The Scientific Journal of Agricultural Economics

Volume 1

Issue 1

Published by
ECO-ENA: Economics & ECO-Engineering Associate, Inc., Canada
The Scientific Journal of Agricultural Economics
ISSN 1923-6514 (Online)

2012

Published by: ECO-ENA: Economics & ECO-Engineering Associate, Inc.

The Scientific Journal of Agricultural Economics
ISSN 1923-6514 (Online): Library & Archives Canada

The Scientific Journal of Agricultural Economics, ISSN 1923-6514 (Online): Library & Archive Canada

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The Scientific Journal of Agricultural Economics

Welcome to the first volume of the *Scientific Journal of Agricultural Economics.*

Agricultural economics is a branch of the Economic Science that studies how individuals who operate in the agricultural sector make their optimal decisions. Research on agricultural economics is extremely important because agriculture is the economic activity that provides food to humankind. The relevance of this sector was formally recognised in the 1940s when starvation affected several European countries during the II World War. The recognition of the agriculture sector as a key economic sector led to the development of formal policies such as the Common Agricultural Policy of the European Union with the purpose of protecting the sector and maintaining high levels of farm income in order to reach subsistence and to avoid by this way, the food scarcity that Europe suffered during the II World War.

Nowadays, the key role of agriculture is still recognised by academics and policy makers. However, this sector is facing important changes in several countries, arising from a change of policy orientation which started in the 1980s. That is, policy programmes adopted in the past have been criticized as a consequence of their distorting effect on the economy. These critics have led important policies reforms with the objective of promoting development and competitiveness in the agricultural sector. This new political orientation has in practice altered the business environment and farmers have been put into a very risky situation (e.g. they are now facing volatile prices of commodities that are traded internationally). Farmers are not only losing their traditional business enterprises, but also are facing important market barriers that limit diversification into more profitable business activities. This transitional period characterised by a transformation from a protected to a more competitive economy has originated a number of investigations. These include studies developed with the purpose of explaining explain farmers' incentives to choose productive plans, the adoption of innovative practices, how farmers adjust in response to changes in the agricultural business environment, the adoption of environmental practices, and the relationship between agriculture and other sectors, among others.

In addition to this transitional period, there is now concern regarding the future of the sector in relation to the expected increase in food demand as a consequence of population growth over the next decades. It is believed that this increase will cause pressure on natural resources and environmental damage. Is the current transitional period from a protected to a competitive economy the best way to address the future higher demand for food? We cannot answer this question with the current state of the available research. On the contrary, there are several research gaps that need to be filled in order to gain a better understanding of the rural sector and its role in the economy and the environment. Consequently, there is a need for the development of investigations that deal with different aspects of the complexity that characterises agriculture. They include research on alternative business models that include environmental considerations, effects of policy reforms in rural areas, trade of agricultural commodities, farmers' economic and social behaviour, globalisation and agriculture, etc.

It is the mission of this journal to publish articles of high quality relating to all aspects of agricultural economics and agribusiness that offer insights of how to deal with the current and future challenges and problems described in the previous paragraphs.

In this first issue we present three papers which are concerned with themes of significant relevance for the rural sector, namely: a methodological approach used to predict future prices of agricultural products; a novel business model that proposes a way to reduce poverty in rural areas; and an up-to-date review of the current research on the environment.

In particular, Suppanunta Romprasert investigates the efficiency of futures pricing for ribbed smoked rubber sheet no.3 (RSS3). This investigation offers useful forecasting models that can be used to assist investors to make decisions. This researcher found that futures prices for ribbed smoked rubber sheet no.3 (RSS3) are influenced by a number of factors such as the Tokyo Commodity Exchange (TOCOM) and crude oil price, among others. This finding proves that the modelling approach developed by the researcher provides a useful tool that could be extended to forecast futures prices of other commodities.

Arif Nindito, on the other hand, proposes a business model based on collaboration across stakeholders that can be adopted to promote development, welfare and business opportunities in poor areas of rural societies. In this model small and medium enterprises play significant roles in the process of economic development and local capacity building by acting as innovation catalysts and community leaders.

Finally, John Adams provides an extensive and up-to-date literature review on the interface between environmental science and its' political and economic context. The article highlights a number of sensitive and critical aspects of the environment that form a basis for the debate of key topics such as climate warming, policies that prioritise economic growth over climate stability, and the transformation of the economy away from dependence on fossil fuels. The article also offers a critical assessment of the reasons that explain the current trends of the environment, and lists a number of issues that might be investigated in future research. According to the author, facing down the perfect storm implies the biggest cultural transformation in human history.

We would like to thank the contributors to this first edition of the journal. We also look forward to the publication of future works in these and other areas related to agricultural economics and agribusiness. We also look forward to receiving contributions from our Third Annual Conference of Economic Forum of Entrepreneurship and International Business in Oxford University in February 2013.

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Applied Econometrics for Agricultural Futures: Case of Natural Rubber Ribbed Smoked Sheets No.3

Abstract

The study investigates the efficiency of futures pricing for ribbed smoked rubber sheet no.3 (RSS3) during the period 2004-2009 and presents forecasting models along with results from the most efficient models that can help investors make more accurate buy and sell decisions. It addresses the question "Is price process in RSS3 futures market efficient?" Time series data from RSS3 futures was used as a leading indicator for the spot price of Thailand. The results indicate that the daily futures prices served as unbiased estimators of future spot prices and there was independence on daily price changes. The tests consistently supported the unbiased hypothesis which implies that Thailand's RSS3 futures market is efficient and aids the process of price. This study would fill the information gap in the prediction of future spot prices with a guide to understanding how the futures market behaves. Part of forecasting, the study employs univariate, market timing and Diebold-Mariano as the criterions for the selection of the best prediction model. It includes an analysis of factors affecting the RSS3 futures prices in Thailand's futures market. The results show that the Tokyo Commodity Exchange (TOCOM), world synthetic rubber consumption, net imports natural rubber China and crude oil price significantly affect the futures prices in the same direction. Particularly, the crude oil price is the leading indicator for the trend in rubber futures prices in Thailand. The analytical model is shown to be applicable and would facilitate related studies in forecasting the futures prices of other commodities. The time-series data is found to be suitable for the forecasting model.

Keywords: Applied Econometrics, Agricultural Futures, Natural Rubber
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The Scientific Journal of Agricultural Economics, ISSN 1923-6514 (Online): Library & Archive Canada

1. Introduction

The development of futures market in Thailand and the unique institutional characteristics, prompted researchers to study the basic properties of how price behaves, at the moment, there are few published literatures on futures market in Thailand and fewer yet that are based on statistical characteristics of prices. The study would provide better information and fill some gap in the literature by making a detailed examination of futures price especially rubber product in Thailand. So, the paper seeks to answer the questions on efficiency and forecasting in price of RSS3 in Thailand. The comprehensive test on efficiency of rubber futures was conducted by examining a period of time over which rubber futures had existed. It examined the random walk and unbiased hypotheses for RSS3. Based on the empirical evidence, the paper argues that Thailand's RSS3 futures market is efficient and aids the process of price because futures price could be unbiased predictor of future spot price.

The forecasting logic of rubber prices in futures market is to a certain extent similar to the price movement in stock market. It can also provide an estimate, taking into consideration the effects of external factors. This is because adjustment of rubber price in the long term may be affected by the law of supply and demand. However, the purpose of the futures market is to serve as an instrument for agricultural rubber groups, producers, agricultural suppliers, and investors to manage risks associated with fluctuations in commodity prices. This involves the buffering of risks related to efficiency, transparency and fairness. Hence, the study will focus on the methods of forecasting by using two cases. The first case uses the technical analysis in which it focuses only on the duration of rubber prices without considering exogenous variables. The second, the fundamental analysis, accounts for the effects of exogenous variables.

Each analysis has its strength and weakness points. The paper integrates the technical and fundamental analyses in investigating the probability of the fundamental analysis results to see the extent to which the fundamental analysis can be trusted. The fundamental analysis in the current year has many forecasting methods, but the most well-known and frequently used analytical programs include the Naïve or Random Walk (RW), Random Walk with Drift (RWD), Vector Auto Regressive (VAR), Autoregressive (AR), Simple Moving Average (MA), Simple Exponential Smoothing (SES), Trend (T), Random Walk with Drift and Trend (RWDT) and Box-Jenkins (ARIMA). In addition, the study highlights proper method in determining the movement of rubber price data in futures market and finds proper period of time and appropriate number of data used in forecasting. The line graph is used in considering trend of rubber prices that occurs in subsequent periods. Generally, the fundamental analysis is used to examine the factors that influence rubber prices and determine the rubber price when the factors that influence rubber price are dynamic. However, the paper focuses on the market price mechanism.

The paper's objectives include the following: (1) to answer the question on efficiency price; and (2) to discover the proper forecasting model. To achieve these objectives, the paper focuses on a number of key considerations.

First, the Agricultural Futures Exchange market in Thailand (AFET). Second, rubber prices, which refer to the natural rubber ribbed smoked sheets no. 3. The reason is because it makes up a major share of exports, taking into account the observation on the level of exports FOB that is applied as the selling price in the futures market. Third, the forecasting model used in

the study. They are classified into two cases: (a) short time prediction, targeted at finding a forecasting model which is most suitable for daily rubber prices, and (b) long time prediction through the use of monthly forecasting. Before making the final decision, the paper considers and examines external factors that may affect the rubber futures prices. The graph-leading indicators are built to determine the period that rubber prices move up or down. Fourth, the time period used in short time prediction. The 310-day period of gathering data starts from 1st August 2007 to 31st October 2008. Fifth, the monthly time period, comprises of 61 months during May 2004 to May 2009. Both daily and monthly periods use 2/3 of the period as the estimator and 1/3 as the forecasting. Sixth, for both short and long time prediction, the paper observes the variables that affect rubber prices by using multiple regressions. The daily data used are taken during 1st August 2007 to 31st October 2008 while the monthly data is taken during May 2004 through May 2009. The variables used include the exchange rates between the Thai baht and U.S. dollar, the exchange rate between the Japanese yen and U.S. dollar, the price of crude oil, TOCOM, net imports of natural and synthetic rubber in Japan, net imports of natural and synthetic rubber in China, and the world consumption of natural and synthetic rubber. Lastly, periods when rubber prices expand or shrink via indicated factors are examined by graphical analysis between monthly rubber prices. The construction of the monthly rubber price model is derived from indicated variables, with the monthly natural rubber ribbed smoked sheets no. 3 price as the reference line. Furthermore, the comprehensive test of the efficiency of rubber futures was conducted by examining a period of time over which rubber futures had existed.

2. Literature Review

There is a relationship between the physicals and futures prices. Not only does the operation of hedging link physical and futures prices, but also futures prices are determined by factors influencing physical prices. In addition, the futures prices are widely used in physical trading around the world. Since there are many similar factors influencing demand and supply of the futures and physicals, the movements in the two prices are generally the same. Prices are likely to increase when demand is greater than supply and vice versa. In fact, movement in the same direction is the rationale behind hedging in the first place. However, even when they move in the same direction, they may not move at the same rate. The difference of the two prices, i.e. the basis, can be widening or narrowing whether price are rising or falling. For example, a rise in interest, with everything else constant, will result in lower physical prices but higher futures prices. The point is that even though prices may not move in the same direction, they are interrelated. In general, the futures prices lead physicals prices rather than the other way around. Because spot price is lower than the futures price and the delivery date is close by in a normal market, there will be a tendency for the increase in demand for spot and supply of the futures. People who are short in futures or those who are starting transactions by selling futures contract will buy spot and make delivery. On the other hand, those who are long or starting transactions by the purchase of a futures contract will liquidate. So, in theory, it can be said that the spot and distant prices do not necessarily move in the same direction and the basis can either increase or decrease.

What dominates and play roles in rubber price determination each day are some general factors that support the uptrend of rubber prices. The downtrend would happen when it comes to the reverse effect at the same. For example, oil price change by all means affects nearly everything in the world. Its by-product is also used as one of the main content to produce synthetic rubber. As synthetic rubber is a perfect substitute goods of natural rubber so when

oil price increase, synthetic rubber price increases and then natural rubber price also increase. Rubber stock at sellers may mean the current seasonal index in annual round. By nature, rubber trees stop yielding latex produce around the end of February until early June. It causes the aggregate rubber volume in the central market to be fewer. This situation tends to push the rubber market price to be in upward trend during the end of rubber season. The expectation of sellers is also set as a condition where the sellers hold the last stock for expectant high price to sell during the closing of the season. The rubber stock at buyers: when the big buyers like China keep collecting rubber stock with the expectation of future price buffer, it may control the price at the low level for some period of time. The big buyers are China, Japan and USA. The special demand for rubber usage from big buyers also counts. Tires and rubber-related goods are heavily produced to respond to the occurrence of economic boom. Furthermore, the signs that convey price significance: rubber price will be higher, when Yen depreciates, Baht depreciates, higher oil price, higher gold price, floods and heavy rains in growing areas, stock markets boom, big three buyer: interest rate down, big three buyers: economic growth, less rubber stock, hedge funds price support. Rubber price will be lower, when Yen appreciates, Baht appreciates, lower oil price, lower gold price, big three buyers slow down the purchase, hedge funds move to invest in gold and oil, big stock markets fall. The macroeconomic stability is an external, yet critical factor in the operations of the futures markets. Commodity price risk is merely one of the diverse risks that users of futures contracts try to hedge against. Thus, it is imperative that Thailand maintains a sound macroeconomic environment for a local exchange and contract to succeed.

Given the importance and the interest in the pricing efficiency of the futures markets, numerous studies have examined the efficiency of the agricultural futures markets. The relationship between spot price and futures prices in the up-dating period is investigated using cointegration econometrics such Haigh (2000) mentioned the stability in the relationship between the spot and futures rates using rolling cointegration techniques: results illustrated that the BIFFEX futures market is unbiased and hence efficient for the current, one, two and quarterly contract horizons meaning the futures contract appears to have become more efficient over time in predicting the spot rate. Similar to the view of McKenzie, Jiang, Djunaidi, Hoffman, and Wailes (2002) studied within the U.S. rice futures market providing that the U.S. long-grain rough rice futures market is efficient. They used standard OLS, cointegration and error-correction models to determine unbiasedness including derived the forecasting performance of the rice futures market from an additive ARIMA model. Based on Johansen's cointegration approach using on efficiency tests of agricultural commodity futures markets in China by Wang and Ke (2005) suggested that a long-term equilibrium relationship between the futures price and cash price for soybeans and weak short-term efficiency in the soybean futures market, but the futures market for wheat is inefficient, which may be caused by over-speculation and government intervention. All these recently researches get the same results by Ali and Gupta (2011) show that cointegration exists significantly in futures and spot prices for all the selected agricultural commodities in commodity exchanges of India except for wheat and rice. They suggest that there is a long-term relationship between futures and spot prices. On the other aspect, Kellard (2002) claimed that the finding of cointegration between commodity spot and lagged futures rates reflects the existence of commodity arbitrage and not, as is generally accepted, long-run market efficiency. Nearly every agricultural futures contract listed by an exchange today has been examined in some context (Garcia, Hudson, and Waller, 1988). In examining the necessary conditions for futures market efficiency, three sets of forecasts are used in predicting the USDA's announced Class III price: futures forecasts, forecasts generated from simple time series models, and expert opinion forecasts. These forecasts are first evaluated

using the traditional forecast accuracy measure of the root mean squared error. In addition to casual comparisons of mean squared error, the Multiple Data Model (MDM) procedure tests for statistical differences in forecast accuracy (Harvey, Leybourne, and Newbold, 1998) are used. The more stringent test of pricing efficiency, the forecast encompassing, is then tested in a multiple encompassing framework using the MS test statistic put forth by Hervey and Newbold, in which they suggest as a test statistic MS based on Hotelling's generalized T2-statistic. Intuitively, the futures market efficiency should be intimately linked to the ability of the market to be forecasted. Nevertheless, Working (1985) was reluctant to call futures prices forecasts.

Besides these, Makridakis, Wheelwright and McGee (1983) studied the accuracy of the combination method by emphasizing on the method of averaging from 14 forecasting methods such as naïve, simple moving average, exponential, ratio, Brown, Holt's, regression, Holt's and Winter, Automaic AEP, Lewandowski's FORSYS, Parzen'ARIMA' methodology, Bayesian forecasting, and BOX by MAPE. They found that accuracy depends on the number of methods that are used to combine because the more we join each method; the higher is the accuracy of forecasting. It is found that the prediction is stable if more than four methods are combined.

There are three forecast selection/combination techniques used to enhance the plausibility of dynamic forecast selection over a long period. When evaluating the ex-post effectiveness of forecasts, standard statistical measures are commonly used. The mean pricing error, mean absolute pricing error, mean absolute relative pricing error (MARPE), median absolute relative pricing error and root mean squared error (RMSE) are typically calculated. The results are used to generate conclusions about the accuracy of forecasts, for example, Just and Rausser (1981: 197-208); Leitch and Tanner (1991: 580-590); Bessler and Brandt (1992:249-263) including Gerlow, Irwin and Liu (1993:387-397). This research will focus primarily on RMSE, which gives a measure of the magnitude of the average forecast error, as an effective measure. It may be noted, however, that the RMSE is a measure that is commodity specific and cannot be readily used for comparing across commodities. Mean squared error (MSE) is used extensively to evaluate the forecasting performance of the futures markets. Early studies relied on casual comparisons of MSE (Leuthod, 1974: 271-279) while more recent studies have examined the statistical difference in forecast error (Irwin, Gerlow and Liu, 1994: 861-875). As previously stated, the necessary standard condition for the futures market efficiency is that no competing forecast such as a time series, econometric, or expert opinion forecast can provide a smaller MSE than the futures market forecast. However, differences in MSE among competing forecasts are often subtle, thus leading the researcher to wonder if differences in MSE are due only to chance. Although significant advances have been made in evaluating the statistical difference in prediction errors (Diebold and Mariano, 1995: 253-263; Harvey, Leybourne and Newbold, 1998:281-291), stating the necessary condition for the futures market inefficiency strictly in a comparative MSE framework is potentially misleading. The Root Mean Square Error (RMSE) is one of the most widely used measures of forecast accuracy. While simple and intuitive, MSE is not without potential drawbacks. First, MSE may be inconsistent with profit measures, as was pointed out in Leitch and Tanner (1991: 580-590); Stekler (1991: 375-384) and Swanson and White (1995: 265-257). Furthermore, MSE is not invariant to non-singular, scale preserving linear transformations. This problem is discussed in Clements and Hendry (1995:127-146).

As the magnitude of the RMSE is specific to each price series, it can be difficult to quickly assess the performance of a model from this statistic. Hence in this application, the RMSE

result is displayed relative to the RMSE of either the random walk model or the others, to facilitate comparison between models. The base model will have a value of unity. If a comparison model has a relative RMSE value greater than unity, it may be considered to underperform the base model in terms of statistical accuracy. On the other hand, a relative RMSE value less than unity would indicate superior RMSE performance in relation to the base model.

