> An extension to a general case of  $n > 2$  follows naturally from the fact that we apply the same  $(\alpha_i, 1 - \alpha_i)$  rule to each asset in the composite.

$$V \equiv \sum_i^m V_i = \sum_i^m a_i + \sum_i^m B_i N_i$$

What this suggests rather unequivocally is that, even though individual value functions imply neutrality, the representative level assures linearity in  $N$ 's, or perfect substitutability. Moreover, it can be shown that this result holds for any scale (or risk aversion) other than  $\log N$  (maximum risk aversion):

$$V \equiv a_i + b_i N^\beta \Rightarrow$$

$$EV = \alpha(a + b(N+1)^\beta) + (1-\alpha)(a + b(0+1)^\beta) = \alpha a + \alpha b(N+1)^\beta + (1-\alpha)(a+b) =$$

$$a + b + \alpha b[(N+1)^\beta - 1], \alpha \equiv \frac{N_1}{N}$$

$$EV = a + b\left[1 + \alpha((N+1)^\beta - 1)\right] = a + b\left[1 + \frac{N_1}{N}((N+1)^\beta - 1)\right] = a + b[1 + cN_1], c \equiv \frac{(N+1)^\beta - 1}{N}$$

$$EV = a + b[cN_1 + 1] = (a+b) + bcN_1 = k_1 + k_2 N_1, k_1 \text{ and } k_2 \text{ const} - \text{QED!}$$

Which suggests there will exist potential for comovement on the downside for *any* elasticity of substitution or degree of similarity between assets, even between styles (i.e. assets with zero ES, or neutrals).

### ***Diversification***

Krugman (1999) suggests that networks can hardly be the candidate sources of increasing returns to scale (that both the 'new trade theory' and the 'new growth theory' maintain to be the linchpin of modern trade and growth). He observes that, for the most part, networks exhibit positive yet *decreasing* returns to scale. Incidentally, our modeling fully complies with this stylized fact:

$$\begin{aligned}
V &\equiv a + b \log N, \\
FOC &: \frac{\partial V}{\partial N} = \frac{b}{N} > 0, \\
SOC &: \frac{\partial^2 V}{\partial N^2} = \frac{-b}{N^2} < 0.
\end{aligned}$$

However, the presence of *decreasing* returns to scale would suggest a rationale for holding as many networks as possible, which would actually justify a continuous CES:

$$\tilde{V} = \int_0^1 a_i + b_i \log N_i di$$

In this light, what are the implications for diversification? Evidently, covariance does not apply conceptually to generic interactive components of value,  $COV(N_i, N_j) = 0, \forall i \neq j$

So, the more important the pure network component of value, the less applicable the conventional diversification is (and accordingly, the more rationale behind style investing). A rethinking of diversification could pertain to the above-discussed diminishing returns to scale reason.

That said, how consistent is this style investing notion with the benefits of diversification? On the one hand, style or intra-type investing is quite at odds with inter-type diversification. However, in our setting, the investors are maximizing value rather than minimizing risk. Moreover, it can be show that style investing—holding many similar assets—is quite in sync with diversification, even if we hold many *perfect* substitutes. If perfect substitutability are assumed, then the style portfolio variance is this,

$$VAR_{PORTFOLIO} = \alpha^2 VAR_i + (1 - \alpha)^2 VAR_j + 2r_{ij} (VAR_i VAR_j)^{1/2} = VAR_i = VAR_j$$

In other words, the resulting portfolio risk will not exceed the maximum individual risks for perfect complements, and will be lower than that for imperfect complements,  $\rho < 1$ ! Now, of course it would be ideal to have uncorrelated ( $\rho = 0, r_{ij} = 0$ ) assets, or for that matter negatively correlated assets. But again, risk minimization is not the whole story. Moreover, there's no conceptual grounds to believe covariances apply to generic network components:

$COV(N_i, N_j) = 0$ . Finally, Shleifer and Barberis find that style investing has in fact outperformed index investing or small cap holding patterns.

### ***Emerging Markets***

What is the candidate profile of market for which the interactive value component ***blogN*** is very important? That's emerging markets, whose fundamental value is just too uncertain (variance high), for lack of history. The previous formal treatment could shed light on why markets with a low or uncertain fundamental component ***a*** are all the more likely to get hooked in contagious comovement.

