A compelling case for a paradigm shift in economics I

Kazem Falahati, Glasgow Caledonian University

70 Cowcaddens Road, Glasgow G4 0BA, UK

Email:kfa@gcu.ac.uk, Tel: 0141 3313708

Abstract

Consider a Competitive, Efficient and Frictionless Economy (CEFE) where resources are scarce at any date, and hence money as a valid claim against scarce resources is also scarce. We prove mathematically that in this economy all transactions, including "spot" transactions, take a non-zero quantity of time to materialize, during when the money and the good (or asset) being transferred between parties represent *tied-up capital* such that this capital cannot be used for any other purpose. We also note that in this economy at any date there will always be price competition, which can generate a greater number of arbitrage opportunities than what is exploitable with the scarce capital available then. This leads to a non-negligible opportunity cost for the capital tied up in arbitrage transactions, represented by the arbitrageur's best missed opportunity, if no better investment opportunity exists. In the unlikely case where collectively arbitrageurs can exploit all arbitrage opportunities, this does not remove the opportunity cost for each single arbitrageur, when he/she cannot do that alone, hence the breakdown of the law of one price in its standard sense in a CEFE. This helps construct a new paradigm of CEFE which resolves many long-standing theoretical, empirical and behavioural puzzles. We address some of the most salient of these puzzles in microeconomics and financial economics in paper I, and those of macroeconomics in paper II.

Key words: Theoretical, empirical and behavioural puzzles in microeconomics and finance.

Jel code: A10, D03, E32, G32.

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1. INTRODUCTION

In announcing the winners of the 2013 Nobel prize in economics, the Royal Swedish Academy of Sciences said that Eugene F. Fama, Lars Peter Hansen and Robert J. Shiller:

"have laid the foundation for the current understanding of asset prices".

However, it is not clear what this "current understanding" is. For, whilst these laureates all agree about the facts and the theory of so-called "rational" pricing, they do not agree on whether this theory accords with the facts, and thus they fail to provide a common understanding on behaviour of asset prices, hence we are still in the dark ages in this respect.

Our aim in this paper is to prove that the standard theory of "rational" pricing is *internally inconsistent* and it is a misnomer to call it "rational". Moreover, we point out that there exists a new coherent overarching theory (or paradigm) which can, inter alia, logically explain many of the findings of behavioural economists in efficient economies i.e. accord with the facts. In particular, we prove that the standard dividend valuation model of the equity of the firm is flawed, and once this model is rectified it can account for the excess volatility of prices of shares compared to their dividend streams. The structure of the rest of this paper is as follows. Section 2 examines the foundation of the law of one price in its standard sense, and Section 3 introduces the CEFE of the new paradigm where this law does not hold. Sections 4-6 show how the long-standing behavioural puzzles in microeconomics and finance are resolved in the new paradigm. Section 7 concludes. Mathematical Propositions are proved in Appendices. We address macroeconomic puzzles in paper II under this title.

2. "RATIONAL" PRICING THEORY IN THE STANDARD CEFE

The foundation of "rational" pricing theory rests on the law of one price in its standard sense for each good (including every service and financial contract) at each *date* (i.e. a point of zero length along a continuous timeline), in any CEFE. The historical justification for it comes

from Aristotelian reciprocity and Aristotle's justice in exchange in Nicomachean Ethics (Crisp, 2000). The modern support for it comes from the cost free theory of arbitrage in a CEFE. In this Section, we provide logical and mathematical proofs against this law, and at the end briefly comment on the shortcomings of its moral justification.

It is common ground in all sciences that any descriptive theory of the world, being an abstraction from a part of reality, can disregard certain facts of the real-world. This is permissible, as long as all assumptions are explicitly made and they are free of *internal inconsistencies*, and the *results* they lead to, are realistic. Thus, we cannot reject any theory for *merely* excluding certain facts of the real-world; however, we must renounce any theory as unscientific and irrational, if it is based on internally inconsistent assumptions, as Debreu (1991, p.2-3) admits. It is trivially obvious that the law of one price in its standard sense fails given any friction, inefficiency or market imperfection. What is not known, and what we prove in this Section, is that this law fails even in the absence of any friction, inefficiency or imperfection, for it is inconsistent with the axiom of scarcity of resources. Therefore, our critique of the cost free theory of arbitrage in a CEFE, unlike that of Grossman and Stiglitz (1980), Shleifer and Vishny (1997), etc..., is *not* based on the *unrealistic nature of the assumptions* underlying this theory (e.g. the same information being available to all freely), instead, it highlights the *internal inconsistency of these assumptions*. For, in a competitive and frictionless economy; price competition amongst traders must exist by definition, leading each good and financial contract, to be traded at multiple prices concurrently. This generates arbitrage opportunities at all times. To justify the presumption that arbitrage transactions are cost free in a CEFE, existing literature *implicitly* assumes the existence of *fiat money*, and hence the existence of *the State in a CEFE*, and offers three different arguments:

First argument: This argument implicitly assumes that the capital available for engaging in arbitrage is not scarce, no matter how many arbitrage opportunities may exist. Thus, Dybvig and Ross (1987, p.100) frame this argument in the case of a single opportunity and note:

> "By assumption, it is possible to run an arbitrage possibility at *arbitrary scale*; in other words, an arbitrage possibility represents a *money pump*. A simple example of arbitrage is the opportunity to borrow and lend costlessly at two different fixed rates of interest. " (Our emphasis)

This argument presumes an infinite amount of money is always available for engaging in all arbitrage transactions concurrently, for example to borrow and lend. However, if money were always available in an infinite quantity, there would be unbounded inflation and the currency would be abandoned. If not abandoned, a market participant could always benefit from a free lunch of size $+\infty > f > 0$ by borrowing a loan of an infinite size, and repaying it, as $+\infty - f \equiv +\infty$, and thus he/she could never become insolvent. Hence, *for fiat money to exist as a valid claim on scarce resources; its quantity must always be scarce.* It follows that the presumption of the availability of an infinite amount of money cannot hold in a world of scarce resources. This is consistent with Keynes (1923, p.107) who states:

> "It must be remembered that the floating capital…for…taking advantage of…arbitrage profits…is by no means unlimited..."

Bernanke (2002) also notes:

> "U.S. dollars have value only to the extent that they are strictly limited in supply."

Moreover, in the foregoing example of Dybvig and Ross, arbitrage transactions must take a non-infinitesimal length of time, as borrowing and lending for an infinitesimal length of time does not guarantee a "money pump". In addition, it is tacitly assumed that *borrowers never default* during this time. Otherwise, in this example the arbitrageur can end up with a loss. Further, it is incorrectly assumed that arbitrage requires "no net investment", as it is implied that the arbitrageur's inflow and outflow of infinite monies from his/her borrowing and lending lead to $+\infty - \infty \equiv 0$ i.e. *a false identity*. Reliance on these untenable assumptions is needed to ensure consistency with Dybvig and Ross (1987, p.100) definition of arbitrage:

> "An arbitrage opportunity is an investment strategy that guarantees a positive payoff in some contingency with *no possibility of a negative payoff and with no net*

investment." (Our emphasis)

These implicit untenable assumptions invalidate the cost free theory of arbitrage in a CEFE.

Second argument: This argument in support of the cost free theory of arbitrage *implicitly* assumes that arbitrage transactions do not require any time at all to take place and be settled (contrary to the case in the foregoing example, and many others like it, and hence the fallacy of this presumption), as if *all* arbitrage transactions could be done by spot transactions *and* spot transactions between money and goods (or contracts) could take place and be settled *timelessly*. This leads to the claim that arbitrage transactions do not tie up any capital, and they will generate a "money pump", if the spreads in prices of goods in a competitive market do not disappear as soon as they arise. This is identical to claiming that traders compete on price for each good; but at each date they all trade at the same price for the same good i.e. do not compete on price, a self-contradictory position. The implicit assumption of timeless spot transactions is endemic to all economic theory on competitive, efficient and frictionless economies. More generally, existing literature implicitly assumes that spot transactions in any economy, *whether frictionless or not*, can take place and be settled timelessly. This assumption not only lacks realism as many authors such as Shleifer and Vishny (1997, p.36) point out, but it also generates contradictions as it can lead to very many buyers for the same item of a scarce private good concurrently, although any specific item of such a good can only have one buyer or owner at any time by the definition of a private good. (This is where we treat a partnership, representing shared ownership of a private good, as a single trader.) We prove in Appendix 1 that the assumption that in competitive, efficient and frictionless economies transactions occur timelessly generates hereto hidden mathematical contradictions.

In a competitive economy where trade occurs continuously, price competition for goods arises naturally and generates arbitrage opportunities *at all times*. In such an economy, arbitrage must take place continuously, which inevitably ties up capital at all times. Even if market participants, individually or collectively, were always able to allocate sufficient capital to

exploit all arbitrage opportunities continuously, a non-negligible amount of capital would be *permanently* tied up to narrow the spreads in the prices of all goods. The opportunity cost of this capital would have to be *zero* permanently for the cost free theory of arbitrage to hold. However, if the opportunity cost of capital was permanently zero, that would imply the existence of a permanent free lunch, making this economy inefficient. Hence, the cost free theory of arbitrage cannot hold in any CEFE.

Third argument: To justify the cost free theory of arbitrage, where capital constraints and arbitrage risk are admitted, Shleifer and Vishny (1997, p.36) express the following argument:

> "... imagine a market with a very large number of tiny arbitrageurs, each taking an infinitesimal position against the mispricing in a variety of markets. Because their positions are so small, capital constraints are not binding and arbitrageurs are effectively risk neutral toward each trade. Their collective actions, however, drive prices toward fundamental values. This, essentially, is the model of arbitrage implicit in Fama's (1965) classic analysis of efficient markets and in models such as CAPM (Sharpe (1964)) and APT (Ross (1976))."

This argument *implicitly* assumes that either the price or the quantity of each good (or asset) that each arbitrageur trades in is infinitesimal, and the arbitrageur requires no compensation for risk-taking. However, this leads to an infinitesimal profit or loss for the arbitrageur, hence *no sure profit from arbitrage*. Moreover, it ignores the need for permanent arbitrage, as a result of which the cumulative and collective cost of capital tied-up in arbitrage and exposed to risk can be huge. Thus, this argument falls apart by the weight of its own assumptions.