Another test of the directional performance of forecast models is the Cumby and Modest (1987: 169-189) test for market timing ability, which is an extension of the Merton (1981: 363-406) market timing test. It was designed to use information about the magnitude of change, as well as the direction of change, to generate a performance statistic. The estimates are applied with the White (1980: 817-835) adjustment for heteroskedasticity. In essence, this differs from the Harding-Pagan statistic in that the dependent variable incorporates both the magnitude as well as the direction of the change. Hence, the Cumby-Modest statistic gives extra weight to situations under which the forecast would have correctly predicted the direction of large actual changes in spot prices. When a forecast misses a directional change in prices that is small in magnitude, it is not penalized as heavily by the Cumby-Modest statistic as it is by the Harding-Pagan statistic. This alternative model selection criterion is suggested by Henriksson and Merton (1981: 513-533); Schnader and Stekler (1990: 99-107); Pesaran and Timmermann (1994: 1-7); and Stekler (1994: 495-505), which can be used to forecast economic turning point. The confusion rate calculated in the paper is retrieved from a 2*2 contingency table, called Confusion Matrix (CM). The best model according to Confusing Rate (CR) is the least confusing one (the one with the smallest value of CR). Pesaran and Timmermann (1994: 1-7) showed that the test of market timing in the context of forecasting the direction of assert price movements proposed by Henriksson and Merton is asymptotically equivalent to the standard chi-squared test of independence in a confusion matrix, when the column and row sums are not a priori fixed, which is the case in this analysis. One examines the standard chi-squared test of independence. The null hypothesis is the independence between the actual and the predicted directions. Thus, rejecting the null hypothesis provides direct evidence that the model is useful as a predictor of the sign of change in the prices. The chi-squared is therefore used to test statistics.

The Diebold-Mariano Predictive Accuracy Test (DM Test): Harvey, Leybourne and Newbold (1998: 281-291) originally proposed a modification of the Diebold-Mariano test for the differences in MSE to account for non-normal distributions of the forecast error series. The paper also constructs the asymptotic loss differential test proposed in Diebold and Mariano (1995: 253-263). Using only the loss differential series and the assumption that the loss differential series is covariant stationary and has short memory, the DM test has a null hypothesis that both forecasting models are equally accurate. Following the suggestion of Diebold and Mariano (1995: 253-263), the paper uses the rectangular lag window defined by $L(\tau/S(T)=1$ for $|\tau/S(T)|<1, = 0$ otherwise. Note that assuming (h-1)-dependence of loss differentials for h-step ahead forecasts implies only (h-1) sample autocovariances needed in the estimation of f(0), so that S(T)=h-1.

3. Methodology

The methodology primarily focuses on the use of the time series technique in understanding time related properties of RSS3 spot and futures market prices in Thailand, and to compare it with the naïve model. Traditional econometric techniques are found to be inadequate when

trying to make inferences with time ordered observational data. Prior theory traditionally suggests the explanatory variables that should go into a model. However, the theory was developed using the ceteris-paribus assumption. When "all other things" are not fixed, as is the case with experimental data, researchers must rely on less "structured" models. The paper used prior theory to suggest variables to be studied.

The methods can be classified into Quantitative forecasting and Qualitative forecasting. The quantitative forecasting is divided into two main groups: 1) Time Series Model: the paper continues to focus on the usage of time-series techniques to understand the time related properties of RSS3 and to compare each model with the naïve model, which views that the past behavior of an object that we want to predict should be enough to forecast behavior in the future, and includes the naïve method: $Y_{(t)} = Y_{(t-1)} + \&$ where & is the mean of the first difference, RWD method: $Y_{(t)} = Y_{(t-1)} + a_0 + e_t$ where a_0 is a constant term, VAR method is a theoretic analysis or non-structural analysis that summarizes the regularities in a set of variables which theory suggests as important, AR method: : $Y_{(t)} = b_1Y_{(t-1)} + b_2Y_{(t-2)} + \ldots. + b_pY_{(t-p)} + a_0 + e_t$ where a_0 is a constant term, moving average method: MA (1): $Y_{(t)} = a_0 + e_t - c_1e_{t-1}$, simple exponential smoothing method or ARIMA (0,1,1) without constant: it is a first-order moving average model with one order of non-seasonal differencing and no constant term, trend method: $Y_{(t)} = a + \sim t$ where t is the time index, RW with drift and trend method: $Y_{(t)} = Y_{(t-1)} + a_0 + e_t$ where a_0 is the constant drift; solving the difference equation $Y_{(t)} = Y_0 + a_0t + \Sigma e_i$ where the summation is over t. The terms $a_0t + \Sigma e_i$ are both non-stationary and ARIMA model extends the autoregressive moving average model. It may be an adequate model for non-stationary time series. Findings reveal that traditional mathematic techniques, such as mean squared error and root means squared error, are found to be inadequate when trying to make inferences with time ordered observational data. So, the suggesting that the explanatory variables that should go into a model; 2) the Casual Model, which views that the behavior of an object can be predicted from others that have suitable aspects to relate to each other, such as the regression method and econometrics method. The forecasting methods have different characteristics, strong points and weak points. None can provide a perfect forecast, therefore the most proper and reliable forecasting method should be selected. Selection criteria include the factors used in the method; for example, time period, data, number, validity, reliability and cost of applying the method (Makridakis, Wheelwright and Hyndman, 1998).

There are 10 statistical methods used in this paper: 1) the regression analysis was used to examine the relationship of a dependent variable or response variable to specified independent variables or explanatory variables. It can be used as a descriptive method of data analysis, such as curve fitting, without relying on any assumptions about the underlying processes in generating the data (Richard, 2004); 2) Random walk method, to model the diffusion of vorticity was first proposed by Chorin (1973). To simulate the diffusion of vorticity in vortex methods, the positions of the vortices are given random displacements (a random walk) (Chorin and Marsden, 1990). The basic idea of the random walk method is that the random displacements spread out the vortices like the diffusion process spreads out the vorticity; 3) Random walk with drift method, the best forecast of tomorrow's price is today's price plus a drift term. One could think of the drift as measuring a trend in the price (perhaps reflecting long-term inflation). Given the drift is usually assumed to be constant. Related: Mean reversion; 4) Vector auto regression; an econometric model used to capture the evolution and the interdependencies between multiple time series, generalizing the univariate AR models. All the variables in a VAR are treated symmetrically by including for each variable an equation explaining its evolution based on its own lags and the lags of all the

other variables in the model. Based on this feature, Christopher Sims advocates the use of VAR models as a theory-free method to estimate economic relationships, thus being an alternative to the "incredible identification restrictions" in structural models (Sim, 1980) Auto regression; a type of random process which is often used to model and predict various types of natural and social phenomena; 6) Moving average, commonly used with time series data to smooth out short-term fluctuations and highlight longer-term trends or cycles. Mathematically, a moving average is a type of convolution and so it is also similar to the low-pass filter used in signal processing. When used with non-time series data, a moving average simply acts as a generic smoothing operation without any specific connection to time, although typically some kind of ordering is implied; 7) Exponential smoothing method, in statistics, exponential smoothing refers to a particular type of moving average technique applied to the time series data, either to produce smoothed data for presentation or to make forecasts. Exponential smoothing is commonly applied to financial markets and economic data, but it can be used with any discrete set of repeated measurements. One disadvantage of this technique is that it cannot be used on the first k-1 term of the time series. A slightly more intricate method for smoothing a raw time series X_t is to calculate a weighted moving average by first choosing a set of weighting factors and then using these weights to calculate the smoothed statistics; 8) Trend, the relatively constant movement of a variable throughout a period of time. The period may be short-term or long-term, depending on the trend itself; 9) Random walk with drift, and 10) Box-Jenkins approach to modeling ARIMA processes was described in a highly influential book by statisticians George Box and Gwilym Jenkins in 1970. The original Box-Jenkins modeling procedure involves an iterative three-stage process of model selection, parameter estimation and model checking. Recent explanations of the process (Makridakis, Wheelwright and Hyndman, 1998) often add a preliminary stage of data preparation and a final stage of model application or forecasting. One of the attractive features of the Box-Jenkins approach to forecast is that ARIMA processes are a very rich class of possible models and it is usually possible to find a process that provides an adequate description to the data. The original Box-Jenkins modeling procedure involved an iterative three-stage process of model selection, parameter estimation and model checking. This is a complicated method and needs specialized expertise in data analysis. However it gives a higher accuracy than others in short-term prediction (Newbold and Granger, 1974).

The paper employs a number of out-of-sample model selection criteria to evaluate the predictive performance of the nine models considered. These criteria can be classified into three criteria: univariate criteria will focus primarily on root mean square error (RMSE), which gives a measure of the magnitude of the average forecast error, as an effectiveness measure, but paper still uses the other such as mean absolute percentage error (MAPE) that are closely related to mean square error (MSE), mean absolute error (MAE) is a common measure of forecast error in time series analysis including Thiel's U-statistic: if U-Statistic = 1, the naïve method is as good as the forecasting technique being evaluated. If it is less than 1, the forecasting technique being used is better than the naïve method. The smaller the U-statistic, the better the forecasting technique relative to the naïve method; however, if it is greater than 1, there is no point in using a formal forecasting method. Since using a naïve method will produce better results; market timing criteria can be used to forecast economic turning point. The confusion rate calculated in the paper is retrieved from a 2*2 contingency table called confusion matrix (CM) and Diebold-Mariano (DM) used only the loss differential series and the assumption that the loss differential series is covariance stationary and short memory, DM test has a null hypothesis that both forecasting models are equally accurate.

All time series data of RSS3 in the futures market, particularly the daily and monthly data, were collected. The reason for considering both daily and monthly prices is the benefit from studying the change in rubber price for both short and long periods. The rubber prices in time series were used for plotting graph checks for moving characteristic.

The equation of each method for daily and monthly rubber price are constructed from the methods previously mentioned. The value of regression on the prediction method is compared to the true monthly value. The model of rubber price for the monthly time series is constructed by studying the variables that affect the rubber price through the regression from May 2004 through May 2009. The paper also constructs the model and looks for the variables affecting rubber prices. It considers the period when the trend in rubber price is influenced by expansion or recession, as well as the business cycle index. This is done by graph analysis showing the relations between monthly rubber price and quantity of variables.

4. Empirical Results and Discussion

The discussion focuses on analyzing efficiency in price and on determining, the suitable forecasting model on the movement of rubber prices in the futures market. The variables are examined with the view of determining the rubber futures price that can help guide, plan, and control rubber price thereby making it less volatile. The last part analyzes the trends of rubber prices using the relationship between rubber prices and the leading indicator variables. The results are classified into four parts, as follows:

Studying efficient market on RSS3 futures to explain the form of price's movement and the return on investment of RSS3 futures, we provide into two parts. First part, we test the independent with futures itself by using tools, i.e, autocorrelation function test, run test and autoregressive model to show the return on RSS3 futures price whether independent. Also, using the variance ratio tests and unit root tests to show the return on RSS3 futures price whether follows by the random walk theory as in Table 1:

Table 1 Results Expressed Tools Analyzing Efficiency in Price

Tools for analyzing	Results
Autocorrelation Function (ACF)	Not Weak Form Efficient
Unit Root Tests:	
*Augmented Dickey-Fuller (ADF) Test	Weak Form Efficient
*The KPSS Test	Weak Form Efficient
Run Test	Weak Form Efficient
First-Order Autoregressive Scheme or AR(1)	Not Weak Form Efficient
Variance Ratio Tests	Weak Form Efficient

The results from Table 1 concluded that there were two methods that showed the RSS3 futures market was not weak form efficient, namely the Autocorrelation Function (ACF) and the First-Order Autoregressive Scheme or AR (1). The other three methods, namely the Unit Root Tests, Run Test, and Variance Ratio Tests, summarized that the RSS3 futures market was weak form efficient. The two methods that showed "not weak form efficient market" were parametric tests, which use only the normal distribution data. The parametric tests are less favorable when compared to the non-parametric tests. The non-parametric tests are now

more accepted for research in Thailand and foreign countries. Moreover, the Run Test and Variance Ratio tests are considered more reliable than the Autocorrelation Function (ACF) and First-Order Autoregressive Scheme or AR(1), in which the two latter tests concluded that the RSS3 futures market was weak form efficient. Furthermore, the Unit Root Tests by Augmented Dickey-Fuller (ADF) test and The KPSS test of stationary showed "non-stationary", following the random walk theory, also supported the weak form efficient market of the RSS3 futures.

Form Table 1, the variables used in cointegration model is non-stationary from testing on Unit Root Test; therefore, paper cannot explain the statistical values because of spurious equation. However, paper can solve the problem by doing the first difference and error correction model (ECM) along with an increasing the lag term into the equation for describing the relationship and the speed of adjustment of future spot price. The coming up process is on estimating error-correction model in data when the equation $\ln Spot_t = a + b_t \ln RSS3_{t-1}$ has cointegration, when the variable on time series that has cointegrated relationship, paper can use ECM which links between short and long run as following:

ΔS_{t+n} = a + b estimated $e_{t-1} + \Sigma c \Delta S_{(t+n)-i} + \Sigma d \Delta F_{t-j} + \mu_t$ where :

ΔS_{t+n} = first difference at natural logarithm of spot future price

$\Delta F_{t,n}$ = first difference at natural logarithm of futures price

b = speed of adjustment of spot future price

estimated e_{t-1} = residual of cointegration coming from S_{t+n} – estimated S_{t+n}

μ_t = residual of error correction model (ECM)

To find out the suitable ECM, paper considers from t-statistic of coefficient on the first difference at natural logarithm of spot future price at time (t+n)-1 by putting k equal five for maximum lag included in the model.

The results from the models show that most of ECM is significant for contract 1 to 3-month, so paper can conclude that the contract 1-month ahead future spot price, will have the speed of adjustment. Considering at contract 1-month ahead finds that the future spot price has the speed of adjustment to the long range equilibrium faster than the other contract month, as mention in previous, the contract near-month future spot price will have less volatile comparing to contract far-month. The further contract far-month, the higher futures price volatile is. When considering with the previous information on the long range relationship, it shows that the future price of futures contract 1 or 2-month can adjust be better than other contract month. However, too far-month on contract will affect the market not efficient causing the price on futures price cannot predict the future spot price. Therefore, paper can test again by combining the model with the leading indicators such as exchange rate, crude oil price and TOCOM (Tokyo futures price).

From OLS results, if the residual is stationary, it will explain that futures price and leading indicator have cointegration. The Wald Test finds that most of the results reject the hypothesis at significant 0.01. Then, it cannot conclude that all leading indicators can be the representative for RSS3 futures price. Even though, the cointegration can explain that only both crude oil price and TOCOM with futures price have long range equilibrium relationship. From cointegration results, it shows that the capacity being the representative for predicting futures price will be drop on using both exchange rate in Baht/$ and Yen/$. It can imply that

for both exchange rates being as leading indicators, the speculators cannot have much using as an effective response. However, they can use crude oil price or/and TOCOM to be the leading indicators helping them to make the decision for investment in futures market.

The ECM results show that all leading indicators cannot reject the null hypothesis of "no serial correlation". It means there is no autocorrelation problem. Using ARCH LM Test, all reject the null hypothesis autoregressive conditional heteroskedasticity. The ECM coefficient results are consistent to result from cointegration that there are long run relationship in crude oil price and TOCOM only. On estimating error-correction model in data when the equation $\ln Futures_t = a + b_t \ln(INDICATOR)_{t-1}$ has cointegration, the variable that has cointegrated relationship can adjust the short run to long run by calling as error correction model (ECM) which model links between short and long run as following:

$\Delta F_{t+1} = a + b \text{ estimated } e_{t-1} + \Sigma c \Delta F_{(t+n)-i} + \Sigma d \Delta INDICATOR_{t-j} + \mu_t$ where :

ΔF_{t+1}	= first difference at natural logarithm of futures price
$\Delta INDICATOR_{t-j}$	= first difference at natural logarithm of leading indicator price
b	= speed of adjustment of spot future price
estimated e_{t-1}	= residual of cointegration coming from F_{t+n} – estimated F_{t+n}
μ_t	= residual of error correction model (ECM)

The ECM needs to check the serial correlation problem by using Breusch-Godfrey Serial Correlation LM test (B-G Test). The results show that all leading indicators do not reject hypothesis "no serial correlation" meaning there is no autocorrelation problem summarizing in Table 2.

Table 2 Results Expressed on Stationary, Cointegration and Volatility of Efficiency in Price

Tests	Results
Without Leading Indicators:	
Stationary of residual without trend and constant (Mackinnon t-statistic)	Reject null hypothesis: futures price and future spot price have long range equilibrium relationship.
Wald Test	Cannot Reject the null hypothesis for both contracts 1 and 2-month: futures price can be the representative for future spot price.
Error Correction Model (ECM):	
Breusch-Godfrey Serial Correlation LM	Reject null hypothesis on no serial correlation: there is the autocorrelation problem excepting contract 1-month.
ARCH LM	Cannot Reject null hypothesis: the models are following the theory; also, the volatility of future spot price has the stationary of characteristic on "Homoscedasticity".
With Leading Indicators:	
Stationary of residual without trend and constant (Mackinnon t-statistic)	Reject null hypothesis: leading indicators and futures price have long range equilibrium relationship only crude oil

	price, TOCOM for daily and only TOCOM and net imports synthetic rubber China for monthly.
ECM: with leading indicators: Breusch-Godfrey Serial Correlation LM	Cannot Reject hypothesis on no serial correlation: there is autocorrelation problem.
ARCH LM	Cannot Reject hypothesis for monthly: the model was following the theory; also, the volatility of the leading indicators has stationary of characteristic on "homoscedasticity".

By adopting the model selection approach to RSS3 price in a real time forecasting scenario, the paper attempts to shed light on the usefulness of econometric forecasting, and the empirical relevance of modeling theoretical relationships between the futures and spot prices when constructing forecasting models providing in Table 3.

Table 3 Model Ranking by Univariate Criteria (1-step-ahead forecasts) in Pure Time Series on Only First Top Three

Criteria	Ranking 1	Ranking 2	Ranking 3
RMSE	VAR	ARIMA(1,1,1)	AR(1)
MAE	ARIMA(1,1,1)	VAR	SES
MAPE	ARIMA(1,1,1)	VAR	SES
THIL'S	VAR	ARIMA(1,1,1)	AR(1)

The univariate criteria in pure time series: VAR and ARIMA (1,1,1) is the best accurate model regarding to RMSE and MAE; ARIMA (1,1,1) is the best perfect fit model relying on MAPE; VAR is the best predictive performance model according to Thiel's U-statistic.

Table 4 Daily Leading Indicators Express by Lag Term on Only First Top Three

Criteria	Ranking 1	Ranking 2	Ranking 3
RMSE	VAR	AR(1)	SES
MAE	VAR	SES	RW
MAPE	VAR	SES	AR(1)
THIL'S	VAR	AR(1)	SES

The univariate criteria in daily leading indicators expressed by lag term: VAR is the best accurate model regarding to both RMSE and MAE; VAR is the best perfect fit model relying on MAPE; VAR is the best predictive performance model according to Thiel's U-statistic.