EMPIRICAL PART

**Modeling**

Our framework suggests a set of testable implications. These can be summarized as follows:

- (A) Emerging markets can be defined for modeling purposes as ones exhibiting insufficient history for their fundamental value components to be very significant determinants driving the investor behavior, whether these be ‘fundamental’ investors (“smart money”) or ‘feedback traders.’ In other words, the pure network component (which interactive part of the value can be studied as the effect of the excess demand on asset prices) will be all the more relevant for emerging markets, in that the slope coefficient  $b$  is higher than that for mature markets, and moreover the intercept (pertaining to the fundamental value component) should be lower and exhibit a higher variance. Accordingly, we have to test the augmented value structure,

$$V = a_i + b_i \log(N_i + 1)$$

as

$$V = \alpha + \beta \log N + \varepsilon$$

The joint null hypothesis would in this case be this: intercept is significant with variance that is time-invariant (does not decrease with history), and the slope is small (economic insignificance) and statistically not different from zero. I now establish some of the results formally, which could be seen as refuting the null hypothesis. When it comes to the variances of the intercept and the slope (we assume a univariate case), it can be shown that:

$VAR\beta = \frac{\sigma^2}{\sum_i x_i^2}$ , where the lower-case  $x$ 's refer to regressors net of their

expected values, and the numerator to the variance of residuals. By substituting excess demands (while noting that their expected level is zero, i.e. general equilibrium) and substituting a time index here, we arrive at the following:

$$VAR\beta = \frac{\sigma^2}{\sum_t (N_t - N^e)^2} = \frac{\sigma^2}{tVAR(N_t)}$$

So, the variance of the slope (which is also the coefficient  $\beta$  mapping excess demand into price or value) does indeed decrease with history, and is moreover inversely related to the volatility of the excess demand (or the network size).

We have no prior grounds to differentiate between the qualities of the generic network components (excess demands) of various assets. Therefore, the role of this component of variance is ambiguous.

Let us now proceed to computing the efficiency of the intercept, or the fundamental component of value:

$$VAR\alpha = \frac{\sum_i X_i^2}{n} \frac{\sigma^2}{\sum_i x_i^2} = VAR\beta \times \bar{X}^2$$

Again, since the excess demand is expected at zero, the first term proves to reduce to the denominator of the second term in the product, so that, in time-series terms,

$$VAR\alpha = \frac{\sigma^2}{tVAR(N_t)} VAR(N_t) = \frac{\sigma^2}{t} .$$

What this suggests is that, the significance of the fundamental component of value is indeed fully captured in the history horizon, and in particular is higher for emerging markets.

- (B) The second part of empirical analysis involves testing our CES function as defined on a sample of assets or markets excess demands. It is particularly interesting to model general equilibrium while taking explicit account of the fact that its various constituents could be related as any deviation from perfect substitutability. Comparison for imperfect substitutes (as well as independent markets for which the rho is zero or complements for which the rho is negative) involves certain complexities. I now proceed to showing one way of estimating the CES function. Since it is a nonlinear case in general (for cases other than independence or log-linearty), the estimation of a general  $n > 2$  setup poses challenges. I therefore demonstrate how the OLS can be used as an approximation to a nonlinear regression for an  $n=2$  case, by following the methodology as in Kmenta (1967).

$$V^{\frac{\rho}{\nu}} = \sum_i b_i X_i^{\rho} ,$$

where the nu parameter stands for scale. Now, this standard denotation can be reduced to a weighted version as follows,

$$V^{\frac{\rho}{\nu}} = \gamma \sum_i \delta_i X_i^{\rho} , \text{ where deltas are weights, s.t. } \sum_i \delta_i \equiv 1 \text{ and}$$

$$\gamma \equiv \frac{1}{\sum_i b_i} .$$

For the simple  $n=2$  case we are going to estimate, and bearing in mind our excess demand notations, the above amounts to,

$$V^{\frac{\rho}{\nu}} \equiv \gamma(\delta N_i^{\rho} + (1-\delta)N_j^{\rho})$$

Now, after stretching it by logs, the regression can, by Taylor series, be approximated as,

$$\begin{aligned} \log V &= \log \gamma + \frac{\nu}{\rho} \log [\delta N_i^{\rho} + (1-\delta)N_j^{\rho}] + \varepsilon \\ \log V &\cong \log \gamma + \nu\delta \log N_i + \nu(1-\delta) \log N_j + \rho\nu\delta(1-\delta) \left\{ \frac{1}{2} \log^2 \frac{N_i}{N_j} \right\} + \varepsilon' \end{aligned} \quad \text{(A)}$$