All the foregoing arguments rest on the existence of fiat money, as arbitrage with commodity money or by barter consumes far greater scarce resources. The standard paradigm recognizes that fiat money is a debt that the State issues as a non-interest-bearing claim on itself. The logic of the law of one price in the standard CEFE requires a single interest rate p.a. on *all* debts of the State, equal to that on fiat money i.e. zero, which makes the State a money pump!

Previous research findings pertinent to this area: As a factual rather than theoretical matter, existing literature notes the impact of time-taking transactions e.g. in the context of exchange rates of currencies, where Benninga and Protopapadakis (1988) observe:

> "The fact that trade takes time causes systematic deviations.....from...Law of One Price ..."

What the existing literature overlooks is that the failure to incorporate this fact in the existing theories generates internal contradictions for these theories, as Appendix 1 proves. Thus, the failure to recognize that spot transactions, including gambles, must take a non-zero quantity of time, however small, to be valid, has generated mathematical contradictions in the form of free lunches in many foundational models of an informationally efficient economy, without the authors of these models being aware of the root cause of these contradictions, giving rise to theoretical puzzles. For example, Samuelson (1958) in the context of overlapping general equilibrium models, Harrison and Kreps (1979) in the context of the pricing of derivatives, Dybvig and Ingersoll (1982) in the context of the pricing financial assets, and Geanakoplos (1987, p. 119) in studying the Arrow-Debreu model of general equilibrium have all realized that these models of informationally efficient economies generate free lunches. Appendices 3 and 5 illustrate mathematical contradictions in the foundational models of Modigliani (1918-2003) and Miller (1923-2000) in the standard theory of finance. McChesney *et al* (2004) point to the internal contradictions of the law of one price from another perspective.

Empirical findings: Rogoff *et al* (2001) document persistent deviations from the law of one price in its standard sense over several centuries, consistent with the overwhelming evidence of many other scholars' research findings which reject this law based on empirical evidence.

The law of one price and "justice in exchange": Aristotelian reciprocity requires that if you borrow a gold coin for a period of time, all you need to do to pay off your debt is to return the same gold coin (or its perfect substitute) at the end of the loan period, as Aristotle considers gold to be a "barren" asset, and its opportunity cost of capital to be zero at all times. Indeed,

Aristotle regards interest on all loans as usury and "unjust". This leads him to the view that the buying and selling price of gold (and by extension any other good) at the same time should be the same for the same trader, and hence all traders. This is the Aristotelian justification for the law of one price in its standard sense. However, in the standard paradigm, Aristotle's views on the opportunity cost of capital, and usury are rejected, as it is recognized that a non-interest bearing loan in gold is a free lunch, which cannot be admitted in a world of scarce resources, and cannot be "just" to the lender. Strictly speaking, this opportunity cost of capital, which is non-negligible in an instant of exchange, leads to the breakdown of the law of one price in its standard sense, as noted earlier in this Section. On the other hand, multiple prices arising from price competition can lead to greater public welfare than a single price imposed by an edict. Therefore, we cannot say that Aristotelian reciprocity offers the public greater "justice" than competition, more so, given the difficulty of defining what "justice" is.

3. THE NEW PARADIGM

A map of a location can exclude many features of its neighbourhood, however, the features it shows will have to be externally consistent and sufficient for it to be useful in finding one's way to it and as such, it will be *realistic*. Analogously, the new paradigm we are about to present, for simplicity, abstracts from many features of an actual economy, nonetheless, it will provide a guiding tool to understand and predict the behaviour of its participants insofar as possible, and for this purpose, it will be realistic. Our aim is to have an overarching realistic outline, rather than an exact detailed image, of the workings of the economy. The context of our study is a CEFE. We refer to the standard paradigm, being the currently dominant paradigm, to identify our common ground with it, and our points of departure from it. This facilitates comparisons of assumptions and findings of the new vis-a-vis the standard paradigm and illustrates where and why the standard paradigm fails and the new paradigm succeeds in terms of internal and external consistency, and why a paradigm shift is necessary. The new paradigm removes the root cause of any internal inconsistency from the standard

paradigm, and as a result it replaces quite a few of its assumptions and definitions to obtain external consistency, which we show is achievable. In particular, we replace the foundations on which "rational" behaviour is defined in the standard paradigm, and introduce a new theory of value and price in the CEFE of the new paradigm. Moreover, we explicitly admit institutions such as the State and the banking system in this paradigm. We illustrate that the empirical and experimental failings of the standard CEFE are not due to its exclusion of such frictions as transaction costs, information asymmetry, agency problems, indivisibilities, externalities, or psychological biases, as claimed by its supporters, but it is due to its internal inconsistencies. To convince the reader that we are genuinely presenting a new paradigm which can replace the standard paradigm, rather than merely provide an ad hoc theory that deals with only one problem, we will demonstrate that our analytical framework resolves not one, but very many salient puzzles of the standard paradigm, hence the length of papers I&II.

CEFE of the new paradigm: We assume each individual can distinguish between the sources of his/her welfare gains and losses. For simplicity, we abstract from transaction costs (including any search costs), bargaining, taxes, information asymmetry, indivisibilities, externalities, etc…and assume that there are no entry or exit barriers in the economy other than those arising from scarcity of resources (see Appendix 2). In the new paradigm, we explicitly admit the State which derives its authority from the agreement of its citizens on its role, and emerges as a natural monopoly for providing public goods and services (see Appendix 3). The Central Bank, as an arm of the State issues the currency of the economy, as the sole means of exchange, and it introduces it into the economy by trading it with certain assets e.g. precious metals, precious stones and financial assets. For fiat money to provide a valid claim against scarce resources, the Central Bank ensures that it never exists in an infinite quantity, even if as Davidson (1972, p.104) notes the scarce resources it takes for its production are negligible.

The State can finance public expenditure by the seigniorage from the issue of its currency,

issuing bonds, or charging fees for its services e.g. toll charges for use of roads and bridges, licence fees for use of publicly owned resources, premia for insurance against certain risks, etc…. We assume that the State will enjoy citizens' support as long as its management of the economy delivers a generally agreed minimum level of welfare in terms of employment, consumer price changes and financial stability, issues that we return to in our paper II on macroeconomics. In no other way, the State/Central Bank interferes with the economy.

When a market participant makes decisions on behalf of others, he/she faithfully represents them. We uphold the principle that at all times in making choices private traders seek to minimize their perceived opportunity costs, based on their evaluations and forecasts, and thus routinely exploit any free lunches they identify, whilst seeking to satisfy their consumption, production and other needs. Leaving out public goods and services, we define an *efficient* economy as one where all identified free lunches are exploited. We recognize that time passes continually and not discretely. We also recognize that when a spot transaction occurs for exchanging a good (or a financial contract) with money, traders must have the good and the money at their disposal prior to the exchange, and it takes a non-zero quantity of time, however small, for the ownership (and hence the right of access to) the good and the money to be transferred between parties to the exchange, as in Figure 1.

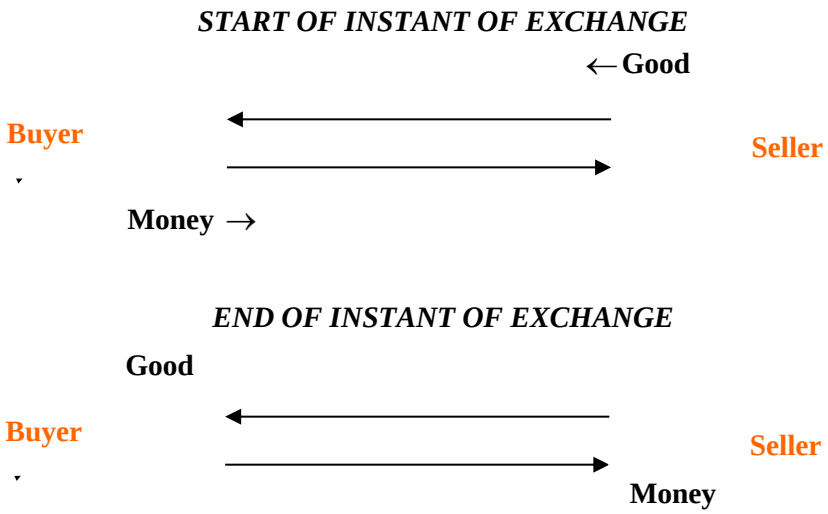

Fig. 1. Instant of exchange when the good and the money are in circulation

A simple theory of value and price: We assume each individual can assign a monetary value to each of his/her sources of potential welfare gain or loss arising from his/her acquisition or deprival of each object, taking account of all available information. Trade requires an individual to declare his/her bid and/or offer monetary values. Thereafter, market processes such as exploitation of arbitrage opportunities and the interaction of demand and supply transform these personal values into market prices, from which rates of return on investments can be obtained. We will discuss these processes in Sections 4 & 5.

Distinction between economic profits in the standard versus the new paradigm: In the standard CEFE, a trader's economic profit in buying and selling a unit of a good is the margin between his/her selling price and buying price of the good. In CEFE of the new paradigm, we recognize that the trader could not possibly do so, without the existence of his/her circulating capital comprising the good and the money in circulation in a round trip of buying and selling the good, hence his/her economic profit will be the margin between his/her selling price and buying price of the good less the opportunity cost of his/her circulating capital, which will be tied up during transactions. For a firm which produces the goods it sells, the economic profit will be the margin between their sale proceeds of the goods and their cost of production less the opportunity cost of the circulating capital tied up during this entire input-output process.

Distinction between insolvency and bankruptcy: A trader becomes *insolvent* when he/she cannot finance his/her existing payment commitments e.g. he/she cannot pay his/her debts on time, and will be *bankrupt* at any date if the maximum receipt from the sale of all his/her assets less the minimum payment to get relief from all his/her debts is negative at that date. An insolvent trader is not necessarily bankrupt, whilst a bankrupt trader will be insolvent.

Distinction between various types of reduction of wealth: A reduction of wealth is *affordable* if it will not make its owner insolvent, and it will be a *loss* for the owner unless it is a voluntary reduction of wealth for the owner's consumption, in which case it is not a loss.