Table 5 Monthly Leading Indicators Expressed by Lag Term Only First Top Three

Criteria	Ranking 1	Ranking 2	Ranking 3
RMSE	RWDT	ARIMA(1,1,1)	IMSRJ
MAE	MA(1)	AR(1)	TOCOM
MAPE	IMSRJ	WCNR	EXR(฿/$)
THIL'S	ARIMA(1,1,1)	RWDT	IMSRJ

The univariate criteria in monthly leading indicators expressed by lag term: RWDT and MA(1) is the best accurate model regarding to RMSE and MAE; MA(1) is the best perfect fit model relying on MAPE; ARIMA(1,1,1) is the best predictive performance model according to Thiel's U-statistic.

Table 6 Daily Leading Indicators Expressed by ECM Only First Top Five

Criteria	Ranking 1	Ranking 2	Ranking 3	Ranking 4	Ranking 5
RMSE	TOCOM	Crude Oil Price	VAR	EXR(Yen/$)	EXR(฿/$)
MAE	TOCOM	VAR	Crude Oil Price	EXR(Yen/$)	SES
MAPE	TOCOM	VAR	Crude Oil Price	EXR(Yen/$)	EXR(฿/$)
THIL'S	TOCOM	VAR	Crude Oil Price	EXR(Yen/$)	EXR(฿/$)

The univariate criteria in daily leading indicators expressed by ECM: TOCOM is the best accurate model regarding to RMSE and MAE; TOCOM is the best perfect fit model relying on MAPE; TOCOM is the best predictive performance model according to Thiel's U-statistic.

Table 7 Monthly Leading Indicators Expressed by ECM Only First Top Five

Criteria	Ranking 1	Ranking 2	Ranking 3	Ranking 4	Ranking 5
RMSE	IMSRJ	IMNRC	RWDT	WCNR	ARIMA(1,1,1)
MAE	MA(1)	VAR	TOCOM	WCNR	RWDT
MAPE	VAR	MA(1)	TOCOM	WCNR	IMNRC
THIL'S	IMSRJ	IMNRC	ARIMA(1,1,1)	RWDT	WCNR

Univariate criteria in monthly leading indicators expressing by ECM: Net imports synthetic rubber Japan and MA(1) is the best accurate model regarding to RMSE and MAE; AR(1) is the best perfect fit model relying on MAPE; Net imports synthetic rubber Japan is the best predictive performance model according to Thiel's U-statistic.

Table 8 Diebold-Mariano Statistics of Predictive Accuracy

UNIVARIATE	RMSE	MAE	MAPE	5% level $\|S\| > 1.96$	Reject or Unable to reject Null hypothesis
RW – RWD	0.195	0.190	0.001793	-0.1675	Unable to reject null hypothesis
RW – VAR	0.169	0.131	0.001222	3.1532	Reject null hypothesis
RW – AR(1)	0.179	0.155	0.001448	2.1902	Reject null hypothesis
RW – MA(1)	0.180	0.157	0.001471	1.7352	Unable to reject null hypothesis
RW – SES	0.099	0.064	0.000617	1.8874	Unable to reject null hypothesis
RW – T	6.029	5.209	0.050018	-2,714.61	Reject null hypothesis
RW – RWDT	0.210	0.180	0.001680	0.9952	Unable to reject null hypothesis
RW – ARIMA (1,1,1)	0.196	0.170	0.001613	3.0268	Reject null hypothesis

Table 8 showed the results that RW - SES; RW - MA(1); RW - RWD and RW - RWDT are unable to reject the null hypothesis of equal predictive accuracy according with RMSE, MAE and MAPE. Moreover, statistically, the Diebold-Mariano test also shows that the pairs of model that do not able to reject the null hypothesis mean that those pairs do not differ in terms of their squared forecast errors. However, for the VAR, AR(1), RWDT and ARIMA(1,1,1) we can find better forecast performance as we can reject the null hypothesis at 5% level.

The last criterion is attempting to predict future market directions, usually by examining recent price and volume data or economic data, and investing based on those predictions; also, called timing the market showing in Table 9:

Table 9 Model Ranking by Market Timing Criterion

Market Timing	Confusion Matrix	Confusion Rate	Ranking	Chi-Square
RW	-597	0.596154	4	2.918402
RWD	-510	0.567308	1	0.838801
VAR	-834	0.644231	5	0.723896
AR(1)	-1,096	0.692308	7	0.621158
MA(1)	-1,192	0.711538	9	0.733287
SES	-1,103	0.692308	8	0.680194
T	-393	0.586538	2	0.135285
RWDT	-569	0.586538	3	0.865951
ARIMA(1,1,1)	-979	0.673077	6	0.556971

Table 9 reports the values of market timing criterion, for RSS3 commodity and forecast horizons. Judging by the confusion rate values, it is interesting to note that most of the models are quite accurate and correctly predict the direction of price changes in time. All of the chi-square values suggest rejecting the null hypothesis of statistical independence. In other words, most of models are useful for predicting the direction of futures price changes.

Analyses on the 310-day time-series multiple regression used the daily exchange rates between the Thai baht and U.S. dollar, the exchange rate between the Japanese yen and the U.S. dollar, the crude oil price and TOCOM that affect the monthly RSS3 futures price. The comparison between time-series and leading indicators models found that the first rank of univariate selection criteria for checking on the most accurate model according to the lowest values in both RMSE and MAE for time-series model was VAR. Furthermore, the outstanding rank in both RMSE and MAE for leading indicator was the exchange rate between the yen and the U.S. dollar. It is noticeable that there is not much difference between the numbers. Therefore, the multiple regression model enables for all the variables to be used as an option for forecasting with leading indicators. Multiple regression can create forecasting model as follows:

$$\begin{aligned} \text{dlog(futures)} = -0.003366 &+ 0.022657\ \text{dlog(oil)} + 0.230491\ \text{dlog(TOCOM)} \\ &\quad (1.237687)^{*} \qquad\quad (6.504277)^{****} \end{aligned}$$

The model shows that RSS3 futures price in AFET at time t has positively relationship with both crude oil price and TOCOM at the time when others are "ceteris paribus". If the crude oil price increases by 1 percent, it will affect the RSS3 futures price in AFET at time t which will increase by 0.022657 percent. If the TOCOM price increases by 1 percent, it will affect the RSS3 futures price in AFET at time t and will increase by 0.230491 percent.

In Figure 1, we select the line graph by visually comparing with "FUTURES" as the reference line. One of the reasons is because the particular line graph should be the leading character for reference graph. Another reason is that change for both leading and reference graph should not be much different from each other.

The study on selecting variables appropriate to be leading indicators for analyzing the RSS3 futures prices trend by using the graph found that the crude oil price can be the proper leading indicator for the futures price.

Analyses on the time-series multiple regression of 61 months used the effect of monthly exchange rate between Thai baht and U.S. dollar, crude oil price, exchange rate between yen and U.S. dollar, TOCOM, net imports of natural and synthetic rubber in Japan, net imports of natural and synthetic rubber in China, and the world natural and synthetic rubber consumption on the monthly RSS3 futures price. According to a comparison made between the time-series and leading indicators models, it was found that the top two ranks of univariate selection criteria for the most accurate model according to the lowest values in RMSE for time-series model was the RWDT and ARIMA (1,1,1). In MAE for time-series model was MA (1) and AR (1). Furthermore, the outstanding rank in RMSE and MAE for leading indicator was net imports synthetic rubber Japan and TOCOM, respectively. The forecasting model can be created as follows:

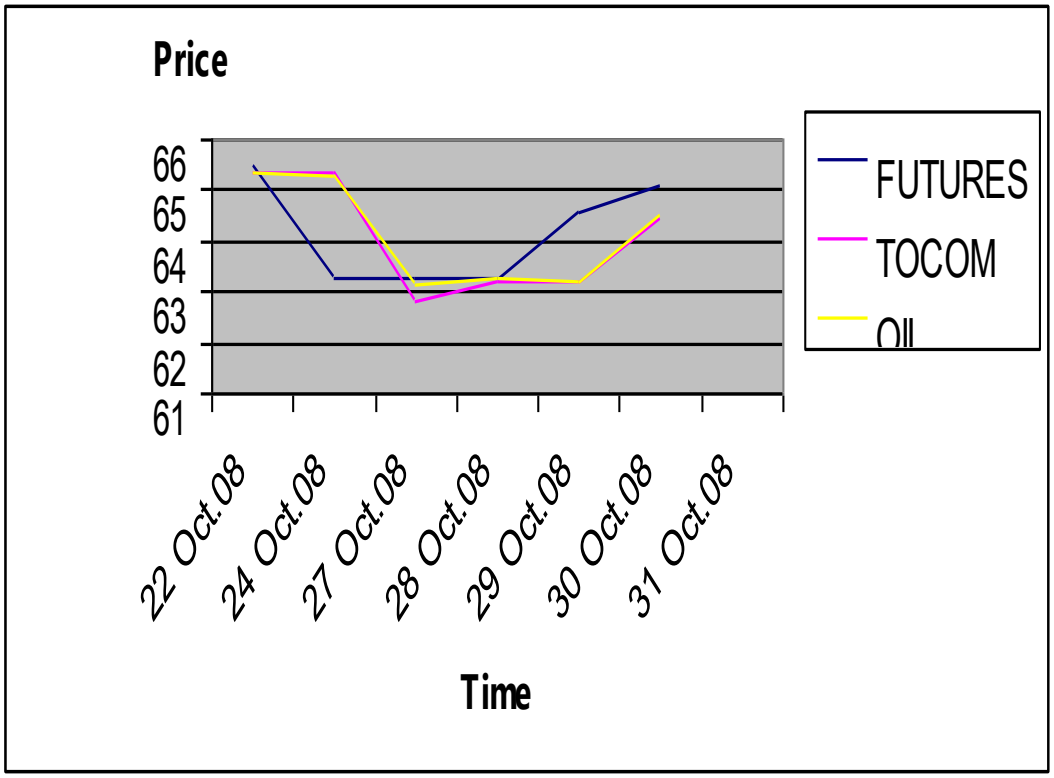

Figure 1 Seven Days Movement on Graph of Rubber Futures Price and Leading Indicators

dlog(futures) = -0.000305 - 0.072949 dlog(IMNC) + 0.232344 dlog(WSC) + 0.031489
(-4.481363)**** (3.507576)**** (2.225023)***

dlog(oil) + 0.992509 dlog(TOC)
(48.43469)****

The model shows that RSS3 futures price in AFET at time t has the positively relationship with world synthetic rubber consumption, crude oil price and TOCOM, but has the negatively relationship with net imports natural rubber China at a time when others are "ceteris paribus". If the world synthetic rubber consumption increases by 1 percent, it will affect on RSS3 futures price in AFET at time t increased by 0.232344 percent. If the crude oil price increases by 1 percent, it will affect the RSS3 futures price in AFET at time t a by 0.031489 percent increase. If the TOCOM price increases by 1 percent, it will affect the RSS3 futures price in AFET at time t by a 0.992509 percent increase. However, if the net imports of natural rubber in China increase by 1 percent, it will decrease the RSS3 futures price in AFET at time t by 0.0575 percent.

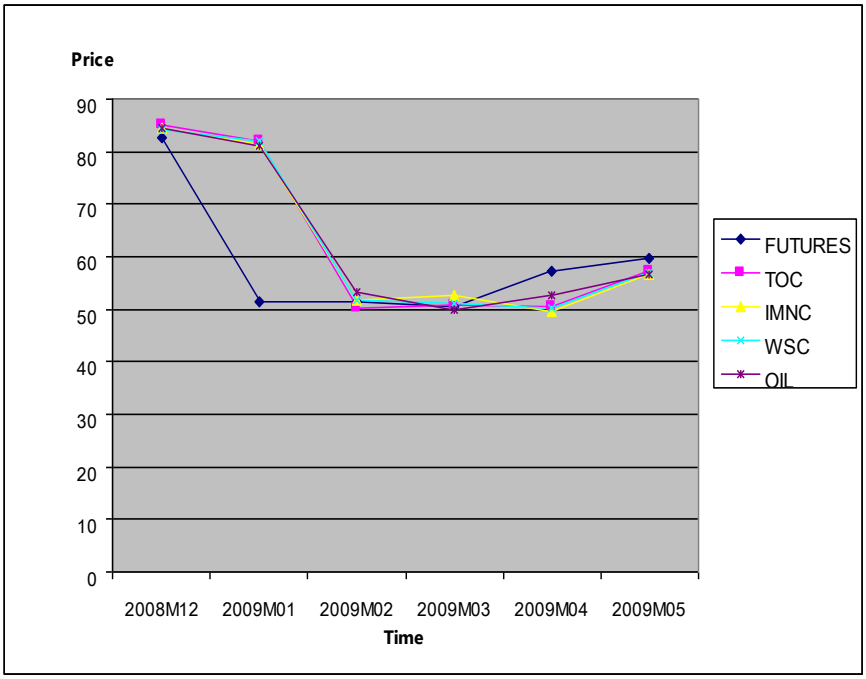

Figure 2 Six Months Movements on Graph of Rubber Futures Price and Leading Indicators

In Figure 2, we select the line graph again by visual comparing with the reference graph, FUTURES regarding on these characteristics. The graph shows that the trend of one-month decrease then two- month increase affects crude oil price, and will also affect the RSS3 futures price in the same direction.

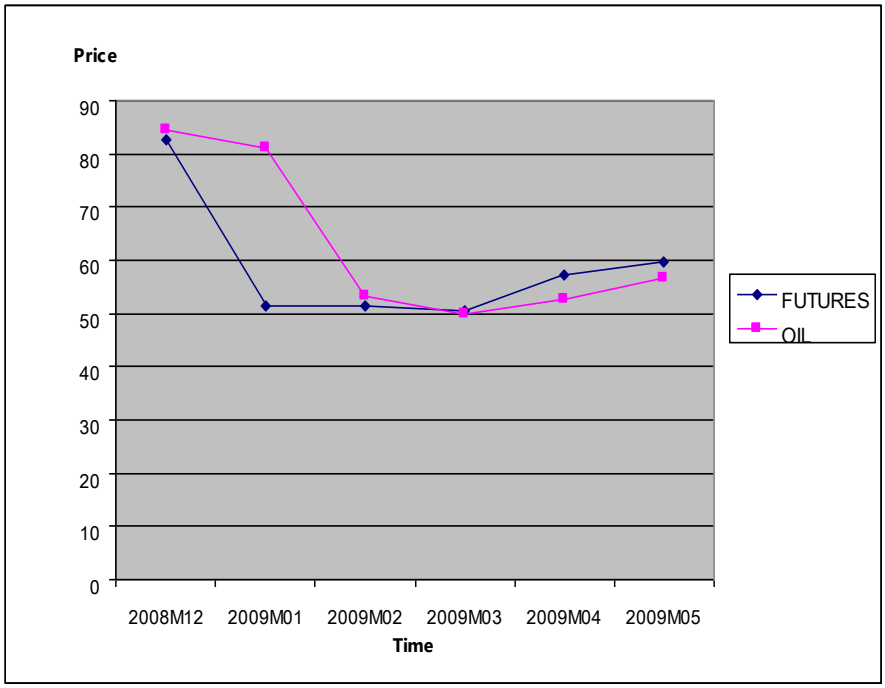

Figure 3 Six Months Movements on Graph of Rubber Futures Price and Crude Oil Price Leading Indicator

In Figure 3, considering the rubber futures price trend that is going to be happen in January 2009, the crude oil price is continuously decreasing to the mid of March 2009. The period with high supply of crude oil is estimated to be around two and a half months which it can expect that the rubber futures price will also drop for two and a half months period. It is expected that in March 2009 the price will be the lowest and then will increase again afterwards. So, the rubber futures price also has an increasing trend in the same period.

Table 10 Compare True Value with Expected Trend

Month Level	Month/Year	True Value
59	March/2009	50.65
60	April/2009	57.20
61	May/2009	59.56
62	June/2009	57.75
63	July/2009	59.11
64	August/2009	68.68

The results shown in the graph and the true value are corresponding to each other which it depicts that the there will be one month decrease and two months increase. The price dropped in March 2009 and after that during April and May 2009 increased to 59.56. In June 2009, the price decreased to 57.75 and increased back for two months until August 2009. However, if this pattern is correct, we expect to see a dropping price trend again in September 2009 and an increasing price trend in October and November 2009, respectively.

5. Conclusion

The result indicated that Thailand's RSS3 futures market was weak form efficient market. The daily and monthly futures prices served as unbiased estimators of future spot prices. Moreover, RSS3 futures price can be predicted by net imports natural rubber China, world synthetic rubber consumption, crude oil price and futures price TOCOM. Investors can use this information with futures price prediction to reduce uncertainty on their risks.

In this regard, the people who involve with the market are speculators, so government should motivate and inform the hedgers who the direct agricultural group is using the futures market as the optional choice on reducing or protecting the risk in the future when the RSS3 price drops. When the volume of RSS3 futures contract is widely accepted, it should reconsider on the other commodities to be the instruments on reducing the fluctuation of agricultural prices. Furthermore, if the futures market has the professional investors using the sophisticated trade to set up the funds for trading, this might be the case that futures price can be the representative of future spot price followed by the theory on the ratio of expected representative equal to one. This will make more knowledgeable in futures market expansion. Therefore, the government should support on setting up the funds to make the futures market efficiency and to develop the potential of agents in the futures market.

And finally, it is interesting to academic researchers and explorers for future research. In future period, the data should collect in addition when the time goes by to make the suitable equation. The study does not include other commodities such as rice (BHMR and BWR5) and potato (TC); if there is available data and more volumes, it interest to test on. In addition, the test of GARCH or EGARCH may be a suggesting for future research on price volatile.

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Arif Nindito

Rural Development through Creating Shared Value at the Bottom of Pyramid: Review and Roadmap

Abstract

The social and economic livelihood of the poorer sectors of society at the Bottom of Pyramid (BOP) still needs a more inclusive market-based solution. Synergy among stakeholders is needed to address poverty and food production problems, particularly in rural areas. However, current BOP literature has not yet incorporated the possibility of such synergy into the discussion. This study proposes a business model in which stakeholders play collaborative roles to create shared values in the BOP society. Small and medium enterprises (SMEs) will play significant roles in the process of economic development and local capacity building by acting as innovation catalysts and community leaders. By doing so, the livelihood quality of the rural poor living in the BOP can improve. Thus, in the long run, the problem of urbanization can also be minimized.

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The Scientific Journal of Agricultural Economics, ISSN 1923-6514 (Online): Library & Archive Canada

1. Introduction

Current increases in the world population are creating a significantly higher demand for food and energy globally. In its 2010 report, the World Economic Forum estimates that by 2050, global food production needs to be doubled from its current level (World Economic Forum, 2010). In the meantime, we are facing resource constraints in our current food production system that makes it more difficult to feed the world (The Economist, 2011). The agricultural sector as the main source of food and fibres is now entering the new era of producing more with fewer resources. Since agriculture accounts for 70% of water use and up to 30% of greenhouse gas emissions, it contributes to and is threatened by environmental degradation (World Economic Forum, 2010).