The regression can then be estimated as,

$$\log V = \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon',$$

where  $X_1 \equiv 1, X_2 \equiv \log N_i, X_3 \equiv \log N_j, X_4 \equiv \frac{1}{2} \log^2 \frac{N_i}{N_j}$

$$\beta_1 = \log \gamma, \beta_2 = \nu\delta, \beta_3 = \nu(1-\delta), \beta_4 = \rho\nu\delta(1-\delta)$$

The constant elasticity of substitution rho can then be estimated based on the coefficient obtained as,

$$\rho = \beta_4 \frac{\beta_2 + \beta_3}{\beta_2 \beta_3} = \beta_4 \left( \frac{1}{\beta_2} + \frac{1}{\beta_3} \right) \quad \text{(B)}$$

### ***Description of Data***

For the purpose of estimation and testing, ideally we would have a sample of markets falling under categories as diverse as mature versus emerging, as denoted by the indices histories. Unfortunately, it is the rare luck to have data available for time series going back several years (to possibly span the pre and post crisis periods) and featuring indices as well as the excess demands (or their proxies, such as ownership, institutional ownership, volumes, or net position

changes). To my knowledge, these data are available at full for a handful of markets only, most notably the South Korean market.

I will therefore use as proxies stocks of individual companies, and time after IPO (history after initial public offering) would distinguish between markets that are more like ‘emerging’ versus those more mature. I use a panel of daily price and volume quotes from NASDAQ, for a period of January 1997 through January 2003. Tests of CES will be run for 3 pairs of companies:

- Ones that belong to the same sector, same industry
- Those in the same sector, different industries
- Those in altogether distinct sectors

One critical limitation to this test is that we do not actually have the right proxies for excess demand on hand. Indeed, to evaluate a proper network size or the effective excess demand, we might want to deploy net changes in holding positions relative to the current equilibrium demand<sup>10</sup>. The data we do have publicly available pertain to volumes, which cannot give us a meaningful picture on the structural relationships within the CES-aggregates. One way to interpret CES relationships across volumes of trades would be in terms of liquidity or indeed activity: markets with the lowest volumes of trades are the thin or inactive markets commonly referred to as the ‘frontier markets.’

One way of going around this issue could be by invoking the results from duality theory once again. In fact, the proper dual function could be estimated in place of the primal function for which the regressors are either unavailable, unobservable, or for that matter imperfectly identified. Accordingly, we may choose to estimate a minimum loss function or a distance function as a dual to

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<sup>10</sup> This is to recognize that marginal sales act to shift the equilibrium by boosting the excess supply, whereas increases in long positions pertain to growing excess demand. Yet, the significance of such oscillations crucially hinges on the past equilibrium total demand as a benchmark. We therefore would use net change in holding as percentage of past equilibrium level of demand, i.e. past holding. Such data are reported on a daily or weekly basis, yet are unavailable as a database for public use.

the original value function comprising the fundamental value and the network component (or the effect of the excess demand). A minimum loss function defined on prices subject to a single constraint (minimum value or stock price as a margin call) could be dual to a value function defined on excess demands (for which data is unavailable) subject to a single constraint (maximum loss). As far as the dual elasticity of substitution is concerned, it can be shown to be

$$r = \frac{\rho}{\rho - 1}, \text{ if the primal ES was } \rho:$$

$$\mathbf{Primal:} \max V \equiv b_i N_i^\rho + b_j N_j^\rho$$

$$\text{s.t. } p_i N_i + p_j N_j \leq e$$

$$\mathbf{Dual:} \min E \equiv A(\delta p_i^r + (1 - \delta) p_j^r)$$

$$\text{s.t. } v \geq \bar{v}$$

As a proxy for loss and/or distance, we could use cumulative conditional variances (as of day t). However, we might really be more interested in tracing the leverage effects of negative surprises, or indeed the lower semi-variance. We therefore can use the excess of an average of two assets prices over and above the expected average price, and employ it as a binary variable:

$$E = p_{AVERAGE} - P_{AVERAGE}^{EXPECTED} = \frac{p_i - p_j}{2} - \frac{p_i^{EXPECTED} - p_j^{expected}}{2} = \begin{cases} 1, & \text{if } > 0 \\ 0, & \text{otherwise} \end{cases}$$

By invoking the Taylor series approximation (A), our regression looks as follows:

$$\mathbf{(A')} E = \beta_1 + \beta_2 \log p_i + \beta_3 \log p_j + \beta_4 \left\{ \frac{1}{2} \log^2 \frac{p_i}{p_j} \right\} + u, \text{ where } u \text{ is an error term}$$

and time indices apply to variables.