Distinction between various preference-orderings in the standard versus the new paradigm: When an individual decides on his/her preferences by way of *choosing* to have a good vis-a-vis another good (or money), none of which he/she already has, the individual's preferences thus derived reflect his/her *choice-ordering*. In contrast, when an individual decides on his/her preferences by way of *exchanging* a good that he/she already has with another good (or money), the individual's preferences thus derived reflect his/her *trade-ordering*. Trade-ordering requires the individual to take note of the fact that during the instant of exchange, the individual ties up his/her capital for a non-zero quantity of time whilst trade takes place, in contrast choice-ordering requires no exchange and hence no tying up of capital. In the new paradigm, unlike the standard paradigm, we recognize that choice-ordering over a pair of goods is not the same as trade-ordering over them. For example, one may be indifferent between choosing a good and its perfect substitute whilst not having any of them already; however, one cannot be indifferent between exchanging the same good with its perfect substitute whilst having one of them already, as the latter exchange ties up one's capital for a non-zero quantity of time with no compensation. Also, in the new paradigm, one may prefer to consume apples rather than oranges, reflecting one's choice-ordering, whilst preferring to trade in oranges rather than in apples, reflecting one's trade-ordering based on the higher profitability of trading in oranges vis-a-vis apples. When a set of goods or gambles are being evaluated for trade in terms of money, trade can require them to be ordered in terms of the individual's bid or offer prices. This leads to their *price-ordering*, where the relative bid prices reflect the price-ordering for buying them, and relative offer prices reflect the price-ordering for selling them. Clearly, price-orderings are not the same as choice-ordering.

Economic risk and risk-caring behaviour: For an individual, leaving out unknown unknowns, an activity, project or contract with more than one possible future known outcome is *risk* generating, if and only if the lack of foreknowledge of realization of the one outcome that will turn out leads to a *net welfare loss* for him/her ex-ante. By this definition, we recognize that risk arises from known unknowns, and it is personal and subjective, although

many individuals can find the same activity, project or contract risky. For instance, for any pension-provider, greater longevity than anticipated is a risk, but it is not a risk for the pensioners receiving their pension income, as long as the pension-providers remain solvent. Moreover, if an activity, project or contract with many possible known outcomes generates no net welfare loss for an individual ex-ante, he/she will regard it as *non-risky*, and bid for it in the same way as he/she bids for any other non-risky good (or service).

We assume that each market participant is *risk-caring*, in the sense that he/she recognizes the change in his/her existing level of risk, and never chooses to offer or bid for an unbounded level of risk. Moreover, ceteris paribus, he/she requires to receive a compensation for accepting a greater level of risk than his/her existing level of risk, and is willing to pay an affordable compensation to reduce his/her existing level of risk. The monetary compensation required by a risk-caring individual reveals an individual's *price-ordering* when buying (or *price-ordering* when selling) protection against various risks, but not his/her choice-ordering.

A risk-caring individual never offers or accepts an unbounded level of risk by definition; hence no one will offer a gamble with the possibility of an unbounded payoff, thus the St. Petersburg puzzle never arises in the new paradigm, whilst it does in the standard paradigm. On the other hand, a risk-caring person may regard a lottery, with an affordable price far less than its prize, non-risky, if he/she considers the possible pleasant surprise of winning it compensates the welfare loss in paying its price. However, the lottery underwriter who must pay the prize may well consider it risky, and as such, will seek adequate compensation for it.

"Rational" expectations hypothesis: Under this hypothesis, based on all freely and readily available information, the economy is assumed to unfold in accordance with the internally inconsistent "rational" pricing theory and produce a recurrent stable pattern (Sargent, 2008). We cannot subscribe to this hypothesis in the light of Section 2, although we recognize that market participants seek to discount all freely and readily available information. The latter

includes the views of *dominant* experts, including philosophers and economists "both when they are right and when they are wrong" (Keynes, 1936, p.383).

4. RESOLUTION OF BEHAVIOURAL PUZZLES IN MICROECONOMICS

Instant endowment effect: Leaving out monopolies or monopsonies, there must be *price* competition amongst suppliers and demanders of private goods (or financial contracts) in any CEFE by definition. This generates multiple prices for each good leading to arbitrage opportunities. Arbitrage transactions take a positive quantity of time, however small, by assumption, and tie up the arbitrageurs' scarce capital during that time. On the other hand there are no limits to the number of arbitrage opportunities that we can have at any date. For example, consider where at any date all demanders' bid and all suppliers' offer prices for the same good are declared, and there is no agreed price between demanders and suppliers. Let us assume there are n offer prices p_i^o and m bid prices p_j^b such that $m > n$ and each p_j^b is greater than each p_i^o where $i = 1,2,3,...n$ and $j = 1,2,3,...m$. Here, there will be m arbitrage opportunities, whilst at most only $n < m$ of them can be exploited concurrently. In the unlikely case that collectively arbitrageurs exploit all arbitrage opportunities, this does not remove the opportunity cost for each single arbitrageur, when he/she cannot do that alone. This leads to an opportunity cost of the capital tied up in arbitrage transactions, represented by the arbitrageur's best missed arbitrage opportunity. For another example, take the case where currently opportunities can exit to buy and sell at fixed multiple prices each one of the contracts for delivery of the same good at an infinite number of future dates, where each party to transactions requires collateral against default of his/her counterparty, which ties up his/her capital. Here, arbitrageurs can exploit only a finite number of arbitrage opportunities with their scarce capital at any date, whilst an infinite number of these opportunities remain unexploited, and each arbitrageur will have a non-negligible opportunity cost for engaging in arbitrage, represented by his/her best unexploited opportunity.

Moreover, arbitrage transactions expose arbitrageurs' capital to at least one of the following two types of risk. First, during a roundtrip of acquiring and disposing an item of a specific good (or financial contract), however small this non-zero quantity of time may be, the characteristics of the item, including its market value, can change adversely from the arbitrageurs' perspective. Secondly, market participants may default on delivery of their part of the transactions. The arbitrageur, being risk-caring by assumption, will require compensation for accepting these risks as part of his/her opportunity cost. Thus, in any case, the spread in prices of each good may narrow on account of arbitrage, but will not be eliminated in the short or long run, leading to the breakdown of the law of one price in its standard sense. Hence, *for the same good (or financial asset), the same market participant's selling price must exceed his/her buying price concurrently, yielding the instant endowment effect found in experiments* (Kahneman et al, 1990) *in the CEFE of the new paradigm.*

In the real-world, a market where arbitrageurs (and speculators) amongst other traders are prominent is the foreign exchange market, which leads Van den Berg (2016, 237) to note:

> **"**…the fundamental international transactions related to international trade and long-term investment…account for … perhaps only one or two per cent, of all foreign exchange market transactions."

The reason is we can always have, for example, a ceaseless number of covered (and uncovered) interest rate arbitrage opportunities, besides instant arbitrage opportunities in the currencies. This leads to the *permanent* presence of arbitrageurs, which is proof that disparities remain wide enough to attract arbitrageurs even after accounting for frictions, consistent with the new paradigm.

A numerical example can explain this situation clearly. Let us assume that we have used all our available lines of credit fully and as a result, we have a maximum amount of $300,000 borrowed at 1.0% for a year to invest, and we have been quoted the following rates:

Current bid and ask spot rates of Australian dollar (A$) $0.70 and $0.72

One-year bid and ask forward rates of the Australian dollar	\$0.74 and \$0.78
One-year interest rates for borrowing and lending in Australia	3.50% and 3.0%

If we conduct covered interest arbitrage in this case, the accounting profit that will be realized in a year is \$300,000/\$0.72=A\$416,667×(1.03)=A\$429,167×\$0.74=\$317,583 less cost of \$300,000×(1.01)=\$303,000 i.e. \$14,583, assuming these transactions involve no further costs.

Let us assume the following rates are also quoted for us at the same time:

Current bid and ask spot rates of the euro (€)	\$1.09 and \$1.10
One-year bid and ask forward rates of the euro (€)	\$1.08 and \$1.10
One-year interest rate for borrowing and lending in Greece	4.0% and 3.5%

If we conduct covered interest arbitrage in this case, the accounting profit that will be realized in a year is \$300,000/\$1.10=€277,777.80×(1.08)=€294,444.40×\$1.035=\$304,750 less cost of \$300,000×(1.01)=\$303,000 i.e. \$1,750, assuming these transactions involve no further costs.

We can only exploit one opportunity with the same amount of investment at the same time. If we choose the first, the economic profit from doing so is \$14,583-\$1,750=\$12,833, exploiting the second leads to an economic loss of the same amount. Given the existence of many other arbitrage opportunities, not only for a year but also for shorter periods, we cannot exploit all arbitrage opportunities with our finite capital, whilst we only need to miss one arbitrage opportunity to have an opportunity cost contrary to interest rate parity theory. On the other hand, there are hidden risks that we have not yet accounted for. For example, any solvency problem of the banks we rely on is a risk to us; also we may run into solvency problems due to our exploitation of *all* our credit lines. Moreover, the forward rates may turn out to be less favourable to us than the actual future spot rates in a year. Therefore, disparities remain, and as everyone is faced with a similar scenario, hence the permanent presence of arbitrageurs.

Asymmetric valuation of gains and losses and related puzzles: It follows from the instant endowment effect in the CEFE of the new paradigm that, for the same trader, the selling price

of a zero-coupon bond is greater than its buying price at the same date. Given that the selling price of such a bond represents the present value of losing its maturity value of S at date d, and the buying price of it represents the present value of gaining its maturity value of S at date d, it follows that the discount rate applicable to a receivable cash sum S at date d is higher than the discount rate applicable to the same cash sum S at date d being payable in the new paradigm. Therefore, the new paradigm leads to different valuations for the price of the same prospective cash flow depending on whether it is a receivable (i.e. an asset) or a payable (i.e. a liability) for the same trader. This resolves behavioural puzzles on the disparity between: valuation of the same cash sum as a prospective gain versus a prospective loss (Kahneman and Tversky, 1984); or willingness to accept and willingness to pay the same prospective cash sum (Bishop and Heberlein, 1979; Knetsch and Sinden, 1984). In the representative agent's view of the standard paradigm, the market value of every loan is the same whether he/she holds it as a lender i.e. an asset or as a borrower i.e. a liability. In the new paradigm, this is not so, for the foregoing reasons.

Hyperbolic discounting: In the new paradigm, we recognize that arbitrage opportunities are investment opportunities which tie up arbitrageurs' capital and expose that capital to risk during the holding periods of these investments. The rates of return on invested capital in exploiting arbitrage opportunities provide *benchmarks* for other investments with the same investment holding periods, notwithstanding the adjustments needed for any risk differentials. We assume market participants can, as in experimental economics, categorize investment holding periods as *immediate*, *near* and *distant* periods from the present date until the date of the realization of their investment returns. In this context, experimental observations can help delineate the immediate, near and distant future periods.