From the social perspective, the estimated two billion increases in world population over the next 40 years will also bring new challenges to the agricultural sector. Agriculture generates 40% of worldwide employment, and this rises to 70% amongst the bottom billion (World Economic forum, 2010). Today, there are 4 billion people living with less than US$1,500 annual per capita income in the world, and this income group is referred to in the literature as the "bottom of pyramid" (BOP) (Prahalad and Hart, 2002; Prahalad, 2004). On its 2010 report on agriculture, the World Economic Forum (2010) mentioned that nearly one billion people are hungry today and half of them are farmers. Furthermore, three-quarters of the poor in developing countries live rural area and over two billion people earn less than US$ 2 a day. In fact, much of the projected increase in food demand will also dominantly come from the developing countries that share a large portion of the BOP. Moreover, the World Bank has estimated that economic growth in the agricultural sector is twice as effective in reducing poverty as growth in other sectors of the economy. Hence, strengthening agricultural value chains may be among the most effective ways to address global poverty (World Development Report, 2008).

Prahalad (2004) estimates a market potential of US$ 13 trillion at the BOP. Particularly in the agricultural sector, the market opportunities created by increasing demand is huge for both established companies and entrepreneurs alike (Pooley and Revzin, 2011). Those huge-yet-untapped opportunities can be captured by formulating a business model that properly address the different environmental and social challenges, which accompany them (Seelos and Mair, 2007). Quoting Seelos and Mair (2007) it is clear that, there is still a gap in the current body of knowledge.

> *"While the first articles and studies on BOP put forward strong arguments for whether and why MNCs should enter low-income market, they remained relatively silent on how to enter." (Seelos and Mair, 2007, p.50)*

Van Aken (2004) argued that management research has a serious utility problem since too much of the research is descriptive in nature rather than prescriptive. Furthermore, practice-oriented researches with applicable propositions are needed by, managers as well as entrepreneurs, in order to align their organization with the current economic, social and environmental landscape. Therefore, this study will propose a feasible and profitable business model for companies and entrepreneurs who would like to capture the BOP opportunities in agricultural sector while doing so in a sustainable manner that seeks to address the issue of rural poverty at the same time. The business model proposed will be based on the philosophy of "creating shared value" which incorporates a greater purpose of serving society's need (Porter and Kramer, 2011).

In order to formulate the business model, a review of the literature from leading journals in the field of business management is conducted. This study is tailored to the context of agricultural development by private sector to address rural poverty. Therefore, it is more relevant for agribusiness managers/practitioners and entrepreneurs interested in developing the agricultural and land-based related sector.

In the following section, the selection method of the literatures will be outlined. It continues with an explanation of the characteristics of the rural poor market. Then, the current paradigm development and business model for rural poor agricultural market will be discussed. Finally, new business model will be proposed and this will be followed by the conclusion and discussion at last.

2. Methodology

In order to propose a new business model, an analytical review of literatures to date was conducted. An analytical review was conducted in order to systematically evaluate the contribution of a given body of literature (Ginsberg and Venkatraman, 1985). In general, the review process consisted of three parts: data collection, data analysis, and synthesis.

Data collection

The process starts with selection of a database to search in. Business Source Premier data base used as the main platform to search for the articles. The articles are searched using basic keywords: 'business strategy', 'bottom of pyramid', 'agriculture', 'sustainable' and its derivatives (i.e. TS=agricultur* and sustainab*). Academic journal articles were selected as the document type, while 'business' and 'management' are selected as the subject area. Moreover, the abstracts of the articles are also being considered.

The impact factor of the journal where the articles are publishes were checked. ISI Web of Knowledge's Social Science Citation Index (SSCI) is used as an indicator of the impact factor. Most of the articles reviewed are published in the journals with impact factor of 1.0 or bigger. However, to provide more coherent discussion on the context, several articles were chosen from journals with impact factor of less than 1.0. By doing so, it reduced the chances of missing out important articles which not been published in high impact factor journals.

Given that the nature of this study is practice-oriented study, a high number of practice-oriented journals are selected. In selecting practice-oriented journals, the top 45 *Financial Times* journals list was chosen, particularly journals in the 'general management' and 'practitioners' sections. The list of the journals and their impact factors are provided in the appendix.

Data analysis

Data analysis follows after data has been extracted from the database. Once the articles are selected for a review, data analyses proceed with identifying the research question. Later, the

theories used, main findings and implications of the articles are extracted. A self-formulated form was used as the analytic tool to analyze the articles.

Data synthesis

Finally, data synthesis is the primary value-added product of this study as it produces an executable business model for agricultural firms based on thorough analysis of the articles reviewed. Concepts, results and arguments extracted from the review are used to build a framework in order to formulate the new business model.

3. Traditional Business Models

Since the late 1990s, a body of research into 'more responsible business practices' has begun to emerge. It was initiated with the notion of a 'natural-resource-based view of the firm' of Stuart L. Hart in 1995. Hart (1995) proposed new perspective on competitive advantage of the firm by suggesting firms should be more responsible over their natural and social environment. Since then, the global community has placed increasing emphasis on the state of our natural environment and the concept of stewardship. The problem of poverty and social inequality however remain unsolved (Hart and Dowell, 2011). The academic endeavour continued when Prahalad and Hart (2002) came up with the idea of 'Bottom of the Pyramid'. They suggested that there is huge market potential for the world's poorest people, and advocate that big companies start entering that underserved market in order to improve the livelihood and wellbeing of the poor.

In general, there are two different paradigms over the role of private sectors in addressing poverty issue. The first is 'the poor as consumers' (BOP 1.0) paradigm that was predominantly advocated by C. K. Prahalad in his best-selling book published in 2004 entitled "The fortune at the bottom of pyramid". Most of the rural poor market research until today is still based on Prahalad's work.

On the other hand, the second paradigm is 'the poor as producers' (BOP 2.0). A. Karnani was advocating BOP 2.0 paradigm in his article "The mirage of marketing to the bottom of pyramid" in 2007. He offers a critique of Prahalad's marketing paradigm and proposes an alternative approach. In the following paragraphs, each of the paradigms will be analyzed and explained within the PESTEL framework analysis. PESTEL stands for Political, Economic, Social, Technological, Environmental, and Legal. PESTEL analysis is widely used in strategic management to scan the macro-environment components of an industry or business. Some of the aspects from PESTEL will not be that relevant on the BOP context. Therefore, the illustration of business model derived from each paradigm will be shown.

3.1 Rural poor agricultural market

The agricultural sector is an inevitable part of human development. For centuries, our society has been trying to increase agricultural productivity to feed its growing population. More importantly, with steady increase in the world's energy prices, nowadays agriculture plays an even more significant role as an important source of renewable energy (Frederico, 2005). At the same time, many social and environmental challenges are still major concerns in the

agricultural sector. The agricultural sector, as the source of food and fibre, is currently entering a new era, which needs to produce more with fewer resources. Since agriculture accounts for 70% of water use and up to 30% of greenhouse gas emissions, it contributes to and is threatened by environmental degradation (World Economic Forum, 2010). The last few decades of industrial agriculture have also contributed to the depletion of soil fertility, making it more difficult for farmers to increase yield.

From the social perspective, agriculture is often associated with rural poverty, especially in developing countries. 5.5 billion people are currently living in the developing countries. Three billion of them live in rural areas; it accounts for nearly a half of humanity. Out of these inhabitants, an estimated 2.5 billion are in households involved in agriculture (World Development Report, 2008). Furthermore, growth in the agricultural sector is twice as effective as growth in any other sector of the economy in reducing poverty (World Development Report, 2008).

In its 2010 report, World Economic Forum called for "a new vision for agriculture" that conceptualized a roadmap for agriculture to become a fundamental instrument for sustainable development and poverty reduction. Such an effort, however, would require a multi-facet partnership between governments, NGOs, and private sector to play their roles (World Economic Forum, 2010). The new vision for agriculture suggested that private sector would be the leading partner and driver for solutions with good support from all stakeholders concerned.

Before any organizations step in into this particular market, it is wise for them to really understand its characteristics. According to Prahalad (2004), the rural poor market has unique social, cultural, and institutional characteristics. The characteristics includes little or no formal education of the people and poor condition of basic infrastructures such as road, telecommunications, running water and electricity, making it difficult to be reached. Furthermore, most of the rural poor also do not have legal title over their assets (Prahalad, 2004; Prahalad and Hart, 2002). Hence, traditional products, services and management processes will not work well to serve this market (Prahalad, 2004).

3.2 The poor as consumers (BOP 1.0)

What is BOP 1.0 ?

Political perspective

The "bottom of the pyramid" (BOP) paradigm was first conceived in 2002. Stuart L. Hart and C.K. Prahalad used the term "BOP" in their article published by *Strategy+Business*. The aim of the proposition was to draw attention to the size of the BOP market and to encourage multinational companies to go into that market. The paradigm does not incorporate any political aspect of the BOP market. It suggests that, in the absence of government presence in providing basic services in rural poor area, MNCs may make profits by offering goods and services they need (Hart and Prahalad, 2002; Prahalad, 2004).

Economic perspective

From the economic perspective, Prahalad (2004) estimates a market potential of US$ 13 trillion. This estimation is based on the market size of 4-billion people who live on less than US$ 1,500 annual per capita income. Furthermore, supporting data from The World Bank suggest over 2.1 billion people live on less than US$ 2 a day and 880 million people on less than US$ 1 a day (World Development Report, 2008).

Prahalad (2004) suggests that in order to address local needs and stimulate economic development in developing countries, companies need to strive to achieve new levels of efficiency and radically rethinking the whole supply chain. According to Prahalad (2004), those changes are required given the unique social, cultural, and institutional characteristics of BOP market.

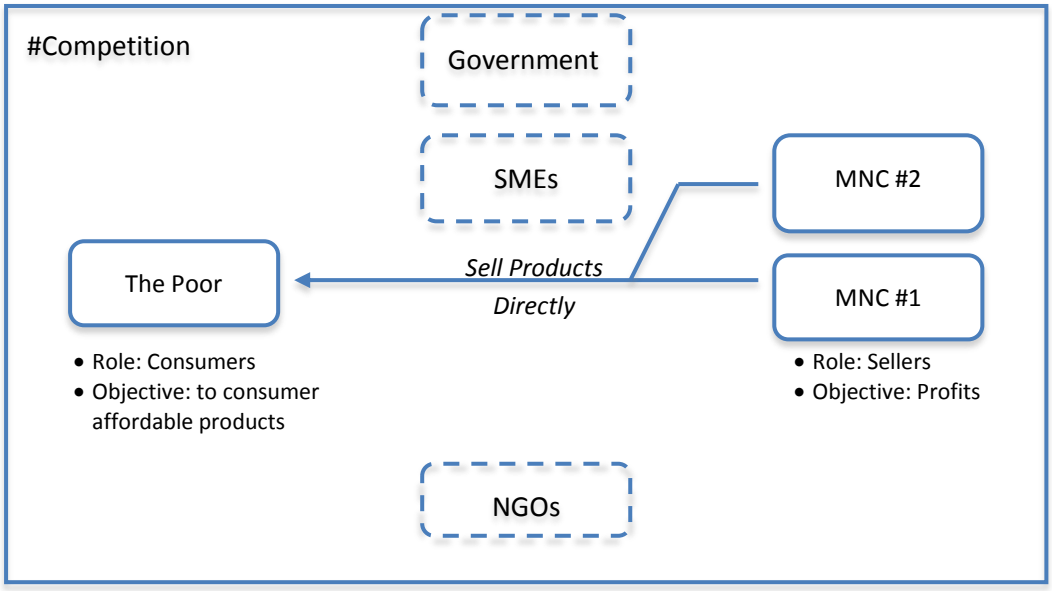
Hart and Prahalad (2002) advised big multinationals companies to offer low cost, good quality, and sustainable products and services to be able to generate profits. They argued that profits could be achieved by three strategies. The first one is to design low margin products and to sell them in high volumes while striving for maximum capital efficiency. Secondly, companies are also advised to have decentralized production and marketing systems with wide distribution networks to reach millions of rural poor. Finally, companies also need to build market infrastructure such as the purchasing and payment mechanisms as their initial investment (Hart and Prahalad, 2002).

Social perspective

From the social perspective, the "selling to the poor" proposition suggests that by selling various goods and services to the poor it is possible to improve their livelihood. This paradigm positioned the rural poor only as 'consumers' who are in need of (mostly basic) products and services to support their lives. The issue of social coherence might be an issue for the rural poor society. By selling them products and services they need without proper preparation to lift their income will spur consumerism among the rural poor. Karnani (2007) argued that microcredit schemes that often come along are mostly used for consumption smoothing instead of for productive activities.

Technology, Environmental & Legal perspective

Furthermore, the first paradigm tends to only implement current technology capabilities available to help sell those products being offered. Finally, from the environmental aspect, most of the products offered with BOP 1.0 tend to only just comply with the environmental regulation with "no harm" principle. It means, the legislations only require the companies not to harm the environment, but not yet require them to enrich it.



Model 1. 'The poor as consumers' paradigm business model (BOP 1.0)

How does it work ?

Prahalad and Hart (2002) mentioned the case of Hindustan Unilever Limited (HUL) in India. HUL at that time was aware that most of the rural poor in India clean and wash their clothes in the river. Noticing water cleanliness of the river, HUL come up with the idea of selling low-chlorine detergent called "Wheel". These detergents are sold in small packaging at low price point so the poor can afford it. In order to succeed, HUL decentralized its production, marketing, and distribution of the product. They sell it with low margins but in high volume. With scale that Unilever possess, it has the ability to adapt to the challenges of selling products to the poor from the manufacturing and marketing point of view.

Another example is the case of Amul, a large Indian diary cooperative. Amul serves ice cream in rural India for only 2 cents per serve. Amul argued that poor people want to buy their children ice cream as much as middle-class families. In reality, Amul's effort to sell their ice cream to the poor did not meet with great success. Amul positioned their cheapest ice cream for 50ml serving at Rs. 5, (equivalent to around $ 0.57 at PPP). This price was beyond the means of the majority of poor people living with less than $ 2 a day (Karnani, 2007).

From the examples of Unilever and Amul above, some might argue the issue of price discrimination because they seem to charge different prices for different customer segments. Despite the different prices being charged, the products they are selling to the poor is not absolutely identical in terms of volume and attributes. Both Unilever and Amul sell a much smaller volume of detergent and ice cream per item, compared to what they sell to their "normal" urban consumers. It is still debateable whether the cost per unit of each items sold to the poor is cheaper compared to their "normal" items. Therefore, the discussion on price discrimination is still ongoing.

Limitations

The first paradigm has encountered criticism and thus needs to be refined. From an economic perspective, the market size projection that Prahalad advocated seems to be over-estimated and debateable. Prahalad (2004) mentioned that the BOP market size is 5 billion people strong, while the World Bank estimate the number to be 2.7 billion people in 2001. Even further, some researchers estimate that the size of BOP market is only 600 million (Karnani, 2007).

Case studies used by the "selling-to-the poor" or "marketing-oriented" perspective illustrates that the poor in developing countries are willing to consume, but often not able to pay (Seelos and Mair, 2007). Such income constraint requires companies to design suitable products and manage cost to achieve new level of efficiencies of size and scale (Prahalad, 2004). Indeed, this particular paradigm of BOP propositions emphasized the role of selling (marketing) products to the poor in order to create economic and social value in BOP market, putting the poor as target consumers.

The most fundamental issue in this paradigm is that the role of MNCs within the framework of the first paradigm is simply to provide goods and services needed. Although Prahalad (2002 and 2004) advised companies to aim to alleviate poverty, as their objective is to sell the products to the poor the focus seemed to be purely on profit making. Hence, this paradigm encountered criticism as "exploiting" the poor (Seelos and Mair 2007).

3.3 The poor as producers (BOP 2.0)

What is BOP 2.0 ?

Political perspective

A few years after its inception, the marketing-oriented perspective on BOP 1.0 has encountered criticism for viewing poor people as consumers only. Aneel Karnani (2007) in his article "The Mirage of Marketing to the Bottom of Pyramid" argued that focusing only on selling products and services to the poor will not address poverty reduction. The BOP 2.0 pointed out that private sector alone cannot fully solve the issue of poverty. BOP 2.0 paradigm suggests a more comprehensive construct in which governments still need to improve the basic infrastructure in order to stimulate more private investment (Karnani, 2007). From the political perspective, in contrast to BOP 1.0, in BOP 2.0 the government's strong political will and consistency is vitally needed.

Economic perspective

Further, the BOP 2.0 also shares a different view over the economic landscape compared to the BOP 1.0. It argued that only by selling cheap products could not really begin to redress the balance in the poverty equation. For example, many companies sell products in smaller

volume per unit in order to increase affordability of its product. In fact, smaller packaging does not increase the affordability since poor people as consumers are still paying the same cost per unit for the product (Karnani, 2007). Karnani (2007) also points out that the micro financing scheme being offered to the poor also does not change the affordability of the products, although it might provides some other value to the poor.

Karnani (2007) also stated that, in fact, the market size of BOP market is smaller than Prahalad claimed. He argued that the BOP market only consists of 600 million people. Furthermore, he explained that the only way to reduce poverty is *to increase the real income of the poor*, by either lowering the price of the products or increasing their income (Karnani, 2007, p.100). Therefore, he advocates that it is not enough to view the poor only as consumers; we also need to help them to become producers. Only in that way can their real income increase.

Social perspective

The BOP 2.0 paradigm places emphasis on empowering the poor by considering them as producers. From the social perspective, the issue of empowerment plays an important role in the context of society building. Karnani (2007) argued that helping the rural poor to produce products and become micro-entrepreneurs is also challenging because not all poor people aspire to become entrepreneurs.

Since not all poor people aspire to become entrepreneur, Karnani (2007) argued that local small to medium-sized enterprises (SMEs) are best suited to exploit the opportunities at the bottom of pyramid and create employment for the rural poor (p.96). SMEs with their local knowledge and expertise may operate better in the rural poor markets that are often geographically and culturally fragmented. In addition, the poor or non-existence of basic infrastructures makes it hard to exploit scale economies that most MNCs aim for this particular market.