From the above, we can compute the dual elasticity of substitution as,

$$r = \frac{\rho}{\rho - 1} = \beta_4 \left( \frac{1}{\beta_2} + \frac{1}{\beta_3} \right), \text{ so that the primal elasticity of substitution (for}$$

excess demands) can be inferred as,  $\rho = \frac{r}{r - 1}$  based on the dual coefficient estimated.

The duality result can be controlled as follows. If we pick two assets whose prices show a lot of complementarity, then their excess demands should exhibit significant substitutability<sup>11</sup>.

### ***Empirical Results***

I have run the above regression for 1,510 observations on the daily prices of Dell Computer Corporation and Microsoft Corp. The results are summarized in below:

$$E = -4.00542 + 2.23 \log p_i + .80 \log p_j + 11.074 \left\{ \frac{1}{2} \log^2 \frac{p_i}{p_j} \right\} + u$$

s.e. (.09768) (.1383) (.1083) (.599) R-square=.67

All p-values are zero, and the coefficients are significant at virtually any level.

We can furthermore compute the dual elasticity of substitution, which equals 18.742. Although the exact correspondence of the model to theoretical ranges for ES is a matter of calibration, this value suggests strong substitutability. The primal elasticity of substitution is implied at a level of 1.056. However, given

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<sup>11</sup> The formal proof (see Diewert 1982) is somewhat involved for most duality propositions, yet the intuition in this particular case can be readily checked by recognizing that the inverse coefficients (of regressing X on Y, rather than Y on X) would indeed suggest inverse values for ES's. For slopes, the covariances in the numerators will be the same, yet the variances in denominators will differ, and the product of the direct and the inverted slopes can be shown to equal the squared correlation coefficient.

the conjectured scale of calibration, this value implies we are very far from substitutability in excess demands, indeed closer to complementarity. Which is confirmed by the two companies profiles: they actually can be thought of as a cluster.

I will now trace a relationship between two companies belonging to a priori distinct industries and distinct sectors: McDonalds (“Restaurants”) and Proctor & Gamble (“Personal and Household Products”). The results of the regression are presented below:

$$E = -9.9588 + 4.2177 \log p_i + 1.667 \log p_j + .668 \left\{ \frac{1}{2} \log^2 \frac{p_i}{p_j} \right\} + u$$

(.19)      (.37)      (.38)      (.82)      R-square=.68.

All coefficients are significant at all levels, except the last one which does not prove significant even at  $\alpha=25\%$  (p-value is .42). The elasticity of substitution in prices is estimated at .559, so that the primal elasticity is imputed at  $-1.27$ . This suggests that the stocks are closer to complementarity, as is seen from the comparative chart (see Appendix A).

IMPLICATIONS AND CONTRIBUTIONS

This paper builds on the standard microfoundations to arrive at key results. To my knowledge, this framework contributes to the existing literature along these lines:

1. I rationalize a possibility of treating assets at large as networks (following the Dowd & Greenaway (1993) treatment of currencies as networks featuring, over and above the fundamental component of value, also the pure interactive component). In so far as this constituent is significant, no players are purely ‘fundamental’ traders. To some extent or the other, all players are feedback traders, converging to positive feedback trading near end game.
2. I propose that, in line with the general equilibrium literature, prices or asset values could be correlated with or determined by changes in excess demands. Some recent studies fully support this hypothesis (see Aspariuhoa et al. 2002). I then apply a CES analysis of aggregates defined over excess demands (for an arbitrary number of markets) and make use of duality relationships. In the theoretical modeling part, duality is invoked to suggest that markets with growing excess demands that are substitutes, will prove closer to complementarity when their excess demands decay (in adverse states). In the empirical section, duality is deployed to estimate a CES function with respect to regressors for which data are available. Direct or primal elasticity of substitution can then be inferred from the coefficients estimated for the regressors unobservable. To my knowledge, this is the first work to deploy CES analysis as an alternative to the conventional covariances or betas, as well as the duality theory in financial markets.