Let $R > 0$ be the rate of return on an investment with a holding period T starting from now, and let our unit of time be an *instant* of length t such that $T = nt$. We define $r > 0$ as the

rate of return per instant for this investment, if $(1+R)=\prod_{i=1}^{n}(1+r)^{i}$.

Now, consider a scenario in which money can be borrowed and lent at multiple rates for each of the fixed terms starting from now and ending at an infinite number of dates in the future. Given scarcity of capital and these infinite arbitrage opportunities, at each date multiple rates for loans of the same term will persist, despite all arbitrage activities. When, for each of these loans, this fixed term is the immediate future, we have the immediate borrowing and lending rates, and when this fixed term is the near or distant future, we obtain the borrowing and lending rates for the near or distant future respectively. Ceteris paribus, the rates of borrowing and lending *per instant* derived from these immediate, near and distant rates will *not* be the same in the new paradigm. Specifically, the rates of borrowing and lending per instant in the immediate future will be the highest, given the benchmark rates of return on investment per instant from the immediate arbitrage opportunities. Consistent with hyperbolic discounting (Ainslie, 1975), these rates of borrowing and lending per instant reduce sharply in the near future in the absence of immediate arbitrage opportunities, and reduce slowly thereafter, on account of the rising *term premia* of lending and borrowing rates for loans of longer rather than shorter terms. The latter is due to the rising level of risk from longer holding periods. Let us note that, in this scenario, if ${}_{i}^{0}R$ is the discount rate applicable to a cash amount at the end of year $i>1$ from our perspective at the start of year 1, and ${}_{i}^{i-1}r$ is the annual discount rate for year i such that $(1+{}_{n}^{0}R)=\prod_{i=1}^{n}(1+{}_{i}^{i-1}r)$, under hyperbolic discounting, ${}_{i}^{i-1}r$ reduces as i gets larger.

Preference reversals: In contrast to the new paradigm, the standard paradigm fails to distinguish between choice-ordering versus trade-ordering or price-ordering of a set of objects, as we explained in Section 3. However, this difference is found in experiments on

lotteries (Lichtenstein and Slovic, 1971, Grether and Plott, 1979), where it is referred to as "preference reversal". Tversky *et al* (1990, p.204) sum up these findings as follows:

> **"**…there is a substantial body of evidence showing that the price ordering of risky prospects is systematically different from the choice ordering [of the same] …"

This phenomenon arises for goods also, as we explained in Section 3, and it reflects the fact that the standard paradigm fails to distinguish between preference-orderings of a set of objects when the same set is evaluated from different perspectives by the same individual.

Prospect theory: The experimental works of Kahneman and Tversky (1979) and Tversky and Kahneman (1992) reveal the individuals' *choice-ordering* of gambles with monetary payoffs against (i) sure amounts or (ii) other monetary gambles; however, they do not reveal the *price-ordering* of these gambles, although these scholars do not make this point explicitly clear. That is to say their experiments do not reveal how much the bid and offer prices of each gamble are. (Incidentally, the latter prices for each gamble will be different at the same date for the same individual, consistent with the instant endowment effect.) In the new paradigm, our definition of risk-caring behaviour does not put any restriction on the choice-ordering of market participants, reflected in the experimental findings of these scholars. Hence, the new paradigm can accommodate their experimental findings.

To support their experimental findings, Kahneman and Tversky (1979) and Tversky and Kahneman (1992) provide a descriptive theory of the *choice-ordering* of gambles in prospect theory, and inter alia, posit that individuals overweight *low* probabilities to justify activities like playing lotteries (which reflect *price-ordering* of these objects) in order to justify why people often buy lottery tickets. However, the latter requires a theory of the price-ordering of lotteries rather than their choice-ordering. Moreover, it is hard to justify the assumption of overweighting *low* probabilities, bearing in mind that everyday life is full of low probability accidents, which people often discount to get on with life. Moreover, the poor record of people's forecasting of rare financial crises does not support the assumption of overweighting

low probability economic events. In the new paradigm, we do not need to resort to psychological biases to justify the frequently observed behaviour of market participants on lotteries. For, we recognize that an individual who buys lottery tickets can see it as non-risky by our definition of a risky activity, and evaluate it as a good/service in its own right. Hence, in the new paradigm, it is quite possible for a risk-caring individual to buy a lottery ticket, *and* also buy an insurance policy to cover his/her risky activities, as seen often in the real-world.

Value addivity principle: The breakdown of the law of one price in its standard sense leads to breakdown of value addivity in its standard sense. Thus, we cannot claim such breakdown, seen empirically and experimentally, is always "irrational", as the standard paradigm does. We introduce in Section 5 the weak form of the law of one price, which retains some realistic features of the standard paradigm, whilst explaining many behavioural puzzles.

5. FURTHER ASSUMPTIONS & DEFININTIONS OF THE NEW PARADIM

The following assumptions and definitions help resolve more puzzles.

Interaction of demand and supply: The multiple prices of each good (or financial contract) fall within a subset of real positive numbers at any date, the upper and lower bounds of which are finite, with arbitrageurs contributing to the determination of these limits. Thus, there will always be a price so high at which no one will buy a good and a price so low at which no one will sell it. We refer to the average price (weighted by traded quantity) of each good (or financial contract) at any date as its *mean* price (See Appendix 2); and we allude to the fluctuation in this mean price over time as *price volatility*. We recognize that traders cannot predict with certainty the demand for the goods that they will trade in, and hence there is no guarantee of having their supplies matching their demands at each date. Within the upper and lower bounds for prices of each good, unless aggregate quantity demanded equals aggregate quantity supplied for it, which is possible but not inevitable, we assume that *excess aggregate*

demand for the good leads to its mean price rising, and *excess aggregate supply of it leads to its mean price falling*, until either of the aforesaid bounds is reached, when the reverse process may start, giving rise to a *cycle of endogenous price volatility* over the short or the long term, which has a direct relationship with the fluctuations in traders' cash flows. We will study the macroeconomic impact of these fluctuations on traders' cash flows in paper II.

Liquidity: An implication of the assumption of timeless transactions in the standard paradigm is that it leads to the denial of the existence of *capital-in-circulation* in the economy, representing the flow of money and goods in-transit between buyers and sellers engaged in continual trading at any time. The money part of this capital, to which we refer as *floating capital*, provides liquidity for the economy. The Central Bank in part decides on its size.

Liquid versus illiquid goods/assets: A specific good (or asset) is *liquid* at any time when at least one transaction for immediate cash settlement, with no likelihood of delay or default in exchange for it, is made; otherwise it is *illiquid*. The *greater* the volume of such transactions in the same good at any time, the *more* liquid the good will then be. In a price volatility cycle, goods can become illiquid when they reach either their highest or lowest prices, i.e. when they either have no buyers or no sellers. The level of liquidity i.e. floating capital chasing different goods need not be the same at the same time and need not show equal variability over time. For instance, consumer goods can show less volatility in their liquidity than financial assets at the same time. At any date, the more liquid a good/an asset is, the quicker it can finish a roundtrip of buying and selling to yield any arbitrage profit. Hence, ceteris paribus, the spread in prices of more liquid goods/assets will be narrower than less liquid goods/assets, reflecting their lower cost of capital tied up in arbitrage transactions.

Liquidity premium/discount: Ceteris paribus, in spot transactions which determine current prices, when there is excess aggregate demand for a good/asset, it trades more, and thus it is more liquid, and has a higher mean price than when there is an excess aggregate supply of it.

This gives rise to a *liquidity premium/discount* for the good. If aggregate demand and supply for the good equal, which is possible but not inevitable, these liquidity premia/discounts disappear. These liquidity premia/discounts, which arise from the normal interaction of demand and supply, are not recognized in equilibrium theories of the standard paradigm, as liquidity fluctuations are completely ignored there. In the new paradigm, the existence and size of liquidity premia and discounts, reflecting the fluctuations in the level of liquidity in the economy (in part decided by the Central Bank), may not be decidable ex-ante, based on freely and readily available current information, contrary to the "rational" expectations hypothesis.

Weak law of one price: In the CEFE of the new paradigm, the law of one price in its standard sense (which we call the *strong law of one price*) does not hold. For, no market participant can buy *and* sell the same good at the same price at the same date without incurring the opportunity cost of the scarce capital tied up during these transactions, which is non-negligible, as we have already demonstrated. However, we may assume that *the same solvent market participant can buy or sell a good, on its own and/or as part of a bundle of goods, at a single price at the same date*. We call this assumption the *weak law of one price*. Thus, the weak law of one price holds if each good bought *or* sold (but not bought *and* sold) by the same trader has the same price at the same date, and the price of each good is the same irrespective of whether it is traded on its own or in a bundle with other goods. Let us note that the strong law of one price implies the weak law of one price, but the opposite is not true. Hence, believers in the standard paradigm cannot reject the weak law of one price, without rejecting the strong law of one price, and thus contradicting themselves.

Under the weak law of one price, from the perspective of the same market participant, the buying price of a bundle of goods is the sum of the buying prices of each good in the bundle; similarly, the selling price of a bundle of goods is the sum of the selling prices of each good in the bundle. However, these two prices for the same bundle of goods at the same date cannot be the same, as the selling price of a bundle of goods exceeds its buying price for the

same trader at the same date. Let us also note that the weak law of one price does not deny the existence of multiple prices at the same date for the same good for *different* market participants in a competitive market. Remarkably, unlike the strong law of one price which can never hold in the real-world or in a coherent theory as we have shown, the weak law of one price can hold in many realistic situations (e.g. your shopping bill), *and* in a coherent theory as we will explain. Nonetheless, we recognize that there are cases where even the weak law of one price does not hold e.g. the difference between the buying price of a complete set of ornate china and an incomplete set of the same may well be different from the concurrent but separate buying price of the missing items in the incomplete set. Hence, the new paradigm, like any scientific paradigm, cannot provide a *full* picture of the real-world.

In the new paradigm, we recognize that at any point in time only a tiny fraction of each good, asset or liability is in trade. For analytical purposes, unless stated otherwise, in our valuations of goods, assets and liabilities we attribute to the untraded goods, assets and liabilities the *mean* prices of their contemporaneous traded perfect substitutes under the weak law of *one* price. However, we can do so either to the buying price or the selling price of a good at the same date and not both. We also attribute to the untraded assets and liabilities the *mean* rates of investment return, and the *mean* discount rates (applicable to cash flows of assets and liabilities) of their contemporaneous traded perfect substitutes (as defined in Appendix 2).