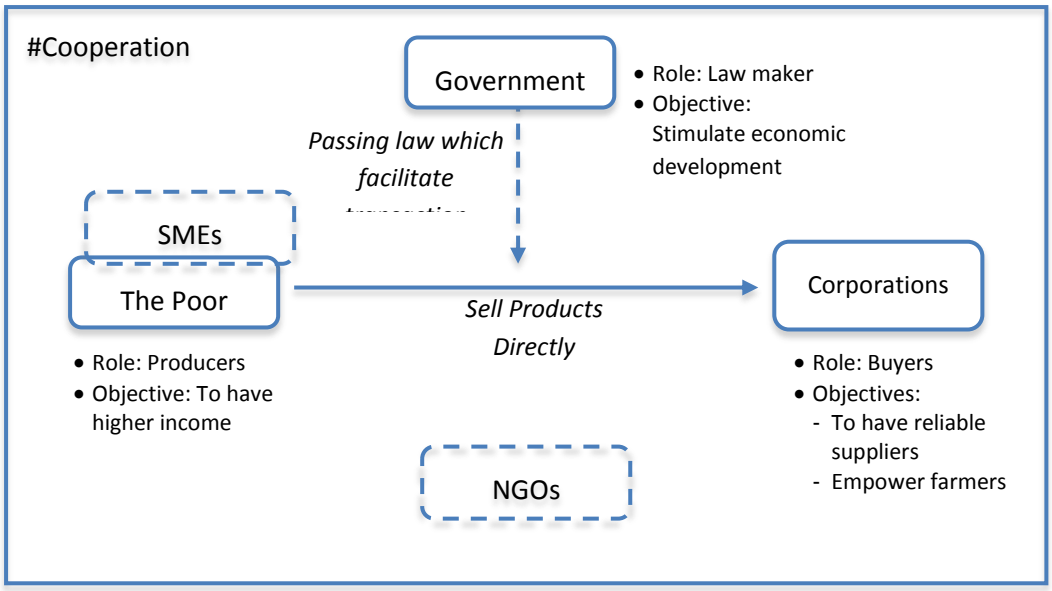
Moreover, the lack of formal education and entrepreneurial skills mean that many micro credit schemes fail to help poverty reduction. Instead of using the money they borrow for production use, the rural poor tend to use it as a tool for consumption smoothing (Karnani, 2007, p103). Karnani (2007) argued the reason for the failure is that many micropreneurs are caught in subsistence activities with no prospect of competitive advantages. They have no specialized skills, and most of the time are unable to scale up their business, leaving the micro financing debt unpaid.

This notion is coherent with the World Bank report. They reports that the emergence of local private entrepreneurs is expected to bring social, as well as economic benefit for society by generating jobs and at the same time, developing more advance and high value agricultural chain (World Development Report, 2008).

Technological, Environmental & Legal perspective

Quite different with BOP 1.0, BOP 2.0 suggests more technological advancement in the production system, as well as in the management practice. It advocates a more environmental sustainable practice, which not only does not harm the nature, but also helps to improve it.

From the legal perspective, the role of government to pass legislations, which support rural economic development is vital and inevitable.



Model 2. 'The poor as consumers' paradigm business model (BOP 2.0)

How does it work ?

Both Karnani (2007) and Seloos and Mair (2007) provide several examples that embodied BOP 2.0 view. For instance, Karanani (2007) provide the example of the e-Choupal service offered by ITC Limited in India. E-Choupal is a procurement system of several agricultural commodities in nine states of India including Andhra Pradesh, Haryana, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh and Uttaranchal (Karnani, 2007; Vachani and Smith, 2008).

In India, food producers are not allowed to purchase raw commodities directly from farmers. Farmers need to bring their product, such as soybean, to the local state-sanctioned wholesale marketplace called "mandi" where traders bid for it. Typically, small Indian farmers suffer tremendous disadvantages when selling their products at "mandi" because they lack of accurate information on market price. Also, they are often bullied and cheated by buyers when trading their goods (Vachani and Smith, 2008).

E-Choupal is an IT system providing real-time information on commodity prices to small farmers, so they can obtain better price for their produce. ITC installed a system in computers located in the village to provide farmers with information on commodity prices, weather forecasts, farming practices, and other important topics in the local language. Furthermore, ITC Limited lobbied the Indian government to allow them to purchase directly from farmers instead of depending on intermediaries at local "mandi". ITC Limited argued that by offering farmer choices where to sell their products would increase trade fairness for small farmers (Vachani and Smith, 2008).

Another example is the case of Calypso Foods. It supplies branded, processed fruits and vegetables sourced from Indian smallholder farmers. Calypso sources its raw material from more than 5,000 small-scale farmers spread across more than 400 villages in South and East India. Calypso provides those farmers with a comprehensive range of services that enable them to improve productivity and quality, and therefore earn more money. These services include high-quality seed and organic fertilizer sales, soil testing services, training in planting and growing techniques, as well as, low-cost drip irrigation systems (Jenkins and Ishikawa, 2009).

The ITC Limited and Calypso Foods' case suggests that corporations can play a role in empowering the rural poor by seeing them as producers. They empower small farmers not only by buying from them but also by providing a more holistic approach towards the whole trade process. By providing the latest current price, informing latest farming techniques, and weather forecast, ITC Limited aim to make profits from their e-Choupal service, as well as securing their supply by helping farmers to produce good quality commodity.

Furthermore, in this particular phase, the government starts to play a role in empowering small farmers. Although they are still not able to improve the market infrastructure, in ITC Limited's case, the Indian government agreed to pass legislation that allows corporations to procure directly from farmers instead of pooling agricultural commodity in "mandi". In that sense, the objective of government is to enhance new market creation in order to stimulate economic growth that will reduce rural poverty.

Limitations

As Karnani (2007) has identified, the limitation of the BOP 2.0 paradigm lies in the difficulty of stimulating entrepreneurship among the rural poor. Not all of them aspire to become entrepreneurs. Even if they do, they still need to be nurtured to have sufficient knowledge and capabilities to have a sustainable business, which relies neither on trade aid, nor on micro-finance scheme. Furthermore, there is a loophole in the role of the government. In the BOP 2.0 proposition, the government only play roles as regulator and infrastructure builder. To tackle many issues in rural poverty, governments need to be more thoroughly engaged in educating the poor, partnering with private sector, and regulating the market.

4. New Business Model Proposition

Since the inception of these two paradigms, further developments have taken place in the discussion. New perspectives over the rural BOP market, environmental degradation, and poverty alleviation need to be integrated. In their article 'Serving the world's poor profitably', Prahalad and Hammond (2002) emphasized the need for "doing good and doing well" approach to market entry in countries with deep poverty.

The latest development of sustainable enterprises and inclusive business model research is the idea of "creating shared values" advocated by Porter and Kramer in their latest Harvard Business Review article. Porter and Kramer (2011) suggest that we need to reinvent our

model of capitalism. They delivered a concept to unleash innovation and growth for both society and firms.

According to Porter and Kramer (2011), shared value is defined as "*policies and operating practices that enhance competitiveness of a company while simultaneously advancing the economic and social conditions in the communities in which it operates*" (p.6). Furthermore, Porter and Kramer (2011) suggested that the purpose of companies should be redefined to create broader social value rather than only focusing on short-term profits.

There is a need for companies to redefine their purposes in doing business. Porter and Kramer (2011) argued that companies should also have social purposes in their business vision in order to create shared value for the society in which they operate. Moreover, they also said that Corporate Social Responsibility (CSR) is not enough to give companies competitive advantage in the current economic landscape. While most CSR programs tend to only enhance companies' reputation, creating shared value is integral with companies' profitability and competitive position (Porter & Kramer, 2011, p.6). In contrast to CSR programs that mostly resulted from external pressure, creating shared value is an intentional act of companies in order to compete in the market while crafting society value creation; it is more an internal sense of purpose.

To achieve this, Porter and Kramer (2011) suggested three ways to create shared value. The first is the concept of re-conceiving products and markets. Companies need to seek growth opportunities in serving disadvantaged communities and developing countries by providing appropriate products and services to those low-income markets. This is coherent with Prahalad's BOP propositions discussed above. The second way is to redefine productivity in the value chain. By this, Porter and Kramer (2011) mean that companies need to examine the use of resources in their whole supply chain. They argued that better efficiency in energy use and logistics, better utilization in procurement process of raw materials, use of water and recycling are affecting companies' performance. Furthermore, companies should also take care of their employees better. Providing better facilities, training and services for employees will benefit companies by not only reducing the rate of absenteeism but also reducing the rate of work-related accidents that can be very costly for the companies (Porter & Kramer, 2011).

Finally, Porter and Kramer (2011) suggest that in creating shared value, companies need to enable local cluster development. Since no company is self-sustained, their productivity and innovation "are strongly influenced by *clusters*, or geographic concentrations of firms, related businesses, suppliers, service providers, and logistical infrastructure in particular field" (Porter and Kramer, 2011, p.12). Companies are advised to foster the development of local clusters like IT in Silicon Valley, cut flowers in Kenya, and diamond cutting in Surat, India.

In the context of the agricultural sector, CSR programs are more embodied philanthropy activities. Philanthropy activities are mostly acts of "giving away"; hence, philanthropy is not enough to empower smallholder farmers or to create real value in the rural society. Corporations need to play more active roles in empowering farmers by providing products and services that can increase their production efficiency, boost their yield and further increase their real income. Even further, companies could also actively engage with farmers by educating them about the latest farming techniques available and fostering the creation of local agricultural cluster that includes input businesses like fertilizers and seeds, to food processing and food distribution business.

4.1 Creating shared value (BOP 3.0)

All concepts outlined above require a more practical concept of application in order for companies to implement them (Seelos and Mair, 2007; Porter and Kramer, 2011; Prahalad, 2004). From the managerial perspective, the concept needs to be translated into a new business model that can facilitate growth of the companies while creating shared value in rural society.

Political perspective

Based on the approaches that Porter and Kramer (2011) advocated, the genesis of the BOP 3.0 proposition emerged. As a point of difference from the previous two paradigms, the creating shared value paradigm will include more actors including national/regional government, NGOs / development agencies, and most importantly local entrepreneurs and microfinance institutions. Moreover, BOP 3.0 proposition puts emphasis on synergy between those actors in creating economic, social, and environmental value.

As corporations need to re-conceive their products and market, managers need to analyze thoroughly the society in which their companies operate. They should ask themselves, 'what can these small scale farmers produce?', 'what products/services might they need?', and 'how can my companies help the current condition of the society?'. These are important questions that society needs to answer to embody a sense of purpose that goes beyond making short term profit and moves towards the 'creating shared value' proposition (Porter and Kramer, 2011).

Economic perspective

Private enterprises, both corporations and SMEs, should envisage the rural poor as business partners, not only as consumers nor as ordinary producers. Firms may place them as both consumers as well as suppliers in an integrative way. For instance, if a company is a food producer, which procures grain commodity such as rice or soybean, it can source their supply from small-scale farmers while at the same time selling good quality seeds to them. Furthermore, in order to secure a quality raw material supply, firms should educate small-scale farmers in the latest farming techniques available, and support them with good information over good quality seeds. They may have a synergy with NGOs / development agencies in providing that educational service to the farmers. By doing so, firms are not only be able to secure a good quality raw material for their production, but also may stimulate new demand for higher quality products or services (i.e. Demand for fertilizers, better seeds, or even farming advice).

Furthermore, the need for rural financing to stimulate local economic growth in so many rural communities is vital and prominent. In many cases, farmers who already have potential buyer for their products (for instance coffee or coca beans) cannot maximize the opportunities they have because of financing problem (Devaney, 2011). Microfinance can be one solution for the challenge. Grameen bank in Bangladesh is one of the most famous examples of the power of micro-financing scheme in empowering the poor in rural areas. Another scheme that can

be implemented is impact financing. Root Capital is pioneering the impact investing scheme by providing financing services for farmers which already have big for micro-financing, but still not bankable; they use the term: the missing-middle (Devaney, 2011). Root Capital works by taking the purchase order from companies who agreed to buy raw material from farmers as the "collateral" of their loans. Once the purchase order is agreed, they disburse the loans needed by the farmers to deliver the agreed goods to the buyer. The buyer then will make the payment directly to Root Capital. Once the initial loan amount plus the interest is taken back, the rest of the payment is then given back to the farmers.

Again, from all the schemes discussed above, synergy is a must to create shared value in rural communities. Established firms cannot act alone in order to stimulate rural economic development and alleviate poverty. As Porter and Kramer (2011) suggested, enabling local cluster of enterprises is important. Firms need to work together with local entrepreneurs, investors, NGOs, and government. The notion of local capacity building in which all actors should synergize and contribute is key. Investments need to be made. The kind of investment needed is not only investment in financial capital, but also investment in human capital, social capital, as well as ecological capital (Wheeler, McKague, Thomson, Davies, Medalye and Prada, 2005).

Social perspective

Although in nature every actor inside the networks does not necessarily have exactly the same aspiration and objectives, Wheeler et al. (2005), in their Sustainable Local Enterprise Network (SLEN) Model, suggested that they may have common expected sustainable outcomes. Those sustainable outcomes are: (1) profits and reliable returns on investment, (2) local economic development and trade, (3) enhanced quality of life; including human development and ecological enhancement, and (4) individual and community self-reliance; sustainable livelihoods (Wheeler et al., 2005).

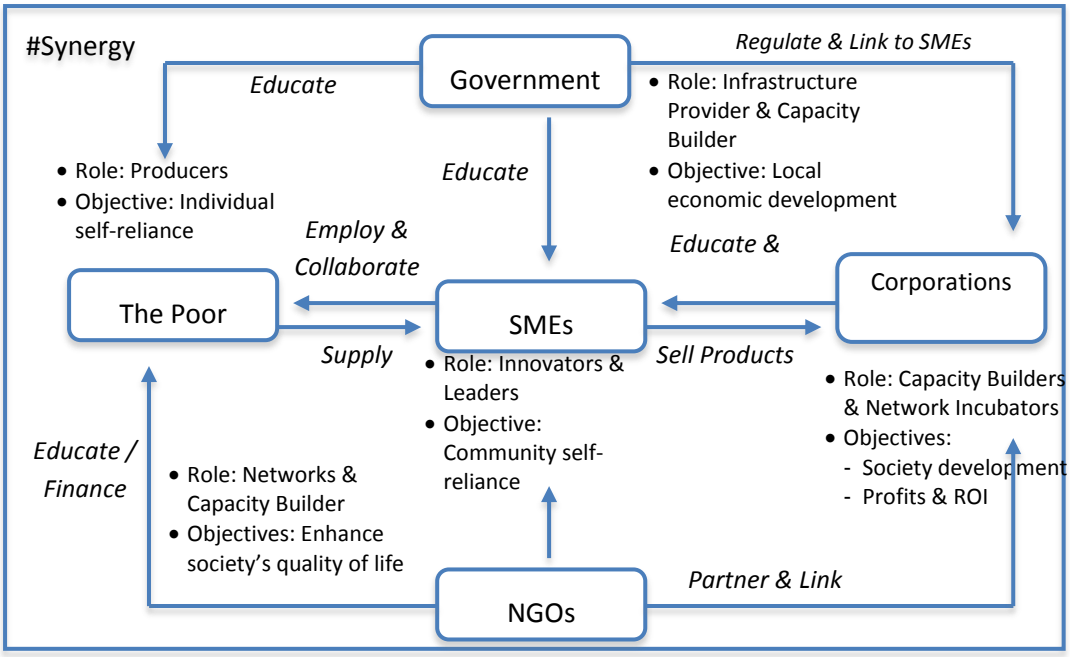
Corporations may expect profits and reliable ROI, while national/regional government wants to stimulate economic development and trade. On the other hand, NGOs and development agencies usually strive to enhance human development and ecological quality. And finally the ultimate goal of small farmers and local entrepreneurs is to have individual and communal self-reliance. In the end, those four individual goals from every stakeholder create a shared value for the society as a whole while each actor benefits from each other's goals (Wheeler et al., 2005).

To achieve those goals and objectives, every actor in the network may play different roles. Development agencies and NGOs may act as catalyst for new partnerships between private businesses (both large and small) with local actors (local entrepreneurs and small scale farmers). They may also provide educational services for those locals. In doing this, NGOs and development agencies play a major role not only as network builder, but also as capacity builder (Wheleer et al., 2005).

In addition, corporations should work as a capacity building and network incubator by mentoring and sharing resources and knowledge. This might be achieved by educating local entrepreneurs in the knowledge of entrepreneurship and technical know-how, so they may increase their capability as business partners. Private enterprises are also expected to provide

capital investment which finance and support local ventures creation (Wheeler et al., 2005; Porter and Kramer, 2011).

As the backbones of the SLEN model, local entrepreneurs are expected to be innovators, leaders, as well as disseminators of the lessons learned from private enterprises and development agencies. Moreover, local entrepreneurs are being stimulated to create new local ventures, which lead to job creation as well as living standard improvements for the local poor.



Model 3. 'Creating shared value' business model (BOP 3.0)

Technological, Environmental & Legal perspective

The role of national and regional government will be also vital in this paradigm. As they are concerned with rural economic development and growth, they need to improve the state of basic infrastructure such as roads, electricity, school buildings and other infrastructure, to facilitate the private sector in stimulating local capacity building (Karnani, 2007; Wheleer et al., 2005). Government need to ensure there is technological transfer in the local cluster they support and make sure that companies are using technologies that improve the environmental condition. Strong government political will and commitment is required in order to deliver the sustainable outcomes discussed previously. Government support in terms of regulation and law, which favour rural economic development, is essential.

How does it work?

The case of Nestle in creating shared value in several coffee growing regions can set example of how the model might be applied. When Nestle builds clusters in its key coffee producing regions, it has multiplier effects. The firm's growth is related to the creation of job creation for its supporting industries (Porter and Kramer, 2011).

For its newly introduced premium coffee product, Nespresso, Nestle built clusters to implement new procurement practices, which are far more effective compared to its previous procurement scheme. Nestle built agricultural, technical, financial, and logistical units and capabilities in each of region, to further support efficiency and high-quality local production (Porter and Kramer, 2011). Nestle led efforts to increase access to agricultural inputs such as seeds, fertilizers, and irrigation equipment. It also strengthen regional co-ops by providing financing facilities, shared wet milling facilities for producing higher-quality beans, and educate farmers in the latest farming techniques.

Nestle also worked in partnership with Rainforest Alliance, a leading international NGO, to teach farmer more sustainable practices that make production volume more reliable. By doing so, Nestle productivity increased, while also at the same time improving the livelihood of farmers and their families.

The example of what Nestle did in their key coffee growing regions might also be applicable to be implemented by smaller companies elsewhere. A smaller company in India called Staragri has also set an example on how to create shared value in rural communities in India. Founded in 2006, Startagri founders had a vision of providing solutions for farmers by building the finest warehousing infrastructure across the country and by delivering value to all stakeholders in the agricultural value chain. It has grown by providing warehouse and laboratory testing for quality and grading, while in the same time try to expand into collateral management, logistics and procurement services (Staragri, 2011). Today, Staragri operates in 183 locations across 7 states in the country (Gujarat, Rajasthan, Haryana, Madhya Pradesh, Maharashtra, Punjab and Uttar Pradesh). Along the way, it accomplished many milestones. StarAgri holds commodities worth Rs. 1500 in 110 Collateral Management locations, 5 lac ton capacity in warehousing, 9 established state-of-the-art commodity testing laboratories and integrated logistics solutions from farm to factory.

Limitations and feasibility analysis

The proposed business model also comes with limitations that need to be outlined. One of the limitations of the model is that its implementation requires fundamental change in the mindset of doing business by the industry players. For the model to work, industry players, many times, need to sacrifice short-term profit and put in a significant amount of investment at the outset. In practice, many of the companies or business owners are simply unwilling to sacrifice the short-term profits, because they do not share a common vision of a better rural future.