LIMITATIONS AND FURTHER RESEARCH

The present work has confronted several constraints and exhibits some weaknesses, as summarized below:

1. I have not been able to obtain the data suitable to proxy excess demands for emerging versus mature *markets*. I therefore had to proxy the notion of emerging versus mature markets by referring to *stocks* with an eye toward the time that has passed since they went public (IPO). However, the only data on sales dynamics, over and above prices, are volumes, which cannot adequately proxy excess demands for stocks either.
2. I have deployed a representative agent approach to arrive at one of the central results showing how any elasticity of substitution on a micro level implies perfect substitutability for aggregated agents. It would appear that mine is a first model applying the representative agent approach to treating the augmented value structure. However, this modeling tool has been in wide use in the literature and proved to exhibit some weaknesses. The present work could be augmented (albeit perhaps to capture only peripheral results) by invoking a heterogeneous agents conceptualizing. Having said that, some elements of such modeling have in fact been implied in that, the two types of agents—large players and infinitesimal players—show similar channels of contributing toward style-induced comovement. Therefore, any mix could be chosen on the continuum in between, or indeed any heterogeneous structure of investor could be interpolated, with the key result expected to prove robust.

When it comes to prospects for future research, this work could be extended and applied in several directions. On the one hand, it proposes an illuminating perspective of interest from the microfoundations point of view, rather than as an ad hoc application in finance. For that matter, the presently attempted approach

stressing an augmented value structure and featuring CES-type relationships, could be employed in studying joint cycles for whole samples of economies. How closely they are similar is to be denoted by the elasticity of substitution as in CES, and the value decomposition could pertain to the structure of their comparative advantages. The latter suggests that, in so far as the agglomeration (network) component of CA is significant in excess of the natural or ‘fundamental’ (non-agglomeration based) constituent, their cycles could co-move as substitutes in favorable states and as complements (i.e. become synchronized) in recessions. Again, this does not presuppose any knowledge of why these changes between states of nature occur, in the first place.

Finally, transaction and information cost analysis could be incorporated. It would be reasonable to think that the fundamental value is the product of relevant [cumulative] *information*, whereas the network size is that of *news*.

We can denote information as  $I$  and news as change or time derivative  $\dot{I}$ , so that  $a_j \equiv a_j(I_j)$  and  $N_j \equiv N_j(\dot{I}_j)$ . This speaks back to the original idea of

studying [intra-industry] trade in information, the latter (information) being an input! Indeed, the shorter the [emerging] market’s history, the more distributed its fundamental value and the less relevant the cumulative information; on the other hand, news (or change in information) will be all the more relevant. We could easily incorporate transaction costs and information costs into the formal analysis, to arrive at some implications of incomplete information or restricted response to news:

$$V = a_i(I(1-t_1)) + (1-t_2)b_i \log \left( N_i \left[ \dot{I}(1-t_1) \right] \right), \text{ where } t_1 \text{ and } t_2 \text{ denote the two}$$

dimensions of efficiency or transaction costs: quality of information and/or news, and the liquidity or stickiness of market (mostly relevant to the network value component, or for the shorter-horizon investors).

Finally, in effect, our framework implicitly addresses a few other important results in the finance literature. The CAPM component is captured in  $a$ , while the finding by Fama & French (1995) of the importance of size and book-to-market value ratio could be captured (and re-motivated) as follows<sup>12</sup>. ‘Size’ pertains to network size or indeed the excess demand for the asset (not exactly the same as capitalization in their test), whose first order effect is positive and second-order negative. This could be in line with the Walras’ law implicating that, assuming the desirability condition, in a GE setting, price will be all the higher, the greater the excess demand on a particular market. This formal result could in fact rationalize our intuition on strategic rationality and end-game horizon—both pertaining to value (network) dynamics!

The very duality result could now be put in excess demand terms: so long as positive or growing excess demands are substitutes, negative or decaying excess demands are complements! In other words, stable or growing networks will be related as  $\rho \leq 1$  substitutes, but networks expected to decrease in size will relate as  $\frac{\rho}{\rho - 1}$  complements. Upper semivariations are substitutes, in which case lower semivariations are complements. Indeed, the generalized value structure  $V = a_i + b_i \log(N_i + 1)$  could be rethought as follows:  $a$  refers to a general equilibrium value at zero excess demand (which is like the long-term, fundamental component), while the interactive part  $b \cdot \log N$  refers to the importance of nonzero excess demand, which can be positive or negative, growing or decreasing.