Other assumptions: We assume production, consumption and trade occur continually for the economy as a whole. We also assume shareholders' unanimity on all corporate policies, unless indicated otherwise.

6. RESOLUTION OF PUZZLES IN FINANCIAL ECONOMICS

In this Section, we show puzzles such as those relating to corporate financial policy, excess volatility of share prices, and corporate control premium in the standard theory of finance

arise from its internal inconsistencies, and demonstrate how the new paradigm resolves them.

Debt-capacity: Appendix 5 proves that in the new paradigm, all market participants, including firms, have a *maximum debt-capacity or equivalently a tolerable limit for their expected borrowing rates* and breaching this limit leads to their insolvency, and possibly bankruptcy. In the case of a firm, the rationale for the existence of this maximum debt-capacity is that as the borrowings of the firm increase, the financial risk of the firm (i.e. threats to its solvency) also increases, leading investors, who are risk-caring, to require greater rates of return to offset the greater risk of the insolvency of the firm. However, the assets of the firm cannot provide an ever increasing rate of return; hence the firm cannot increase its borrowings indefinitely, otherwise it will become insolvent, and possibly bankrupt. This underscores the need for maintaining *at all times* a non-negligible amount of *retained equity* after payment of dividends, as a minimum to protect the solvency of the firm. This remains true in any infinite horizon. For, in the light of findings of Cantor (1845-1918), the end of one infinitely large time-horizon cannot be the end of all time altogether, and the firm will still need to trade after any infinitely distant time from now.

Corporate dividend policy: Miller & Modigliani (1961, p.418) base their views on the standard dividend valuation model of the equity of the firm, as they regard it to be "entirely valid". However, this model generates an internal inconsistency, as Appendix 6 proves. In the new paradigm, given the existence of a maximum debt-capacity for each firm, the dividend policy of the firm must be such that, as far as possible, the firm will always retain a minimum amount of equity for its debt-capacity to stay below its maximum level, and thus remain solvent. This implies that investors cannot be indifferent towards any arbitrary dividend policy, contrary to Miller and Modigliani (1961). Indeed, risk-caring shareholders prefer a smooth dividend policy as it reduces the volatility of their cash incomes. Therefore, for a firm, it is necessary to have a non-negligible permanent retained equity at all times in the

face of uncertainties to support its smooth dividend policy whilst maintaining its solvency.

Excess volatility of prices of equities compared to their income streams: Consider a jeweller firm which permanently maintains a fixed quantity of jewellery in gold with a fixed quality as its inventory, representing its retained equity at all times, which we assume it can sell at $200m currently. The current selling price of the equity of this firm is the capitalized value of its forecast dividend stream, arising from its trading activity, which we assume to be a perpetuity that it can sell at $1000m currently, plus the present value of the selling price of its forecast retained equity i.e. $200m in the infinite horizon. This yields $1,200m as the current selling price of the equity of the firm, which clearly will fluctuate, ceteris paribus, with the price of gold, whilst its dividend stream is smooth. The standard paradigm cannot explain the price volatility of the equity of this firm, and regards it as "excess" volatility.

We now explain how this puzzle arises in the standard paradigm and how it is resolved in the new paradigm. (See Appendix 7 for a formal treatment of the resolution of this puzzle.) Consider a perfectly durable and loan-able/rentable asset (such as gold or certain land) that never changes its intrinsic characteristics by assumption. The standard paradigm in computing the present selling price of the asset, when it is leased for an indefinite period with an annual rental income, capitalizes all its expected receivable annual rent, but overlooks the present value of the expected selling price of the asset in the infinite horizon, as it implicitly assumes the latter always tends to zero. This leads to the presumption of "excess" volatility of the price of the asset compared to its income stream.

In the new paradigm, under the weak law of *one* price, the present selling price of such an asset (as gold or certain land) is the capitalized value of all its expected receivable annual rent, plus the present value of its expected selling price at the end of all of the lease period. No puzzle arises when the lease period is finite. For, if, for example, we were to assume no volatility for the rental income, and a fixed degree of volatility for the selling price of the

asset, all in terms of present values, no "excess" volatility appears. When the lease period ends in the infinite horizon, the latter present value could be ignored (and the puzzle would reappear as in the standard paradigm) *if* the expected future selling price of the asset were assumed to grow by an annual rate less than the annual discount rate applicable to deriving its present value. However, in the new paradigm, as noted earlier in Section 4 under hyperbolic discounting, the annual discount rate will reduce as we approach the infinite horizon, whilst the expected selling price of the asset need not fall, and hence its present value cannot be ignored. Thus a similar case to when the lease period is finite arises, and this "excess" volatility disappears for a loan-able asset. We can now turn to the equity value of a firm.

Assuming unanimity of shareholders on corporate policy and on their investment holding period, under the weak law of one price, the selling price of the current equity value of the firm is the capitalized value of its expected receivable dividend stream, plus the present value of the selling price of its expected retained equity at the end of the shareholders' investment holding period. This is true even if the shareholders' investment holding period is in the infinite horizon. The present value of the selling price of the expected retained equity of the firm is implicitly assumed to tend to zero as we approach the infinite horizon in the standard dividend valuation model of share prices used by Shiller (1981). This leads to the claim that there is "excess" volatility in the share prices of firms compared to their dividend streams. In the new paradigm, as noted earlier in this Section under corporate dividend policy, it is necessary for a firm to have a non-negligible permanent retained equity in the face of uncertainties to help maintain its solvency at all times and have a smooth dividend policy, which risk-caring shareholders prefer as it reduces the volatility of their cash incomes. If the firm and its dividends are expected to grow in perpetuity, its expected retained equity must also grow to support its solvency. Thus, the present value of the expected retained equity of the firm in the infinite horizon cannot be negligible, given the non-negligible size of its retained equity and hyperbolic discounting in the new paradigm. Moreover, this retained equity will be volatile, given the endogenous volatility of all prices in the new paradigm. If,

for example, we were to assume, no volatility for the dividend income of the firm and a fixed degree of volatility for the selling price of the retained equity of the firm, all in terms of their present values, this "excess" volatility would disappear, as in the example of the jeweller.

Remark on discount to net asset value and corporate control premium: In the absence of shareholders' unanimity on corporate policy for a publicly listed firm, the strategic direction of the firm becomes uncertain, thus the share price of the firm becomes more volatile. This uncertainty generates the risk of shareholders losing control of the firm (an endogenous risk unrecognized in the existing literature); hence, ceteris paribus, the share price of such a firm will be lower than what it would be if shareholders were unanimous. Therefore, the equity value of such a firm may well suffer from a *discount* to its net asset value under shareholders' unanimity. As a result, the debt-capacity of the firm, measured by its debt-equity ratio, will also be lower. In such a case, if a single investor were to take over the firm and put in place his/her own corporate policy and remove the uncertainty regarding its *control*, then the share price of the firm could rise, reflecting its control *premium*, which would eliminate the discount to its net asset value. The standard paradigm of CEFE cannot explain either the discount to net asset value of listed firms or their corporate control premium.

7. CONCLUSION

The position of this paper is that an internal inconsistency is inadmissible in any scientific theory, as it makes that theory incoherent, meaningless and misleading. Scarcity of resources is the reason for the existence of economic theory. However, in this paper, we prove that this axiom is inconsistent with the law of one price in its standard sense, which has dominated economic theory since Aristotle. This unfortunate oversight underlies the many internal and external inconsistencies of the existing literature, attempts for the removal of which has consumed a huge amount of intellectual capital over centuries, without bringing about a common understanding of economic behaviour and price formation, including asset pricing.

We prove that the implicit assumption in the existing literature that the transfer of goods or money between parties in transactions can occur timelessly leads to internal contradictions; hence transactions must take a non-zero of quantity of time to be valid. This makes it impossible for the law of one price in the standard CEFE to hold. For, in any competitive and frictionless economy, price competition amongst traders leads each good, including every asset, to be traded at multiple prices concurrently. This generates arbitrage opportunities, the exploitation of which ties up scarce capital for a non-zero quantity of time. On the other hand, there is no limit to the number of arbitrage opportunities that can exist at any date. Given that no single arbitrageur can have sufficient capital to exploit all arbitrage opportunities in every good (or asset) concurrently, each arbitrageur will have a non-negligible opportunity cost, represented by one of his/her unexploited arbitrage opportunities, if no better opportunity exists. This leads to the breakdown of the law of one price in its standard sense.

More generally, the perennial nature of price competition in a CEFE gives rise to continuous exploitation of arbitrage opportunities. This ties up scarce capital permanently; the opportunity cost of which would have to be permanently zero for the cost free theory of arbitrage to hold, giving rise to a free lunch, and making this economy inefficient. This invalidates the cost free theory of arbitrage in any CEFE, and leads to: the breakdown of the law of one price in its standard sense, and the emergence of the CEFE of the new paradigm with no inevitable equilibrium tendency. In respect of asset pricing, the new paradigm does not reject the assumption that market participants discount freely and readily available information. However, it points out that this information includes the dominant paradigm of the day irrespective whether it is right or wrong, and it rejects "rational expectations" hypothesis, based on "rational" pricing behaviour, which is implicit in Fama's efficient market hypothesis. Moreover, the new paradigm explains and recognizes the impact of endogenous volatility of prices and fluctuating levels of liquidity, which are not recognized in the standard paradigm. The latter fluctuations generate liquidity premia/discounts and impact all prices, including equity prices, the measure of which may not be decidable ex-ante.

Hansen and Shiller are right to say that market participants do not behave in accordance with so-called "rational" pricing theory, contradicting Fama. However, all these laureates are wrong in assuming that "rational" pricing theory is founded on a rational premise, as this theory ignores the opportunity cost of the scarce capital necessary for engaging in arbitrage in competitive, efficient and frictionless economies. This leads to internal inconsistencies within the standard paradigm, which, we propose, are the root cause of its external inconsistencies. Taking account of this opportunity cost leads to the CEFE of the new paradigm which presents a new theory of price formation and explicitly admits the role of the State in the provision of fiat money via the Central Bank. Leaving out unknown unknowns, the new paradigm defines a risky activity for an individual as a future event that the lack of foreknowledge of its outcome before the event occurs generates a welfare loss for him/her, and assumes risk-caring market participants require greater compensation for greater risk-taking. The new paradigm resolves many behavioural puzzles in microeconomics e.g. instant endowment effect, asymmetric valuation of gains and losses, hyperbolic discounting, preference reversals, and explains how a risk-caring individual may also play lotteries.