Furthermore, in so many rural areas in the world, the presence of agricultural middlemen is very difficult to eliminate. In many cases, the implementation of new business model, which would be more beneficial for the farmers, requires the elimination of middlemen. There is strong resistance from those middlemen to accepting and participating in the new business model, simply because they think they will lose their source of income.

Finally, the issue of companies' willingness to share their precious business resources is still debatable. Many would argue that by sharing their business resources, companies might lose their relative competitive advantages in the industry.

Feasibility analysis

The implementation of 'creating shared value' business model, has mostly take place in the raw commodity sector so far. We can see several initiatives in coffee and cocoa procurement sector initiated by trading companies with their clients. The "Source Trust" by Armajaro Trading Limited and the Nestle case are two examples of these initiatives. The reason why the business model might works in the commodity sector is because there is key incentive for trading and food companies to implement this. Soft commodity trading companies and food companies need to secure their raw material supply over a long-term period to enable their business to survive. Empowering coffee and cocoa farmers seem to be key element in securing raw material supply for these companies. Even further, the greater pressure towards sustainably sourced coffee and chocolate products push the model to be implemented in a wider scope and in more farming communities in developing countries (Bitzer et al., 2008).

Finally, governments' involvement is crucial in the success of such initiatives. Although the initiatives came from private companies, the endorsement and proactive engagement of government officials are needed. In several areas in Indonesia, the private-public partnership has already take place. In Aceh province, the local government partnered with coffee traders and built clinics, as well as school buildings in order to empower local communities in key coffee growing areas; the aim was to stimulate local economic development (UNDP Indonesia, 2008). Other examples of government involvement in public-private partnership can also be seen in many other regions worldwide.

5. Conclusion

The table below summarizes the differences between each BOP paradigm using the PESTEL framework.

The evolution of BOP paradigms has shown that collaboration between all stakeholders in the society is essential in order to improve the welfare of rural poor. Corporations cannot view small-scale farmers only as consumers, but must view them more as business partners. The objectives of improving the livelihood of rural poor as well as stimulating local economic development can only be achieved by enabling creation of sustainable local enterprise network. Furthermore, every stakeholders (actors) needs to know and understand the roles that they need to play in order to create a shared value in rural society.

Given the nature of this study, which is a literature review, more and deeper empirical evidence should be investigated in the future. The use of case-study research and deeper qualitative research for instance, interview or focus-group discussion, is suggested. More specific topics like research in the reasons companies are willing/unwilling to implement the model can also be investigated further.
The model suggested in this study is applicable to poverty problems both in urban and rural settings, although the examples and concepts are drawn from the context of rural poverty in which agricultural sector play a very important role to address the issue. Further researches are needed to explore feasibility of further development of this model into other sectors

outside agriculture. As the academic discussion continues, private sectors need to implement the concept and ideas into action in every area they operate in immediately if they are to contribute to the development of rural areas. It requires a radical change in the mindset of corporate leaders from just only making short-term profits by any means, to creating shared value in the society in order to have long-term and sustainable economic benefit for their firms.

So far, the soft commodity sector has provided several examples of how radical change in mindset of the business could take place. There are at least two main incentives for companies to implement the new business model. First, by empowering farmers and its community, companies may secure its supply over a long-term period, which would provide long-term business continuity for the firms. Secondly, the model can reduce the amount of social conflict caused by bad corporate governance and poor community involvement in the areas in which they operate.

Finally, the study provides a review of different business models in empowering disadvantaged rural communities. The study gives an overview how the models evolve and how of each model might help to increase the livelihood of the farmers. The model proposed in this study is not intended to eliminate the whole bottom of the pyramid from the society's economy. In fact, it is more how we, as society, can play our roles as individuals, corporations, NGOs, and even governments to support and improve the livelihood of the people at the bottom of the pyramid. Together, we can help alleviate global poverty and live in a more sustainable world.

Table 1. Summary of the Paradigms

Aspect	**BOP 1.0**	**BOP 2.0**	**BOP 3.0**
Model Characteristic	Competition	Cooperation	Synergy
Politic	Non-existence of government's political will	Little support from government	Government is fully engaged
Economic	• Over estimated market size • Exploitation of the poor as consumers	• More realistic market size • Force the poor to become producers	Local economic development & growth as backbone
Social	Spur consumerism among the poor	Empowerment towards the poor emerged	Focus on capacity building
Technology	Only used by big companies	Empowering farmers through technology	Local technology creation (innovation)
Environment	No harm principle	Start to be taken more seriously	Focus on how to improve environmental condition
Legal	Non existence	Limited legal	Full legal back up

		back up from the government	by being endorsed by the government

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Appendix

List of journals in which the literature are published and its impact factors

#	Journal Title	Impact Factor
1	*Harvard Business Review*	1,655
2	*Academy of Management Perspective*	1,405
3	*California Management Review*	1,983
4	*MIT Sloan Management Review*	1,141
5	*Journal of Management Studies*	2,805
6	Journal of Management	4,429
7	*Academy of Management Review*	7,867

The journals written in *italic* are the journals listed in Financial Times 45 Journals used in FT Research Rank.

John Adams

Facing down the 'perfect storm' – is it time to think the unthinkable? A review of global warming science and policy

Abstract

This paper aims to synthesise an ecologically literate narrative around the findings of recent global warming research, using evidence from both the natural and social sciences. The paper is intended to form a basis for urgent debate about the implications for future economic development, and to provide a contextual underpinning for future research. There is an increasing body of scientific literature indicating the need for rapid transformation of the economy away from dependence on fossil fuels, but current climate policy is not science-based. Policy prioritises economic growth over climate stability, preventing appropriate responses to the challenges we face. Economic growth is having a negative impact on quality of life, increasingly through the growing atmospheric burden of greenhouse gases. This political display of cognitive dissonance and lack of leadership can be explained by the cultural values of neoliberal capitalism; successful industry lobbying and funding of the global warming denial industry; blind faith in the ability of technology to solve any problem; public cognition of risk; and the reluctance of scientists to address policy implications of their work. A "raw and dispassionate" assessment of the challenge for development prompts the following conclusions: Global warming is the 'killer issue' that will dramatically change the world for better or worse. Science suggests far greater impacts than is generally believed, absent a rapid change in energy policy. Effective response depends on democratically expressed demand for action due to cultural and regulatory 'capture' of existing institutions. Stabilising climate needs to be prioritised over economic growth. Finally, facing down the perfect storm implies the biggest cultural transformation in human history.

Keywords: Climate Stability: Neoliberal Values: Sustainable Development; Cultural Transformation
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The Scientific Journal of Agricultural Economics, ISSN 1923-6514 (Online): Library & Archive Canada

1. Introduction

"*Education is the ability to perceive the hidden connections between phenomena*"
Vaclac Havel

"*Education is the most powerful weapon which you can use to change the world*"
Nelson Mandela

Environmentally, socially and economically, the world is in crisis and the future is characterised by uncertainty, particularly regarding future prospects for young people. It seems crucially important that the current generation of young people should understand the context in which solutions to these related crises are being considered, and be empowered to play their part in ensuring the future integrity of the natural and anthropogenic environment. How these challenges, often referred to as the 'perfect storm' (Porritt, 2009), are perceived and prioritised depends greatly on whose voices are heeded.

Existing political and economic institutions seem powerless to fix the broken economy, and increasing social inequality is having a negative effect on a whole range of social outcomes (Wilkinson and Pickett, 2010). These problems are within our power to resolve, though even that may require cultural and institutional transformation. The environmental crisis, on the other hand, could before long be completely beyond our control. Recent understanding of climate science raises the probability that the survival of life as we know it will be at risk if the wrong decisions are made now (Hansen, 2009). Just as the world could not tolerate (counter-intuitive as this may seem) the doubling of one grain of wheat 64 times (Daly, 1993), it could not tolerate even one doubling of the pre-industrial level of carbon dioxide (CO_2) in the global atmosphere (Hansen, 2012). Nevertheless, such a doubling is widely accepted as inevitable by around 2050 (Anderson and Bows, 2011; UNEP, 2012), leading to at least 3-4°C temperature increase above the pre-industrial level and probably more (Hansen, 2007). The chief economist at the International Energy Agency has warned of a possible 6°C increase if radical change is not effected within a few years (Montaigne, 2012).

Although there is broad consensus on the causality of anthropogenic global warming (IPCC, 2007), a distinct lack of political leadership is evident in the failure to acknowledge the scale of the threat and the urgency of addressing it without delay. In summarising the futility of existing global warming policy, Anderson and Bows (2011) conclude:

> *"Real hope and opportunity, if it is to arise at all, will do so from a raw and dispassionate assessment of the scale of the challenge faced by the global community"* (p41).

This paper aims to contribute an ecological perspective to the debate in presenting a review of the current state of relevant research. Section 2 will summarise recent evidence and implications of the science of global warming. In Section 3 this evidence will be used to identify a variety of reasons for the lack of appropriate responses by policy makers and the general public. Section 4 will then outline measures that could simultaneously address the multiple crises. After all, it may be that the perfect storm of crises can be tackled in an integrated manner to provide an ecologically sound, socially just and economically viable

society that current and future generations of young people deserve. Indeed, effecting such an integrated transformation may be our best hope for a healthy and prosperous future.

The paper is also intended to provide a context for future research into the requirements of a sustainable food system. The Food System is the sector of the global economy with the closest relationship to Nature (Wohlmeyer, 2002) and, including land use change and deforestation caused by agriculture, accounts for between about one third (Garnett, 2011) and one half (GRAIN, 2011) of global total greenhouse gas emissions. Food therefore represents a bigger challenge for sustainability than is faced by any other sector of the economy, along with the energy sector which is closely related in respect of global warming. It follows that lessons learned from developing a sustainable food system could facilitate such development in other sectors of the economy (Wohlmeyer, 2002).

2. Global warming

2.1 Policy

The parties to the 1992 UN Framework Convention on Climate Change (UNFCCC) determined to protect the climate system for present and future generations, and agreed the objective to "*prevent dangerous anthropogenic interference with the climate system*" (UNFCCC, 1992). The main criticism of the Convention is that the agreed text could have been more specific in defining dangerous man-made climate change (Cicerone, 2011). Although it noted the great uncertainty in making predictions about the timing and magnitude of global warming, it also emphasised that uncertainty should not be used as an excuse for inaction, invoking the Precautionary Principle:

> "*The Parties should take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures"* (article 3.3).

The Parties also acknowledged the requirement for "*the widest possible cooperation by all countries and their participation in an effective and appropriate international response*" (p2). The UNFCCC framework was a major achievement that should have set the world on a transformational path for human behaviour and interaction with the natural environment that would ensure future generations the opportunity for a healthy and fulfilling life. The Intergovernmental Panel on Climate Change (IPCC) was established under the framework to produce periodic scientific assessments to enable policymakers to formulate appropriate responses and protect the climate system.

The methods of enquiry that can be used by scientists to generate the data to inform policy include, in order of importance (Hansen, 2009):

- paleoclimate data that records past climate changes into the fabric of biological and physical systems (although there is no historical record of change as rapid as humans have effected)
- direct observations, which are rapidly accumulating, particularly from increasingly sophisticated satellite observations

- computer modelling, that is extremely useful for anticipating future change, but depends on the accuracy of the first two techniques of enquiry for it's usefulness.

The IPCC suggested that significant problems would occur if global warming reached 2-3°C above the 1990 global temperature (Schneider *et al.,* 2007). The IPCC analysis led the European Union (EU, 2008) to support policies aimed at keeping global warming to less than 2°C relative to pre-industrial times. This target was originally established by EU Governments in 1996. The EU (2008) acknowledged that 2°C is not a 'safe' limit, recognising that:

> "*Significant global impacts on ecosystems and water resources are likely at global temperature rises of between 1 and 2°C, and the risks of net negative impacts on global food production occur at temperature increases upwards from 2-2.5°C*" (p3).

Nevertheless, the EU settled for only a 50:50 chance of keeping within the 2°C target by suggesting that greenhouse gas (GHG) concentration should be stabilised below 450ppm (parts per million) of CO_2equivalent (all GHG converted to global warming potential of CO_2) (EU, 2008). The 2°C target was later reaffirmed by the US led agreement, the Copenhagen Accord, at the 2009 United Nations Climate Change Conference in Copenhagen (Copenhagen Accord, 2009). However, this agreement failed to include any commitment to reduce emissions to achieve the 2°C target (Anderson and Bows, 2011). The chief negotiator of the G77 group of developing countries called the agreement "*nothing short of climate change scepticism in action*" (Vidal *et al.,* 2009).

2.2 Scientific findings since IPCC 4th Assessment Report (2007)

Mann (2009) suggested that defining 'dangerous anthropogenic interference' implies a level of risk that will not be shared equally, and poses the perceptive question 'dangerous to whom'*?* He concludes that the current policy trajectory, under which the GHG concentration could stabilise well above 450ppm CO_2equivalent (CO_2e), would be very risky. In fact, we have already passed 450ppm CO_2e, and it is only the net cooling effect of anthropogenic aerosols such as sulphate (around -80ppm CO_2e according to Mann, 2009) that keeps us below the target concentration.

Anderson and Bows (2011) assert that analyses of required emission trajectories do not differ as much over the science of climate change as over their political and economic assumptions about:

- The line between acceptable and dangerous climate change
- The acceptable risk of entering dangerous climate change
- The year when global emissions are expected to peak
- The feasible post-peak reduction rate in emissions
- Whether the primacy of economic growth can be questioned to avoid dangerous climate change

They conclude that there is now little chance of limiting temperature increase to 2°C due to political inaction resulting from prioritisation of economic growth over global warming mitigation. They also note that 2°C is now considered to be verging on 'extremely dangerous'

climate change, and conclude that avoiding dangerous climate change is no longer compatible with targets for economic growth. They suggest that extremely dangerous climate change can only be avoided if a period of planned austerity replaces economic growth in developed countries, and if the world makes a rapid transition away from fossil fuels. The great irony of the dominant cultural paradigm of neoliberal capitalism is that the corrupt values resulting in the financial meltdown of 2008 (Mason, 2010) actually led to some reduction in developed country emissions, and have imposed a level of austerity on much of the developed world. However, the economic crisis has further diverted attention away from protecting and preserving the environment. A deeper, planned economic contraction, though politically unacceptable, would actually allow the radical emission reduction necessary to avoid exceeding the 2°C threshold and the time to develop very low or zero emission technologies (Anderson and Bows, 2011). Hope lies in that what is politically unacceptable today may have popular support tomorrow. When the proximity and magnitude of the global warming threat is widely appreciated, and when people realise that sacrificing economic growth need not prevent improvements in health and wellbeing (Wilkinson *et al*. 2010), public support has the power and potential to drive political change.

The 2°C target set by the EU is equivalent to 1.3°C relative to the 11-year running mean global temperature in 2000 (Hansen and Sato, 2012), who state that paleoclimate data imply 2°C global warming would actually be a disaster scenario for much of humanity and many other species on the planet. They conclude that eventual sea level rise of several tens of metres must be expected in response to the global warming of several degrees Celsius that is foreseen under IPCC 'business-as-usual' (BAU) climate scenarios. Business as usual is clearly not an option. If BAU does nevertheless continue, Hansen and Sato (2012) suggest that, in the second half of the 21st Century, high latitude cooling (due to ice melt volume) and low latitude warming (containing more moist air) would drive hugely powerful mid-latitude cyclonic storms. These storms and rising sea level would be disastrous for many coastal cities and would devastate the global economy.

The IPCC concluded in the 4th Assessment Report (AR4) that most of the observed increase in global average temperatures since the mid-20th century is *very likely* (confidence level >90%) due to the observed increase in anthropogenic greenhouse gas (GHG) concentrations (IPCC, 2007). Based on research published since AR4 was completed, summarised below, it seems likely that AR5, due for publication in 2013-14, will highlight the rapidly changing state of current knowledge and may finally convince policy makers of the overriding urgency of the problem. However, recent evidence suggests that the scale of the challenge may be significantly greater if action has to wait for the findings of AR5 to be digested and responses formulated.

2.2.1 Global warming

The fundamental problem is that waste products from the fossil-fuelled economy, released to the atmosphere through human activity, have altered the energy balance of the climate system (IPCC, 2007). The delicate, dynamic balance that Nature has evolved over many millions of years to sustain life (Capra, 2002) has been dangerously disturbed by the ecological ignorance and arrogance of *homo sapiens*.

Earth absorbs about 240 W/m^2 of short wave solar energy averaged over the planet surface (Hansen and Sato, 2012) and to maintain stable temperature an equal amount of energy must

be radiated back to space. Anthropogenic GHGs have made the atmosphere more opaque to long wave (infra-red) radiation emitted from the Earth's surface, trapping additional energy and causing a positive energy imbalance and global warming.

Hansen *et al.* (2008) conclude that avoiding dangerous climate change requires restoration of the Earth's energy balance, which would be achieved by reducing atmospheric CO_2 concentration to 350ppm. This implies reversing the current upward trend (391ppm CO_2 at Mauna Loa in 2011 according to NOAA, 2012) by halting CO_2 emissions and actively removing CO_2 from the atmosphere rather than merely halting the year on year increase. Whether this herculean challenge can best be met through technological engineering or via ecological engineering should be a major topic of debate in the immediate future.

Huber and Knutti (2011) modelled known changes in earth's energy balance and factors affecting radiation of energy to space using the principle of conservation of energy. They found an energy imbalance of about $0.54Wm^{-2}$ of Earth's surface prevented from escaping back to space. Huber and Knutti concluded that it is:

- *Extremely likely* (>95% confidence) that anthropogenic causes dominated the observed warming since 1950
- *Extremely unlikely* that natural variability contributed more than 26% of the observed trend
- *Extremely likely* that at least 74% of observed warming since 1950 is due to anthropogenic activity.

Hansen *et al.* (2011) summarised understanding of the physics of global warming and calculated an energy imbalance of 0.58 W/m^2 for the period 2005-2010, despite the longest solar minimum (when solar radiation is at the low point of an 11 year solar cycle) ever recorded. This represents good evidence that variation in solar radiation cannot be blamed for observed changes. They estimated an imbalance of $0.75Wm^{-2}$ over the whole solar cycle.
Although $0.75Wm^{-2}$ may not seem a lot, the total energy is sufficient to cause sea level rise of close to 1 metre per decade if all of it was used to melt ice (Hansen, 2007). In fact 90% of the excess trapped energy is currently absorbed by and warms the oceans, raising sea levels through thermal expansion and increased melting of exposed ice.

2.2.2 Sea level and Continental Ice

Since 1993 when satellite measurements began, sea level has risen by an average of about 3mm per year (Church *et al*. 2011) or 3 metres per millennium, double the rate that occurred in the 20^{th} Century (Hansen, 2009) and much higher than the rate that occurred over the last several thousand years (Hansen *et al*. 2012a). Since 2004 the contribution from melting of Greenland and Antarctic ice sheets accounts for around half of the total increase in sea level (Church *et al*. 2011).