---

<sup>12</sup> French and Fama (1995) find that alternative regressors, such as the stocks capitalization and the book-to-market gap prove more successful in capturing valuation and pricing (or for that matter in predicting the returns) than the CAPM single-shot beta. Their finding for the period when small caps and value stocks were in fashion, does not show as much explanatory power outside the sample.

Book-to-market value (as in the French and Fama [1995] criticisms of CAPM) could, in turn, suggest either undervaluation or deteriorating value. Indeed, a growing book-to-market ratio could point out to a short end game horizon (or to downside times). Alternatively, this gap (which could go either way) could be interpreted as an effect of transaction costs (market or institutional stickiness). In particular, higher transaction costs could prevent an overvalued asset from deteriorating and an undervalued market from appreciating—exactly in line with the minus sign of the  $\frac{BV}{MV}$  coefficient in their study. To draw a bottom line, it is to be expected that empirically our model should fare about as well as these studies whose scopes are implicitly captured therein (let alone that it might rationalize or re-motivate these empirical stories conceptually). The model we suggests captures both the “book-to-market value” and the “size” as the sign and size of excess demands  $N$ , respectively. Moreover, the  $\alpha$  component captures the fundamental value *a la* CAPM pricing.

### **Politically Incorrect Afterthoughts**

I may have owed a most special debt of gratitude to the reviewers and advisers that have done their best to fail this effort, while ironically facilitating some groundbreaking areas being spawned, partly as a response to their invariably tenuous feedbacks. Essentially, these amounted to asserting cautiously that my findings were “either wrong or obvious or too counterintuitive, or possibly long said,” and even if none of the above, I was anyway “not allowed to say anything unless (sic!) it was already there in the literature;” so all I was supposed to do is locate and cite. And when, after one year, the seminal working paper by Barberis and Shleifer (2002 [2003]) appeared in print claiming to be the “first study,” not only did I see my priority forgone, I now indeed was interested in showing how my own research was supplementary—only to hear back that I should not have focused on that single study and could long have looked up some prior papers (sic!). That’s probably how the “young”

researchers hungry for tenure may have construed allegiance to the idol of mainstream.

More specifically, Mr. Stefan Lutz initiated this assault on the “way too independent students” on the pretext that this might be “bad for character formation.” He was prompt in rejecting my initial research proposal “now that it has been well thought through,” the reason being that “it might not be very well received by the more conservative mainstream committee members.” I readily switched—having a meager 3 months to go—only to witness that I would be pressured for either having cooked my topics like hot cakes or for failure to keep at it. His interim report (following my desperate search of another adviser) was unswervingly intransigent table-turning, on the mere expectations that, “this student is unlikely to see his research through given the time constraints and the scope attempted.”

Mr. Charles Steele (the then-program director) seconded this stance in wondering why I had picked a complex theoretical theme whereas “we are no PhD program, and you’re basically supposed to come up with some transition crap” (sic!). I was well advised to first “knuckle down and get an MA, then a PhD,” whereupon I might be in a position to “do some independent research.” The well-intent last alert pointed out that “see, we do not grade the ideas.” The final evaluation said that mine was a “no breakthrough” and [informally] “a piece of crap” (or even harsher than that).

Mr. Michael Bowe (my last accidental advisor on this theme) would be at a loss for comments because he was “not a math person.” On my retort that this is fairly straightforward stuff and “after all, we’re all microeconomists, aren’t we?” he wrote a sign-off saying he would not be able to evaluate my work. Following that initial runaround, he did fail my paper on the strength of a singular perception (possibly after consulting someone): “All you’ve shown is an affine function, so what are your findings?” Futile were my attempts, once I had adequate breath, to refer this strange question to Hansen’s own contribution to begin with—and anyway that was an afterthought. Worse yet, this person

drew upon my own follow-up letter (see Appendix B) exposing the two nuisance typos I had committed, as grounds to deny any chance of defense.