The new paradigm proves that corporate financial policy matters to investors. In particular, it shows that there is a maximum debt-capacity and a maximum risk-underwriting capacity for each market participant, irrespective of the nature of the activities that they engage in. The new paradigm explains why investors in equities prefer smooth rather than volatile dividend income streams, and it accounts for the excess volatility of equity prices of firms compared to their dividend income streams, and shows how discount to net asset value and corporate control premium arise for listed firms. Moreover, many more puzzles that are generated by the standard paradigm such as the equity premium puzzle never arise in the new paradigm. In resolving these puzzles, we have shown that the critical factor is the removal of the internal inconsistencies from the standard paradigm, as we have not admitted frictions into the CEFE of the new paradigm. We therefore conclude that the standard paradigm cannot resolve its many puzzles without removing its deep-seated internal contradictions.

Appendix 1: Why transactions cannot be assumed to take place timelessly in a model

Existing literature in economics and finance implicitly assumes that when a spot transaction occurs, as in Figure 1 of Section 3, it does not take even a non-zero infinitesimal quantity of time for the transfer of the good or money to take place between the parties to the exchange. In other words, it assumes that the "Instant of Exchange" in Figure 1 has zero length of time, hence the use of "spot" as an adjective to describe such cash-for-goods transactions which are settled immediately. Although certain models admit the need for some positive quantity of time for such activities as auctioneering, bargaining, searching or ordering which take place *prior* to any transaction, none of these models admit the need for the elapse of any non-zero quantity of time for the exchange of goods or monies *during* transactions. This presumption holds not only in timeless "static" models but also in extant "dynamic" models. Here, we prove that this assumption violates the fundamental axiom of scarcity of resources.

Proposition: *Market participants in competitive, efficient and frictionless economies of the standard paradigm can always obtain a free lunch/money pump within a finite time, given that in this paradigm transfers between parties in a transaction can take place in no time.*

Proof: Consider a private market participant who borrows from another private market participant a loan at the start of time-period θ_{d-1}, and pays off this loan with its accrued interest at the end of time-period θ_{d-1}, which is also the start of time-period θ_d, for every date $d = 1, 2, 3, \ldots$ (of no length in time) such that at every $d > 0$ the new loan equals all that is needed (in terms of principal and interest) to pay off the previous loan, hence the market participant never defaults. *This is based on the assumption that at each date* $d > 0$ *valid transactions e.g. repayment of the old loan and the borrowing of the new loan can take place concurrently without taking any time, which is permissible in the CEFE of the standard paradigm.* (Notice that we do not claim that this assumption can hold in real-life.)

Let us assume the initial loan is $l_0 > 0$ at date 0 and the total amount of the principal and interest payable is l_d at date d, and the amount re-borrowed at date $d > 0$ is also l_d. The new lender at each date need not be the same as the old one. Hence, the cash transfers of the borrower in respect of these loans and their repayments at dates $d = 1, 2, 3, ...$ as perceived in the standard paradigm are as shown in the following table.

Table 2: Cash flows of the borrower in respect of loans from the capital market

Date	0	1	2	3	…….
Cash flow	l_0	$l_1 - l_1$	$l_2 - l_2$	$l_3 - l_3$	…….
OR: Net cash	l_0	0	0	0	…….

Thus, the borrower obtains a sure free lunch of l_0, which can be of any finite size. Remarkably, this process can take place not only over an infinite horizon, but also over a finite horizon $0 < T < \infty$. For example, the length of the duration of each successive loan starting at dates $d = 0, 1, 2, 3, ...$ can be $\theta_d = 2^{-d-1}T$ where $\sum_{d=0} \theta_d = T$. In this case, at the end of T, the duration of the loan at this date is zero, which is equivalent to having had no loan. We thus have to recognize that the CEFE of the standard paradigm always offers arbitrage opportunities in the sense of Dybvig and Ross (1987, p.100):

> "An arbitrage opportunity is an investment strategy that guarantees a positive payoff in some contingency with no possibility of a negative payoff and with no net investment."

In this connexion, it is worth noting that the existing literature already recognizes the generation of free lunches in some of the central models of CEFE of the standard paradigm, without identifying the cause of this problem, for example:

(1) Geanakoplos (1987, p. 119) notes that in the Arrow-Debreu model of general equilibrium:

> "...owners...of firms collect [economic] profits even though they have contributed

nothing...".

(2) Dybvig and Ingersoll (1982) in the context of the pricing of assets and derivatives observe:

> "…the familiar CAPM pricing relation can hold for all assets in a complete market only if arbitrage opportunities exist."

Moreover, instead of engaging in repeated borrowing and repayment by re-borrowing during period T, we can do the same in every one of the periods θ_d where $d = 0,1,2,3,\ldots$. This leads to a free lunch of an infinite size by the end of T, hence breaching the axiom of scarcity. These free lunches/money pumps disappear as soon as we drop the assumption that valid transfers between parties in a transaction can take place timelessly. For, that makes it impossible for the same market participant to re-borrow and repay the same amount of money at the same point of no length in time at dates $d = 1,2,3,\ldots$ in any model. This is why when borrowing and repayment by re-borrowing takes place repeatedly in real-life as in a Ponzi scheme, the borrower eventually defaults. Finally, let us note that this Proposition holds in the CEFE of the standard paradigm, irrespective of whether we take money to be in the fiat or commodity form e.g. gold.

Appendix 2: Definitions of scarcity of resources, fiat money, mean price, mean rate of investment return, mean discount rate, aggregate demand and aggregate supply

A *good* (including a service) is a welfare-gain generating object for an individual with the right to its enjoyment. Many individuals may find the same object having characterises of a good. We assume at any date in the economy: each physical good is finite in quantity and all physical goods are finite in number; moreover, the number of hours of work by any individual for providing future service is also finite, as is the population of individuals. At each date, the proper set comprising all *scarce resources* (i.e. physical goods and labour time available to

provide future services) on which individuals can have valid property rights is finite. The set of scarce resources can be different at each date. No one will relinquish his/her private property right over any positive quantity of an element of the set of scarce resources at a specific date without obtaining a valid claim against another element from the same set or other sets of scarce resources at future dates. *Fiat money* represents a valid claim against scarce resources, and for this reason the Central Bank ensures that its quantity is always finite. Contracts can exist for future delivery of scarce resources or fiat money.

The *mean price* of a good at a particular point in time is: $p = \sum_{i=1}^{k} P_i Q_i / \sum_{i=1}^{k} Q_i$ reflecting the ratio of the total quantity of money $\sum_{i=1}^{k} P_i Q_i$ in all concurrent transactions in that good to the total quantity of the good $\sum_{i=1}^{k} Q_i$ in those same transactions, where $i = 1, 2, 3, ...k$ represents the number of these transactions in the same good at price P_i and quantity Q_i. We can derive the mean prices of traded contracts (e.g. financial contracts) in a similar way as traded goods. For analytical purposes, given that at any date, only a fraction of each good or contract is traded, we attribute the mean prices of traded goods or traded contracts to their contemporaneous untraded perfect substitutes. Thereafter, we can determine the *mean rates of return* and the *mean discount rates* of traded financial contracts, given their receivable and payable cash flows. For analytical purposes, we attribute the mean rates of return and discount of traded financial contracts to their contemporaneous untraded perfect substitutes.

Aggregate demand for a good represents all the quantities of the good which market participants are willing and able to buy; and *aggregate supply* for a good represents all the quantities of the good which market participants are willing and able to sell. The excess of the quantity supplied over the quantity demanded for a good at the same date is called *excess supply* for it, and the excess of the quantity demanded over the quantity supplied for a good is

called *excess demand* for it. These concepts extend to a sector, or the whole, of the economy: At each date, the set of aggregate demands for all goods in a sector of the economy represents aggregate demand of that sector at that date. At each date, the set of aggregate supplies for all goods in a sector of the economy represents aggregate supply of that sector at that date.

Given that the ultimate aim of production is consumption, we define at each date the set of aggregate demands in all sectors producing consumer goods in the economy as *aggregate demand of the economy*. For the same reason, at each date, the set of aggregate supplies in all sectors producing consumer goods represents *aggregate supply of the economy*. Excess aggregate demand or excess aggregate supply for all goods of a sector or the economy as a whole at each date is computed at the mean price of each good at that date.

Incidentally, we should make it clear that the word *mean* in this context represents a weighted average of the actual prices, and it does not have the same meaning as *expected value*, as the weights attached to the actual prices are not the probability of the realization of those prices. Moreover, if a good is not traded at a specific point in time, it will have no price and hence no mean price (rather than a zero price), and thus it will be illiquid. For brevity, we may refer to aggregate demand and aggregate supply just as demand and supply, when the context does not generate confusion.

Appendix 3: Roles of institutions

We take it as given that for a society and its economy to survive beyond a generation, it needs to engage in certain activities in groups comprising more than one individual, continually and effectively. These activities include those aiming to: keep peace and order, fight natural disasters, exchange and produce goods or services, and pass on knowledge and skill from one generation to next. To achieve these aims, society organizes itself into *aim-specific* bodies which we call *institutions* such as households, farms, firms, markets, clubs, educational,

training and research organizations and the State (with its various specialist arms).

A *firm* in the CEFE of the new paradigm is a market participant which has various types of explicit or implicit contracts with other market participants e.g. suppliers of its inputs or customers for its outputs, with the aim of *transforming* the inputs it acquires into the outputs it generates, with the inputs being different objects from outputs. In contrast, *markets* do not transform objects, but *facilitate their exchange*. Coase (1937) does not recognize the role of firms in transforming inputs into outputs, and thus does not realize the distinction between firms and markets, and implies that the transformation process of inputs into outputs requires no entity, and attributes the reason for the existence of firms solely to minimizing transaction costs in an efficient economy. We do not deny that firms seek to minimize their transaction costs; however, this is not the primary aim or the reason for their existence in the first place.

The transformation of inputs into outputs which occurs internally in the firm may well be beyond the capability of a single individual, and can require different skills and specialists whose tasks need planning, coordination and continuity, hence giving rise to explicit and implicit contracts of various durations within the firm and amongst many market participants, with the firm as a market participant in its own right. These contracts help the orderly conduct of the operations of firms, and lead to what Williamson (2002) calls the "governance structure" of firms; however, they are not the primary aim or the reason for the existence of firms. Another aspect of the transformation process of the firm is that non-financial firms transform real assets (e.g. land, machinery and materials combined) into financial assets (e.g. in the form of equity and debt contracts), whilst financial firms (e.g. banks or insurers) transform one type of financial asset/liability into another, and thereby link the economic prospects of the citizens with each other and across different generations. Theories of Coase or Williamson do not pick up these transforming characteristics of firms.