Projections of sea level rise this Century have increased since the IPCC (2007) suggested a likely rise of about 29cm without any contribution from melting continental ice sheets. It was thought that, for Antarctica in particular, increased water vapour in the atmosphere as a result of global warming would lead to increased deposition of snow over the ice sheets (Velicogna and Wahr, 2006). Despite loss from ice sheet margins exposed to warmer oceans, the expected net effect would be an increase, rather than a decrease, in ice mass. Subsequent

research showed that Greenland and Antarctica are indeed losing mass (Velicogna and Wahr, 2005; 2006), and further studies raised projections of 21st Century sea level rise to 1-2 metres, assuming a linear response of ice sheets to global warming (Hansen and Sato, 2012).

Figure 1 shows Greenland ice mass changes from April 2002 to February 2009 relative to average ice mass since 2002. Velicogna (2009) analysed monthly data from the GRACE (Gravity Recovery and Climate Experiment) satellites from 2002 and concluded that annual ice mass loss from the Greenland and Antarctic ice sheets is accelerating with time ($p<0.01$), rather than following a linear trend (Figure 1). Over the period from April 2002 to February 2009 the annual loss from Greenland increased by 100%, while annual loss from the Antarctic more than doubled (140% increase).

Over the period 1992-2009 for Greenland and Antarctica combined, Rignot *et al.* (2011) found an acceleration in ice mass loss of 36.3Gt/yr^2 over the 18 years, and estimated a combined loss of 475Gt in 2006, sufficient to increase global sea level by 1.3mm/year (360 Gt=1mm sea level rise according to Hansen *et al*., 2011).

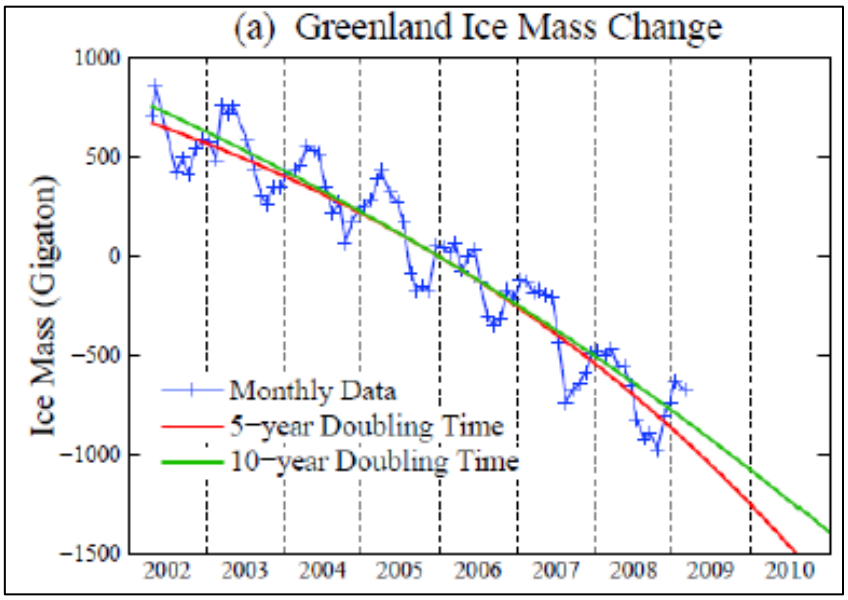


Figure 1 Acceleration of Greenland ice loss (Source: Velicogna, 2009 adapted by Hansen and Sato, 2012)

Based on analysis of paleoclimate data indicating that rapid disintegration of ice sheets has previously resulted in sea level rise of several metres on a century timescale (Hansen, 2007), supported by the GRACE observations of Velicogna (2009), Hansen and Sato (2012) concluded that if 'business as usual' emissions continue, disintegration of the Greenland and Antarctic ice sheets will accelerate further and could result in sea level rise of up to 5 metres before the end of the 21st Century, based on a 1mm per year ice sheet contribution to sea level in the decade 2005-2015 and a doubling time of a decade (Figure 1). As they readily acknowledge, the conclusions of Hansen and Sato (2012) do not yet represent the mainstream scientific consensus in the published literature. However, Hansen and his colleagues have been at the forefront of climate science for over 30 years, since the publication of a paper in the journal *Science* (Hansen *et al.*, 1981) made the front page of national newspapers in the

US. He has since suffered unjustified personal and professional attack from industry and political appointees, but the projections made in that paper have now been realised (Mann, 2012). Hansen's work displays great personal integrity and the sytems thinking approach that is required to be ecologically literate (Capra, 2008). Given the evidence compiled here, his analysis is considered likely to become the consensus in the near future. The doubling time for ice loss is uncertain due to limited gravity satellite data but Figure 1 shows that it is plausible given the data available. Hansen and Sato (2012) assert that goals to limit human-made warming to 2°C are therefore a recipe for disaster, and conclude that rapid reduction of fossil fuel emissions is required "*if we are to succeed in preserving a planet resembling the one on which civilization developed*". Figure 2 shows GRACE data updated to September 2011 by Velicogna.

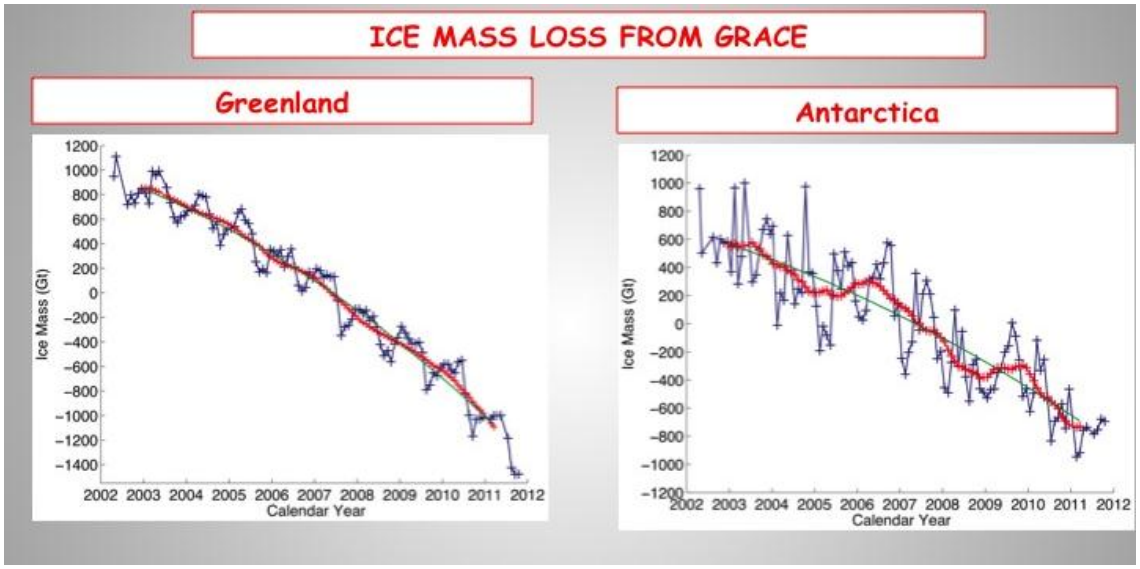


Figure 2 Antarctic & Greenland mass changes relative to average ice mass 2002-2011. (Source: Velicogna, 2009 updated at: http://ess.uci.edu/researchgrp/velicogna/research)

The non-linear decrease in ice mass shown by Velicogna (2009) has continued through September 2011, adding to the evidence (Hansen, 2007) that exponential ice sheet disintegration has already begun. Figure 2 suggests that for Greenland, there was a larger increase in mass loss due to extensive summer melt in 2010 and 2011.

On 24th July 2012 NASA reported that the surface of the Greenland ice sheet had undergone "*an extreme melt event about which scientists are very confident*" (NASA, 2012). Between the 8th and 12th July summer thawing suddenly increased from about 40% to 97% of the ice sheet surface (Figure 3).

Figure 3 shows darker pink areas where 2 or 3 different satellites detected melting and light pink denotes detection by one of the satellites. The extreme melt event was thought to be due to an unusually strong ridge of warm air over Greenland, one of several that have dominated Greenland's weather since the end of May (NASA, 2012). Whether this event will significantly increase the loss of ice mass in 2012 should become clear within several months, but given the recent changes shown in Figure 2, it would be surprising if there were no consequences. One of the expected ice sheet positive feedbacks to warming is initiatiation

of the 'albedo flip' mechanism (Hansen, 2007) whereby wet ice is expected to absorb much more solar energy than snow-covered ice. The increased volume of surface melt water finds its' way through crevasses to the base of the ice sheet, lubricating it and so speeding up the discharge of icebergs to the ocean (Hansen, 2007). The two mile thick ice at the highest, coldest point on Greenland is thought to undergo some surface thawing at around 150 year intervals (NASA, 2012), so appropriate attribution of the event to natural or anthropogenic causes is currently unclear. If such thawing were to occur again in the near future, attribution to anthropogenic warming would appear to be inevitable.

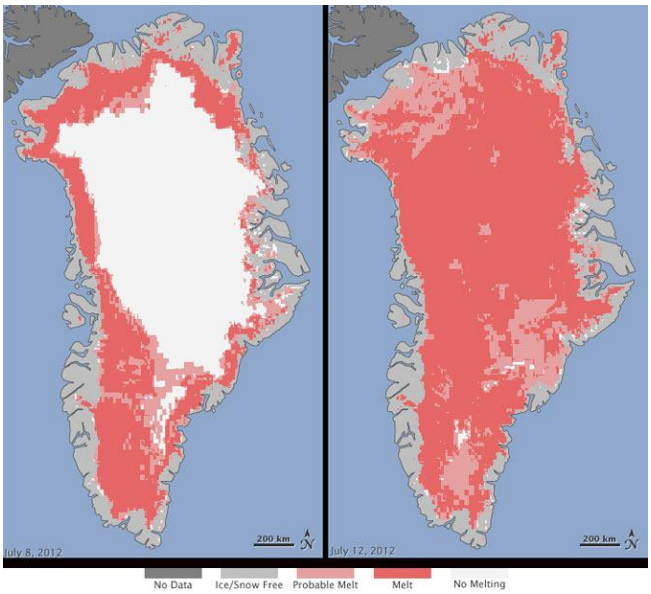


Figure 3 Greenland Ice Sheet Surface Melt 8-12th July 2012 (Source: NASA, 2012)

Box *et al.* (2012) studied changes in the reflectivity (albedo) of the Greenland ice sheet from 2000-2011. The overall surface reflectivity showed a significant decrease over this period as the ice sheet's surface had become darker due to global warming. The authors concluded that continuous melting across the entire ice sheet in summer could occur within a decade. In fact, they note that warmer air carrying more water vapour increases snowfall at higher elevations and slows the overall decrease in albedo by increasing local surface reflectivity, without which complete melting of the surface may already be seen. Box (2012) illustrates Greenland albedo change by updating Figure 6 of Box *et al.* (2012) to the 15th August 2012 (Figure 4).

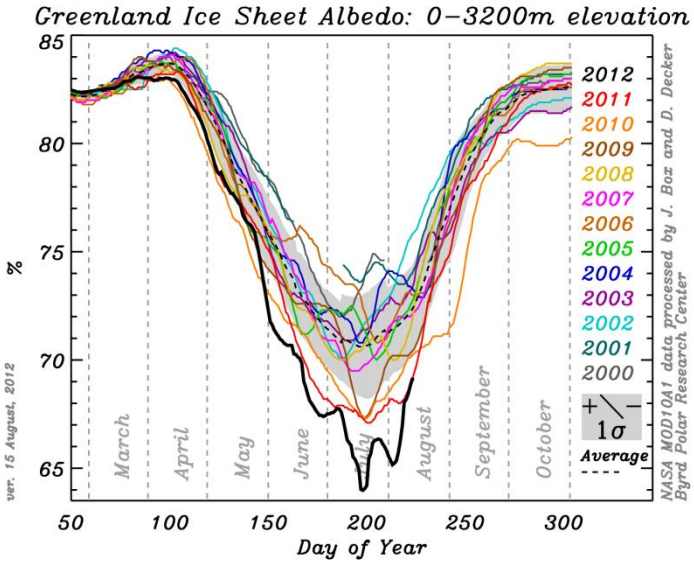


Figure 4 Decreasing reflectivity of Greenland 2000-2012 (Source: Box, 2012)

The fact that the prediction of Box *et al.* (2012) of 100% surface melting has been all but realised in 2012 (Figure 3) indicates that Greenland may be very close to a tipping point of abrupt increase in melting of surface ice.

Figure 4 shows the unprecedented low value of 64% reflectivity, on 16th July 2012, the lowest since satellite observations began in 1978. Increases in reflectivity in early and late July 2012 are due to the brightening effect of snowfall, but the low point is more than 2 standard deviations below the average for the period (Box, 2012). This record low albedo coincides with the extreme melt event reported by NASA (2012) (Figure 3).

2.2.3 Sea Ice

The 40% decline in September Arctic sea ice extent since 1980 is illustrated in Figure 5. Stroeve *et al.* (2012) argue that statistical evidence is starting to emerge of a growing non-linear response of Arctic sea ice to global warming. The annual minimum in September shows a decreasing linear trend of -12.4% per decade but Stroeve *et al.* (2012) conclude that the system may be poised to experience rapid change due to acceleration of sea ice loss.

A consequence of reaching such a threshold or 'tipping point' and accelerated sea ice loss would be further rapid warming caused by the decreasing albedo effect and increased absorption of solar energy by the darker ocean. The large scale release of frozen methane hydrates from under the Arctic could soon follow (methane being a GHG with 25 times the Global Warming Potential of CO_2), and restoring Earth's energy balance would then be impossible.

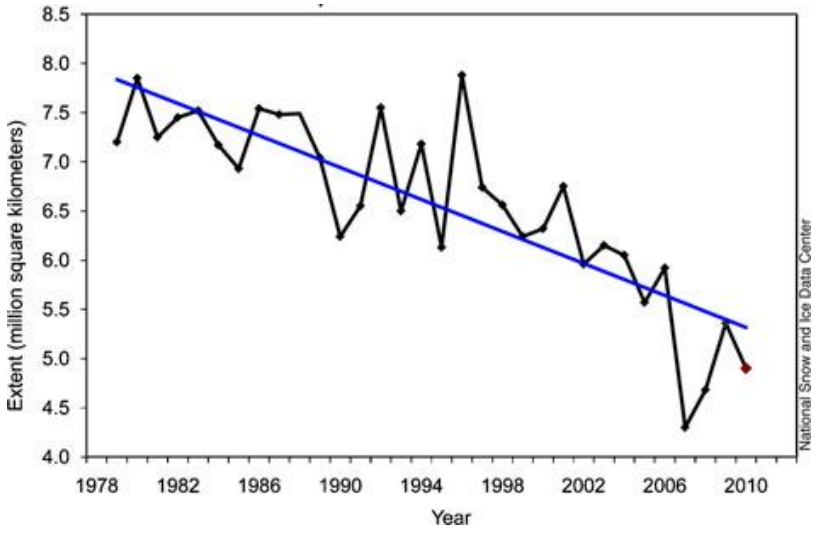


Figure 5 Arctic sea ice minimum extent 1979-2010 (Source: Stroeve *et al.*, 2012)

The Arctic has warmed twice as fast as the northern hemisphere as a whole over recent decades via a phenomenon called Arctic Amplification (AA) (Francis and Vavrus, 2012). The reduced temperature gradient between the Arctic and lower latitudes appears to be slowing down the West-East flow of the Jetstream, which depends on the temperature differential between high and mid-latitudes, and influences northern hemisphere weather systems (Francis, 2012). The reflectivity (albedo) of the Arctic decreases as sea ice is lost through warming, creating a positive feedback that causes additional heat to be absorbed by the ocean and further warming. This heat is released back to the atmosphere as the autumn freeze begins, affecting large scale atmospheric circulation.

2.2.4 Extreme weather events

These changes to the Jetstream are expected to increase the frequency of extreme events caused by persistent weather such as drought, heat waves, rainfall and flooding, *and* cold periods (Francis and Vavrus, 2012). It is interesting to speculate whether the persistent wet weather during April and June in the UK in 2012, leading to record rainfall, might be a consequence of Arctic Amplification or global warming more generally.

Readily available temperature and rainfall data from one location in Shropshire, England were analysed according to Figure 9 of Hansen *et al.* (2012a) to discern whether April-June weather was an 'extreme' event that could be attributed to global warming (Figure 6). Monthly and quarterly temperatures during April-June were all found to be well within one standard deviation of the mean of the 30 year period 1951-1980. This period of climatology is preferred to more recent 30 year periods (Hansen *et al*. 2012a) because most of the post-industrial warming of 0.7-0.8°C has occurred since 1980 (Figure 8). In contrast, the rainfall data show that total rainfall in the period April-June 2012 (335 mm) was 4.41 standard deviations above the mean total for April-June (157 mm) over 1951-80 (Figure 6b). April is the month with the lowest 30 year mean in the climatology record at 44mm. Precipitation in April 2012 alone (174.9mm) was 5.35 standard deviations above the 1951-80 April mean (Figure 6a).

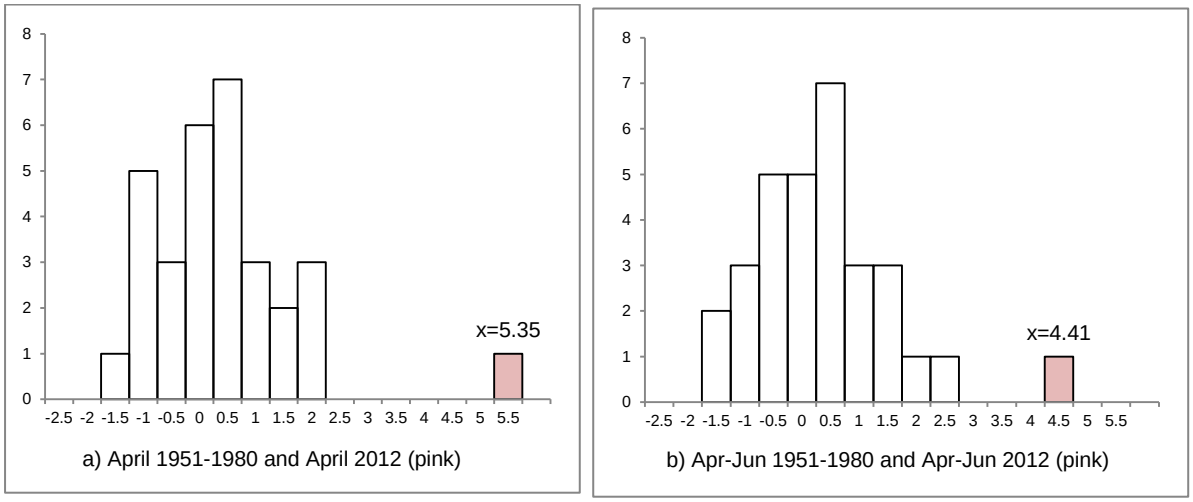


Figure 6 Frequency of occurrence (y-axis) of rainfall anomalies divided by standard deviation (x-axis). Anomalies and standard deviations are relative to 1951-1980 mean local climatology at one location in Shropshire, England.