At the end of the day, Mr. Tom Coupe (one other program director hearing my case) reserved the right not to understand a thing, try though I might simplifying the exposition. On his suggestion, I even provided a preliminary empirical section aimed at merely demonstrating that this, obviously theoretical, paper still had some refutability potential. All he did was to count this add-on against me, suggesting that it was insufficient for an empirical (sic!) output. In retrospect, while lacking a full-blown set of data checks (let alone power or meta-analysis of the tradeoff between effect sizes and degrees of freedom, which wasn't widespread back then anyway), this paper never earned me a mere passing D+ just because some people believed there were more tits and bits to render it perfect without quite caring to peruse it. These people failed to allow me a day or two to fix whatever they might have presumed to be at odds with their sentiments, without me ever having a hunch on what it was—weeks ahead of the defence, with the rest of not-so-theoretical papers being polished through the eleventh hour.

One grand corollary might be meant as an insult (sic!) to some “religious” sentiments referring to half-shrewd, half-fanatical propensity to cater for the mainstream idol's whims (be it the Caesar or mammon). Such young advisers and research assistants should take with a grain of salt dubbing theirs a divine ministry.



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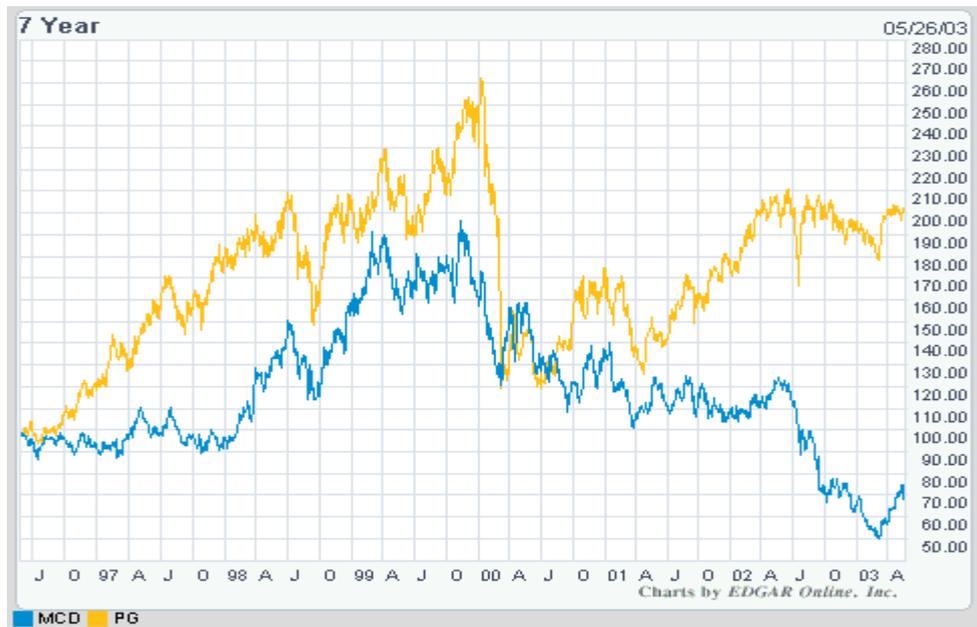
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## APPENDIX A



APPENDIX B: Follow-Up Letter on Self-Detected Typos

**Typo 1:** p.38, the analytical expression showing the structure of the variance of the intercept (standing for the ‘fundamental’ value component):

$$VAR\alpha = \frac{\sigma^2}{tVAR(N_t)}VAR(N_t) = \frac{\sigma^2}{t}$$

The paragraph then says,

“  
What this suggests is that, the significance of the fundamental component of value is indeed fully captured in the history horizon, and in particular is higher for emerging markets.”

It’s a blunder: Of course, the significance is LOWER for emerging markets (and frontier markets like Ukraine), as follows from the relationship above and as maintained by our theory. (Hence the relative weight of the network component  $\frac{b_1 \log N_1}{V_1}$ ). Emerging markets exhibit a smaller  $t$  and a lower significance in the fundamental components of value, all else held same.

**Typo 2:** p.41 (42 on status bar), the second regression estimating the elasticity of substitution between McDonalds and Proctor & Gamble. We have obtained a coefficient  $\beta_4$  that’s insignificant at any level (p-value .42). Our CES therefore reduces to Cobb-Douglass, so that the rho collapses to zero, which is *independence*. Moreover, independence will hold in the primal (wrt quantities or excess demands) and in the dual (with respect to prices). So, this does confirm our prior design: McDonalds and P&G belong to different industries, different sectors (they are independent). Duality has worked out correctly, and its use in these tests has of course been motivated by our theory. We do not observe excess demands directly and were unable to test our proposition in the primal, yet a dual inference seems to prove consistent with prior design/expectations.