All institutions (e.g. households, markets, firms) need a governance structure; as the latter is a

necessary apparatus for the orderly conduct of their operations, what distinguishes the firm from other institutions is its input-output transformation. Therefore, *in the new paradigm, the firm is a transformer with a governance structure*, and not a mathematically ill-defined production function (Robinson, 1954, Cohen and Harcourt, 2003) as in neoclassical economics. In the new paradigm, the existence of each firm becomes necessary to the extent that other market participants cannot, or choose not to generate the specific transformation it can provide. Consequently, *the State becomes the transformer for providing public goods and services including the governance structure of the society*. In this respect, the State/Central Bank emerge as natural monopolies. For instance, the Central Bank emerges on account of, inter alia, the need for a *unique* means of exchange with a single issuer of a unique risk profile leading to a single currency in the same economy rather than many means of exchange with many issuers with different risk profiles.

If economic equilibrium was always inevitable as in the standard CEFE, there would be no need for an economic role for the State/Central Bank. It is the natural emergence of economic imbalances that lead to an economic role for the State/Central Bank to moderate and fight off the publicly undesirable aspects of economic imbalances insofar as it is possible. This is not to gainsay the possible misuse/abuse of the State/Central Bank with adverse consequences for the public, which may result from a deceptive dominant paradigm or ideology.

Appendix 4: Internal inconsistencies of *the* Modigliani and Miller (1958) Propositions

Proposition: *The Modigliani and Miller (1958) Propositions on corporate capital structure in frictionless competitive markets of the standard paradigm generate inconsistencies.*

Proof: Modigliani & Miller (1958, p.267-268) take leverage i.e. the debt-equity ratio of the firm as the indicator of its financial risk. Proposition II of Modigliani & Miller (1958, p.271) on capital structure states that irrespective of shareholders' risk preferences:

"... the expected yield on a share of stock is equal to the appropriate capitalisation rate ... for a pure equity stream ... plus a premium for financial risk …" (Excerpt 1)

This requires that shareholders' expected yield (i.e. return on equity) must rise, if financial risk or leverage increases. However, Modigliani & Miller (1958, p.274, top of the page) recognize that ceteris paribus when companies increase their leverage, borrowing rates can also rise for them; and given a finite rate of return on assets which does not increase with increased financial risk (being fixed under ceteris paribus conditions), a point can arise when:

"... increased cost of borrowed funds as leverage increases will … be offset by a corresponding reduction in the yield [i.e. return] of common stock. " (Excerpt 2)

This requires that shareholders' expected return must fall as a result of their increased financial risk, hence a contradiction for Proposition II. Modigliani & Miller (1958, p.274, bottom of the page) note that in the light of their admission in Excerpt 2, their Proposition II becomes invalid, and they state:

"…the relation between common stock yields and leverage will *no longer be the strictly linear one* given by … Proposition II. " (Our emphasis)

However, they fail to recognize the implication of this for their Proposition I, and deny any implication. In fact, we can prove that as a matter of mathematical logic that, if Proposition II of Modigliani & Miller (1958) does not hold, their Proposition I cannot hold either. To see this, let us assume that at a point in time A represents the aggregate price of the assets, and D and E represent the aggregate prices of the debt and equity contracts of the firm respectively, where A, D and E are all positive. Consider a fixed investment holding period T during when there is no distribution to, or contribution from, the providers of capital of the firm. Let us assume that the expected rates of return during period T are: r_A on assets, r_D on debt and r_E on equity, and the debt-equity ratio of the firm at the start of T is $h = \frac{D}{E}$.

Proposition I of Modigliani & Miller (1958) states: $A = D + E$ (1)

Proposition II of Modigliani & Miller (1958) states: $r_E = r_A + h(r_A - r_D)$ (2)

We can now prove that:

Lemma*: If equality (2) does not hold, then equality (1) cannot hold either*.

Proof: For, if (1) holds, at the end of T we must have

$$(1+r_A)A=(1+r_D)D+(1+r_E)E \tag{3}$$

On the other hand, if (2) does not hold, we have $r_E \neq r_A+h(r_A-r_D)$, then by adding hr_D to both sides of this inequality and replacing h with $\frac{D}{E}$, and multiplying both side by E, we obtain $r_D D+r_E E \neq r_A(D+E)$. Combining this last inequality with $A=D+E$ yields $A+r_A A \neq D+r_D D+E+r_E E$ or $(1+r_A)A \neq (1+r_D)D+(1+r_E)E$. The latter inequality contradicts equality (3), hence we cannot assume that equality (1) holds either. Therefore, neither Proposition I nor Proposition II of Modigliani & Miller (1958) can hold.

Appendix 5: Resolution of the capital structure puzzle in the new paradigm

In the standard paradigm of competitive, efficient and frictionless economies, it is no surprise that Modigliani and Miller (1958) find that the capital structure of the firm, or indeed any corporate financial policy, does not matter. For, their propositions rely on the cost free theory of arbitrage, which implicitly rules out scarcity of capital in the form of fiat money, as noted in the main text of this paper.

Standard textbooks build on the internally inconsistent Modigliani and Miller (1958) model and claim that after accounting for bankruptcy costs and taxes, a firm will have a fixed optimum debt-equity ratio, despite the fact that prices of debt and equity have very different volatility, and hence no firm can maintain a fixed debt-equity ratio. It is thus no surprise that there is hardly any empirical evidence to support this view.

The following Proposition upholds the *weak* law of one price (with the latter being the mean

price), and the unanimity of investors' views on corporate policy, and on the holding period of their investments. We further assume that each market participant has a probability distribution for his/her prospective rates of return on each of his/her investments, with a well-defined expected value. (However, we do not claim to know anything else about the precise characteristics of this probability distribution.) We take leverage i.e. the debt-equity ratio as an indicator of *financial risk* as in Modigliani & Miller (1958, p.267-268). We also assume that each market participant is *risk-caring* such that he/she never accepts a project with an infinite measure of risk, and always requires more compensation for greater risk-taking.

Proposition: *In the CEFE of the new paradigm, all market participants who borrow to invest have a maximum debt-capacity or equivalently a tolerable limit for their expected borrowing rate; and breaching this limit leads to their insolvency*.

Proof: We prove this Proposition initially in the case of firms, and thereafter extend it to other market participants. We consider a firm which is currently solvent with its existing combination of equity and debt, and we wish to know when it may become insolvent. At present $A>0$ represents the aggregate buying price of the assets, whilst $E>0$ and $D>0$ represent respectively the aggregate buying prices of the equity and debt of this firm. Let us evaluate this firm from the perspective of a prospective holder of all its assets and liabilities under the weak law of *one* price with the mean price representing this single *one* price. There are two ways for a single investor to acquire all the assets of such a firm:

(i) Purchase all the assets directly from the firm at price A or

(ii) Purchase all the claims on the assets of the firm from holders of its equity and debt contracts at price $E+D$.

In the CEFE of the new paradigm, under the weak law of one price, the same investor can buy a bundle of goods only at a single price in this economy at any time, thus for the firm as a whole at the same date, this investor's purchase price of its assets in (i) must equal his/her

purchase price of claims on these same assets in (ii), hence:

$$A = E + D \tag{1}$$

Consider a fixed investment holding period T from now, during when there is no distribution to, or contribution from, the providers of capital to the firm. Let us assume that the expected rates of return during period T are: r_A on assets, r_E on equity and r_D on debt, and the debt-equity ratio of the firm at the beginning of T is $h = \frac{D}{E}$. At the end of T i.e. at the point of the distribution of returns for period T to the providers of capital of the firm, under (1) one can write: $(1+r_A)A = (1+r_E)E + (1+r_D)D$, which, given $A = E + D$, simplifies to: $r_A A = r_E E + r_D D$ or

$$r_E = r_A + h(r_A - r_D) \tag{2}$$

Let us recall that equalities (1) and (2) hold only when we assume the existence of a solvent firm with the combination of equity E and debt D generating the debt-equity ratio h at the beginning of T. This is in the new paradigm where arbitrage cannot eliminate the spread in prices of each good, and all market participants are risk-caring. These equalities do not imply Modigliani & Miller (1958) Proposition I on irrelevance of capital structure of a firm, or Proposition II on the relationship of its expected return on equity and financial risk, as the strong law of one price, on which their Propositions rely, does not hold in the new paradigm.

The question for us now is to find the combination of equity and debt that makes the firm insolvent, bearing in mind that all investors are risk-caring. We know that the firm is solvent when its debt-equity ratio is equal to or less than h. Clearly, $h \neq \infty$ as a risk-caring investor does not voluntarily accept any project with an unbounded measure of risk. Hence, we cannot have a solvent firm financed with 100% debt and no equity, or a debt of an infinite size. We specify further conditions to derive the maximum debt-capacity of the firm: Consider when a rise of Δh in the debt-equity ratio of the firm generates an increase of Δr_D in the expected

rate of return payable on loans to its risk-caring lenders such that $\Delta r_D > (r_A - r_D)\frac{\Delta h}{h + \Delta h}$. It follows that $\Delta h \times (r_A - r_D - \Delta r_D) - h \times \Delta r_D < 0$, if $r_A + h(r_A - r_D)$ is added to both sides of the latter inequality, one obtains:

$$r_A + (h + \Delta h)(r_A - r_D - \Delta r_D) < r_A + h(r_A - r_D) \tag{3}$$

The right hand-side of (3) represents the expected rate of return on the equity of the firm when its debt-equity ratio is h; and the left hand-side of (3) represents the expected rate of return on the equity of the firm, following the increase of Δh in its debt-equity ratio. Under these conditions, for the firm, the expected rate of return on equity will *fall*, whilst the financial risk borne by the shareholders *increases*, which will be unacceptable to risk-caring shareholders, hence the breakdown of (1) and (2). On the other hand, if $\Delta r_D < (r_A - r_D)\frac{\Delta h}{h + \Delta h}$, then $\Delta h \times (r_A - r_D - \Delta r_D) - h \times \Delta r_D > 0$ and if $r_A + h(r_A - r_D)$ is added to both sides of the latter inequality, one obtains:

$$r_A + (h + \Delta h)(r_A - r_D - \Delta r_D) > r_A + h(r_A - r_D) \tag{4}$$

Under the latter conditions, the expected rate of return on equity will rise, whilst the financial risk borne by the shareholders also increases, which can be acceptable to risk-caring investors, hence maintaining (1) and (2). This means that for this firm, there is a maximum debt-equity ratio of $h_m = h + \Delta h$ where $\Delta r_D = (r_A - r_D)\frac{\Delta h}{h + \Delta h}$. This is the maximum rise in the expected cost of debt that shareholders of this firm will tolerate, leading to a maximum debt-equity ratio of:

$$h_m = h(1 - \frac{\Delta r_D}{r_A - r_D})^{-1} \tag{5}$$

Thus, the maximum debt-equity ratio of the firm depends on the shareholders' maximum tolerable rise in its expected cost of debt. For example, when $r_A = 9\%$, $r_D = 1\%$ and $h = 50\%$, assuming the maximum tolerable rise in the expected cost of debt is $\Delta r_D = 3\%$, the maximum debt-equity ratio will be $h_m = 80\%$.

It is important to note that the maximum debt-capacity of the firm can be breached due to reasons outside the control of the management of the firm such as a general decline in the level of liquidity of the economy in a negative economic imbalance, which we will study in a paper II. Let us note that when this maximum debt-capacity is breached the firm will not be able to finance its ongoing operations unless its risk-caring investors can accept lower return for higher risk, which is not possible. Therefore, investors, being dissatisfied with their expected returns, will stop financing the firm, and will withdraw their stakes in the firm and the firm will not be able to raise funds at a tolerable cost to run. It will thus become *insolvent*. If this happens to a bank, in the absence of support from the Central Bank, the bank will face a bank run.

Let us also note that insolvency arrives *before* the equity value of the firm falls to zero and the firm becomes bankrupt, for example in the above case, insolvency arises when the debt-equity ratio is $h_m = 80\%$. Thereafter, the firm may try to sell its assets to remedy its insolvency; this can lead to sharp falls in the price of these assets, and in the extreme case, it may lead to a point when the firm becomes bankrupt. Finally, let us note that the firm in this Proposition can be any market participant who invests his/her endowed and borrowed money in his/her business. Moreover, *as long as the weak law of one price with the mean price as the single price holds, this Proposition will hold even for a monopoly*. This is significant bearing in mind that a natural monopoly, such as the State as the provider of public goods, can exist in the CEFE of the new paradigm (see Appendix 3). We have thus proved that any market participant who borrows to invest has a maximum debt-capacity or equivalently a tolerable limit to his/her expected borrowing rate, and breaching this limit leads to his/her insolvency.

A typical case: We can now determine the maximum debt-capacity of a firm, assuming as a first proxy a linear relation between its expected cost of debt and its debt-equity ratio which, given the risk-caring characteristic of market participants, requires that ceteris paribus the

expected cost of debt of the firm to rise with its debt-equity ratio, thus we have:

$r_D = ah + b,$ where $\infty > a > 0$ and $\infty > b > 0$ (6)

This case is in fact very much in line with Modigliani & Miller (1958, p.273) views:

> "Economic theory and market experience both suggest that the yields demanded by lenders tend to increase with the debt-equity ratio of the borrowing firm (or individual)."

We assume goods (including services and financial assets) and monies are perfectly divisible in this case. By replacing r_D in equality (2) with $r_D = ah + b,$ we have $r_E = r_A + h(r_A - ah - b)$ or $r_E = r_A + (r_A - b)h - ah^2$. We thus can obtain the maximum debt-equity ratio of the firm: $h_m = (r_A - b)/2a$ (7)

This is when the maximum expected return on its equity is also obtained (i.e. where $\frac{dr_E}{dh} = (r_A - b) - 2ah = 0,$ and $\frac{d^2 r_E}{dh^2} = -2a < 0$) as in Figure 2.

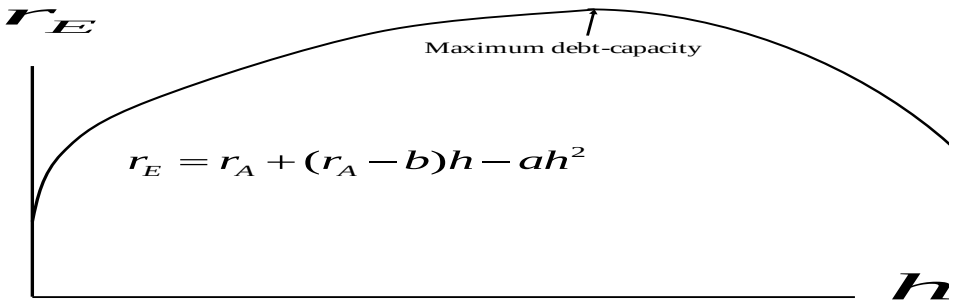

Fig. 2. The Maximum Debt-capacity of the Firm

Appendix 6: Internal inconsistencies of the Miller and Modigliani (1961) Proposition

Proposition: *The Miller and Modigliani (1961) Proposition on corporate dividend policy in frictionless competitive markets of the standard paradigm is based on an internally inconsistent dividend valuation model.*

Proof: Miller and Modigliani (1961, p.418), like the current believers in the standard paradigm, think that the standard dividend valuation model, which completely ignores the value of any retentions of the firm held in the infinite horizon, is "entirely valid". Thus, they base their dividend irrelevance Proposition on this equity valuation model. We illustrate here that this model generates contradictions.

Let us consider two all-equity companies in an efficient, frictionless and competitive economy in a world of perfect foresight i.e. *certainty,* with one company having a greater amount of invested assets (in monetary terms) than the other. Thus, the equity value of one company must be greater than the other. In the standard paradigm under certainty, the rate of return on all equity investments held in the same period is the same, and thus the discount rate applicable to the future cash flows of these two companies for computing present values of their equity are also the same. Now, consider the following situation:

Let both companies have exactly the same dividend policy in terms of amount and timing for ever, which they can both afford to pay. Given the same risk free discount rate under certainty, it follows from the standard dividend valuation model that the present value of the prospective dividends of each company will also be the same. Thus, both companies will have the same equity value, hence a contradiction for the standard dividend valuation model, and proof that it is not '"entirely valid" contrary to Miller & Modigliani (1961, p.418), who rely on this to justify their "theorem".

Appendix 7: The reason why the equity of the firm shows "excess" volatility

Let us consider a firm in the CEFE of the new paradigm where the weak law of one price (with the latter being represented by the mean price) and the unanimity of investors on corporate policy hold and the holding period of their investment in this firm is the same. For simplicity, we assume there will be no new issues of shares or own purchase of shares by the

firm in the future, and the prospects of the firm indicate that it is not in continual decline.

We consider the share price of a shareholder who owns one of the m numbers of shares issued by this firm. Let F_i be the prospective retained equity of the firm at the end of year i after all its expected dividend payouts upto and including year i, where $i = 1, 2, 3, ...$. For shareholders of the firm at the end of year i, the value of F_i will equal the selling price of the assets of the firm less the payment required for relief from its liabilities. We assume ${}^{0}_{n}P$ is the current selling price of a share in this firm from the perspective of a shareholder who intends to hold this investment from now until the end of year n.

It follows that ${}^{0}_{n}P = \sum_{i=1}^{n} \frac{E(D_n)}{1+{}^{0}_{n}R} + \frac{m^{-1}E(F_n)}{1+{}^{0}_{n}R}$, where $E(\cdot)$ is the expectation operator, D_i is the dividend per share of the firm at the end of year i and ${}^{0}_{i}R$ is the discount rate applicable to the receivable cash from this firm at the end of year i from the perspective of this shareholder currently (i.e. at the start of year 1 or the end of year 0). This is where the discount rate ${}^{i-1}_{i}r$ for the period starting at the end of year $i-1$ and finishing at the end of year i is such that $(1+{}^{0}_{n}R) = \prod_{i=1}^{n}(1+{}^{i-1}_{i}r)$.

When the holding period is in the infinite future, the current selling price $\lim_{n\to\infty}{}^{0}P$ of the share of the firm with a retained equity of $F_{n\to\infty}$ after payment of all prospective dividends for this shareholder will be: $\lim_{n\to\infty}{}^{0}P = \sum_{n=1} \frac{E(D_n)}{1+{}^{0}_{n}R} + m^{-1}\lim_{n\to\infty}\frac{E(F_n)}{1+{}^{0}_{n}R}$. Let us assume the firm retains only a minimum amount of its equity after payment of its dividends to stay solvent in any year. Given that the firm is not in continual decline, we can assume that the expected dividends of the firm are never to fall from their current level, in which case, the expected retained equity of the firm must also never fall from its current level. Thus

$E(F_n) = (1+g_n)E(F_{n-1})$, where $g_n \geq 0$ represents the annual growth rate of the expected retained equity of the firm in year n. This remains true even when $n \to \infty$. Let us note that we are not assuming that the expected dividends and the expected retained equity of the firm grow at the same pace.

In the new paradigm, hyperbolic discounting leads to the discount rate ${}^{n-1}_{n}r$ for year n to decrease as n increases, the pace of which declines the further we move in the future. Thus as long as $g_n \geq {}^{n-1}_{n}r \geq 0$ under hyperbolic discounting for any $n > q < \infty$ with q being a year in the distant future, but not the infinite horizon, which is perfectly possible, the present value of the expected retained equity of the firm in the infinite horizon does not tend to zero, for:

$$\lim_{n\to\infty} \frac{E(F_n)}{1+{}^{0}_{n}R} = \lim_{n\to\infty} \frac{(1+g_n)E(F_{n-1})}{(1+{}^{n-1}_{n}r)(1+{}^{0}_{n-1}R)} \geq \lim_{n\to\infty} \frac{E(F_{n-1})}{1+{}^{0}_{n-1}R} \geq \lim_{n\to\infty} \frac{E(F_{n-2})}{1+{}^{0}_{n-2}R} \geq \ldots \frac{E(F_q)}{1+{}^{0}_{q}R} > 0.$$

Therefore, given that the firm is not in decline, its retained equity will not vanish at any time, and it will be volatile, ceteris paribus, in line with liquidity fluctuations in the market for its retained assets and liabilities, even if the dividend stream of the firm were smooth. Hence, the present value of its expected retained equity will not vanish either and will be volatile, and thus ${}^{0}_{n\to\infty}P = \sum_{n=1} \frac{E(D_n)}{1+{}^{0}_{n}R} + m^{-1} \lim_{n\to\infty} \frac{E(F_n)}{1+{}^{0}_{n}R}$ i.e. the share price of the firm will be volatile.

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