Global warming means the atmosphere holds more water vapour, which acts as a positive feedback and traps more heat, and is expected to result in more extreme rainfall events (Hansen *et al*. 2012a). An increase in heavy rainfall in the northern hemisphere has been linked to global warming (Min *et al*., 2011). Figure 6 shows that 2012 was unprecedented relative to 1951-1980 and is extremely unlikely to have occurred through natural climatic variability.

Although the Intergovernmental Panel on Climate Change (IPCC) notes that it is challenging to attribute single extreme events to anthropogenic climate change (IPCC 2012), the IPCC is subject to political as well as scientific consensus. Research that was used in the IPCC 4th Assessment Report, by Stott *et al.* (2004), estimated that it is *very likely* (confidence level >90%) that human influence has at least doubled the risk of a heatwave such as occurred in Europe in 2003. Continuing efforts are being made to estimate the degree of climate attribution that is appropriate for extreme events such as the Moscow heatwave of 2010 and the 2011 drought in Texas. For example, Christidis *et al*. (2012) found that anthropogenic climate forcing has increased temperatures in Europe in all seasons and that it is *extremely likely* (confidence level >95%) that, apart from winter, the probability of extreme warm seasons has more than doubled in the decade 1999-2008. Rahmstorf and Coumou (2011) addressed the question of how the number of temperature extremes is linked to global warming. They note that, over the last 30 years, global mean temperature has increased by 0.17°C per decade. Global warming shifts the mean of the temperature distribution to warmer values, causing above-average warming of continental interiors and increasing the likelihood of extreme high temperatures. The authors calculate about an 80% probability that the July 2010 Moscow heat record would not have occurred in the absence of global warming. Hansen *et al*. (2012a) also emphasise the asymmetry of shifting temperature distribution (Figure 7).

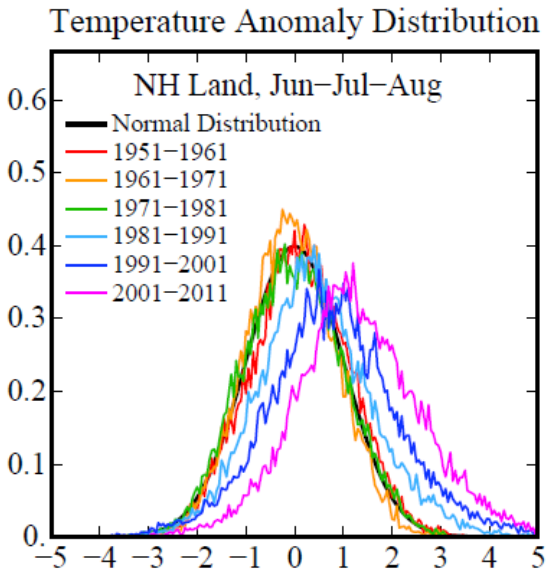


Figure 7 Northern hemisphere land temperature anomaly distribution (in units of standard deviation) for Jun-Jul-Aug over the last six decades (anomalies are relative to the base period 1951-1980) (Source: Hansen *et al*. 2012a).

Figure 7 shows that global warming has increased the 2001-2011 northern hemisphere (NH) summer mean temperature on land by at least 1 standard deviation relative to 1951-1980. The variability of the temperature distribution has also increased, but in an asymmetric fashion: the hot tail has shifted more than the cold tail. The likelihood of extreme high temperatures (defined as three standard deviations above the mean) in the northern hemisphere has therefore increased from about 0.1-0.2% of the land area each year during the base period 1951-1980, to about 10% of the land area in the period 2001-2011. Extreme high temperatures therefore appear to be about 50 times more likely than a few decades ago. Extreme cold events are becoming increasingly rare overall. Unusually cold recent winters led many people to wonder how global warming could be real. Figure 7 emphasises that during 2001-2011 about 15% of the NH land area still experienced summer weather cooler than the 1951-1980 mean. In 2001-2011 relatively cold summer weather events more than 2 standard deviations below the 1951-1980 mean also occurred despite global warming (Hansen *et al*. 2012a). Similarly, cold winters between 2-3 standard deviations below the 1951-1980 mean still occurred over 1-2% of the NH land area during 2001-2011 (Hansen *et al*., 2012b). This overall shift in the temperature distribution is due to warming of around just 0.5°C globally since 1980 (Figure 8). Hansen *et al*. (2012a) conclude with a high level of confidence that the heat waves in Europe in 2003 and in Moscow in 2010, along with the 2011 drought in Texas (each more than 3 standard deviations above the mean) almost certainly would not have occurred in the absence of global warming. A similar event is now occurring in summer 2012 in the US midwest and is already affecting the economics of agricultural production and consumption globally.

According to NCDC (2012) the U.S. has suffered 134 weather/climate disasters since 1980 where overall damages/costs reached or exceeded $1 billion. The total losses for the 134 events are estimated at over $880 billion. Agricultural losses due to the 2011 drought in

Texas are estimated at $7.62 billion, or over 40% of average agricultural receipts in recent years (Fannin, 2012).

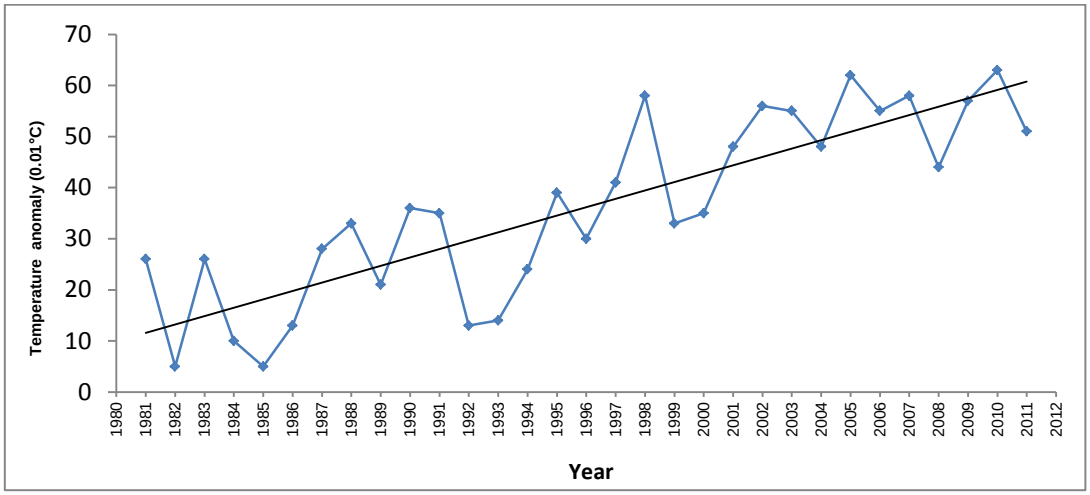


Figure 8. Global annual mean temperature anomaly 1981-2011 (relative to 1951-1980 mean). (Source: Adapted from: http://data.giss.nasa.gov/gistemp/tabledata_v3/GLB.Ts+dSST.txt)

Global warming is now becoming personal for ordinary people, but the discernible changes are yet as nothing compared to rational and objective projections of future climate. It is therefore extremely important to preserve climatic stability, and that means halting emissions of greenhouse gases.

2.3 Biodiversity

The other major impact that will define 'dangerous anthropogenic interference' is the reduction in biodiversity (UNEP, 2009). Barnosky *et al.* (2011) point out that humans may have started the 6th Mass Extinction Event already, without the rapidly increasing stressor of global warming. They note the urgency of reducing the anthropogenic pressure on the world's remaining species. If current trends continue, the IPCC (2007) suggests that around 30% of species will be committed to extinction. UNEP (2009) notes that since the IPCC 4th Assessment Report in 2007, "*serious and irreversible changes in Earth's Ecosystems due to anthropogenic activities are increasingly recognized*". The 2012 Global Environmental Outlook (GEO5) notes that the world failed to significantly reduce the rate of biodiversity loss by 2010, a Millennium Development Goal, and that about 20% of vertebrate species are now under threat (UNEP, 2012). The sustainability of a system is a function of its' persistence and resilience (resilience is the ability to resist shocks and stresses), and crucially, in living systems resilience depends on biodiversity (Fiksel, 2006; Capra, 2008). It is therefore extremely important to preserve biodiversity, and that means halting emissions of greenhouse gases.

2.4 Policy implications

Science is like a torch shining a light to guide us as we stumble through the darkness. Understanding the implications of global warming and formulating appropriate corrective policies is of the greatest importance for current and future generations. The observed changes in sea and land ice, along with the frequency and severity of extreme weather events, are occurring much more rapidly than scientists had previously predicted (Lydersen, 2009; UNEP, 2009).

Any rational policy response to growing scientific understanding of the processes involved must be highly precautionary, despite the genuine scientific uncertainty that exists around the timing and severity of impacts (IPCC, 2007). The global warming signal is now emerging from the noise of natural climate variation (Hansen *et al.* 2012a) but lack of observational data on effects of anthropogenic aerosols makes targeting a 'safe' level of atmospheric GHG problematic. Time is itself the enemy for predicting impacts of anthropogenic global warming with certainty, due to the inertia of the ocean in absorbing the bulk of the energy imbalance, and uncertainty over the rate of mixing of ocean heat content between shallow and deep waters. Critical thresholds could be crossed at any time now or in the future, leading to a qualitative change in the state of various elements of the climate system (Lenton *et al.*, 2008). The window of opportunity for effective action appears to be very short, and certainly is if energy balance is to be restored by the end of the 21st Century (Hansen *et al.* 2012c).

There is surely sufficient evidence, given probability of occurrence and potential for catastrophic damage, for those formulating policies to *'protect the climate system for present and future generations'* (UNFCCC, 1992) to effect a rapid transformation of the global economy away from its pervasive and destructive dependence on fossil fuels?
This message is not being communicated to the public by politicians who ostensibly represent the public interest. Section 3 explores some of the factors that may be responsible for the lack of a rational political response.

3. Reasons for Inaction

3.1 Politics and Economics

The unfortunate reality is that global warming policy is not focused on meeting the commitments made under the UNFCCC and is not science-based, but instead prioritises what is considered to be politically and economically 'feasible' (Anderson and Bows, 2011). The Precautionary Principle is not being applied, though the need for it is clearly indicated.

Fossil fuel extraction is still being subsidised to the tune of around $400bn/yr globally (IEA, 2011) and prospects for economic growth are recognised in the development of unconventional fossil fuels such as shale gas and tar sands, particularly in the US (Hansen, 2012). Details of the preferential subsidy treatment given to the US fossil fuel industry over the renewable energy industry during 7 years from 2002-2008 are provided by Adeyeye *et al.* (2009). For fossil fuels they identified $54.164bn of tax breaks and other revenue foregone, along with $18.309bn in direct government spending, just over one third of which was help for low income households. The total for fossil fuels was $72.473bn. Renewable energy sources received $28.943bn in total: $17.940 in tax breaks and other revenue foregone, along

with $11.003bn in direct spending. Almost half of the renewable subsidies were attributed to corn-based ethanol.

3.1.1 Cultural values of neoliberal capitalism

Busch (2010) explains that the laissez-faire approach of early 20th Century capitalism, presuming that markets would work best if the state merely did not interfere with them, was considered to be failing in the late 1930's. What was needed was a new liberalism – a *neoliberalism* – in which nation states would actively be at the service of the market.

The values of neoliberal ideology: market supremacy over democratic government; deregulation, allowing corporate 'freedom to operate' (Busch, 2010) resulting in economic globalisation; privatisation; monetarism; individualism; competition and institutionalised inequality, became the dominant cultural paradigm following the 1979 election of Margaret Thatcher (Lean and Cooper, 1996; George, 1999; George, 2008a; Busch, 2010), and established the myth that freedom to create wealth would see it trickle down to those at the bottom of the wealth pyramid (Stiglitz, 2012) and lift the poor out of poverty. These values were embodied in Mrs. Thatcher's favourite acronym TINA ('*There Is No Alternative'*), demonstrating the belief that free-market capitalism was the only possible economic theory (Wahl, 2012). In an interview with Woman's Own magazine in 1987 Margaret Thatcher famously stated:

"*There is no such thing as society*" (Thatcher, 1987).

These values of neoliberal capitalism have been adopted by political parties of both Left and Right. Even the traditional left of British politics became infected with neoliberal values. Peter Mandelson, director of Labour's successful general election campaign in 1997, told *The Times* in 2002:

> *"...globalisation punishes hard any country that tries to run its economy by ignoring the realities of the market or prudent public finances. In this strictly narrow sense, and in the urgent need to remove rigidities and incorporate flexibility in capital, product and labour markets, we are all "Thatcherite" now"* (Tempest, 2002).

Apart from this cultural capture of national policy making, the EU Commission is described by George (2008a) as the most neoliberal in its history. The World Bank, International Monetary Fund (IMF) and World Trade Organisation (WTO) promote the neoliberal belief in markets internationally, while preventing countries from acting to limit the market (Busch, 2010).

The traditional division of left and right in politics now seems largely irrelevant for solving the problems the world faces. The neoliberal paradigm makes the consideration and acceptance of new ideas in economics and other disciplines very difficult:

> *"The current world trade system arose from an almost* ***fundamentalist*** *belief in the capacity of the free market economy always to increase the standard of living.... This unfailing belief in an invisible mechanism, which unites the egoistic tendencies of individuals to the benefit of public welfare, leads to a simplistic (reductionist) perspective of the world where important observations and even*

> *logical conclusions with the opposite outcomes are not acknowledged"* (Wohlmeyer 2002, p16).

A former chief economist at the IMF (Johnson, 2010) asserts that the cultural and regulatory capture of policy making by the financial sector was the cause of the 2008 economic meltdown. Porritt (2009) observes that the causes of the economic collapse of 2008 and the continuing environmental collapse can both be related to neoliberal values. The desire for deregulation that led to the financial collapse through mispricing of risk; misallocation of capital; and misalignment of incentives, has also caused enormous environmental damage. Mason (2010) suggests that the pivotal moment leading to the financial meltdown of 2008 was the repeal of the Glass-Steagall Act in November 1999. Glass-Steagall had separated investment banking from retail banking. A law that prevented banks from operating as insurance companies was also repealed. At the ceremony where President Clinton signed the Gramm-Leach-Bliley Act (GLBA) into law, Republican senator Phil Gramm, chairman of the Senate Committee on Banking, Housing and Urban Affairs, said:

> *"In the 1930s, at the trough of the Depression, when Glass-Steagall became law, it was believed that government was the answer. It was believed that stability and growth came from government overriding the functioning of free markets.*
> *"We are here today to repeal Glass-Steagall because we have learned that government is not the answer. We have learned that freedom and competition are the answers. We have learned that we promote economic growth and we promote stability by having competition and freedom.*
> *"I am proud to be here because this is an important bill; it is a deregulatory bill. I believe that that is the wave of the future, and I am awfully proud to have been a part of making it a reality."* (Gramm, 1999)

Revealingly, Mason (2010) notes that the GLBA resulted from $300million of lobbying by the banking industry, and that Gramm had received $4.6million in campaign donations from the finance industry in the previous decade.

In 2000, Gramm introduced the Commodity Futures Modernisation Act without democratic debate (Mason, 2010). The Act made futures and derivatives exempt from the legal definition of gambling, and made any regulation of derivatives illegal. Mason (2010) notes that these pieces of legislation laid the framework for the meltdown of 2008.

The evidently corrupt values embodied in the application of neoliberal ideology show that there is an urgent need for consensus around a new set of cultural values (Capra, 1982) that will enable the 'perfect storm' of environmental, social and economic crises to be overcome.

3.1.2 Neoliberal economics and global warming

Carbon trading is central to global climate policy and is projected to become one of the world's largest commodities markets. Carbon trading is the preferred market-based approach of governments, the financial sector and corporations to dealing with global warming. Carbon trading is based on economic theories of economists such as R. Coase and later J. H. Dale. which suggested a market-based means to tackle pollution could be developed. Carbon trading elevates the right to pollute as equivalent to the right to use land. According to theory, the best way to distribute pollution was to put it on the market just like any other commodity.

The perfect market would automatically optimise pollution so that there is not too much of it (Gilbertson and Reyes, 2009).

In reality the Coase theorem assumed zero transaction costs, and Coase himself noted that this meant it was rarely applicable in economic reality (Morgan *et al*., 2006). In addition, according to economic theory, in a market with perfect information there will be no profits made. Carbon trading appears to be just one more neoliberal approach to creating new markets for pollution, rather than a real attempt to deal with the problem of global warming. Carbon trading is predicted by it's many critics to fail because:

a) Pollution allowances are given free to the worst polluters
b) Permits to pollute are worth real money but do not guarantee real carbon reduction
c) It distracts attention from other solutions that involve real emission reductions of the scale needed to avoid uncontrollable global warming. A solution is needed that keeps the carbon in the ground (Gilbertson and Reyes 2009).

The consequence of allowing the market to determine the path of human development (Wohlmeyer, 2002) is that carbon dioxide emissions from burning fossil fuels are still increasing. In 2010 global annual CO_2 emissions increased by 5-6% (Olivier *et al.*, 2011), the largest increase ever recorded, and at current rates of emission GHG concentration could double in less than 50 years (UNEP, 2012).

Leaton (2011) analysed the extent to which global financial markets are aligned with the need to keep temperature increase to within 2°C or less. He cautions that the next big financial bubble to burst could be the inflating 'carbon bubble'. Leaton (2011) concludes that less than 25% of currently proven fossil fuel reserves can be burned unabated by 2050, if we are to have an 80% chance of avoiding 2°C. There is potential for exposing investors to the enormous systemic risk of 'stranded' fossil fuel assets. Even the existing stock market listing of fossil fuels would be sufficient to take the world beyond 2°C (Leaton, 2011).

Adherence to the dominant neoliberal paradigm of market supremacy (Dunlap and McCright, 2011), particularly to the values of institutionalised inequality and the pursuit of self-interest through competition, determines what risk is 'acceptable'; whose interests are being served by climate policy (Mann, 2009); and keeps the world on a 'business as usual' trajectory that is likely to at least seriously degrade the quality of life of the majority of the world's population during this century (Smith *et al*., 2009). The market has not been capable of providing the leadership that is needed, and global warming has been called '*the greatest market failure the world has seen*' (Stern, 2007). George (2008b) explains that the lack of effective leadership is due to belief in the supremacy of the market:

> *"We humans normally think about our future, that of our children and the future of our countries and the world. The market, on the contrary, operates in the eternal present which, by definition, cannot even entertain the notion of the future and therefore excludes safeguards against future, looming destruction unless these safeguards are imposed upon it by law".*

The market demands economic growth (McCright and Dunlap, 2011a), but even when it occurs, economic growth is no longer providing improvements in quality of life (George, 2008b). In developed countries:

> *"We know that economic growth is not the yardstick by which everything else must be judged. Indeed we know that it no longer contributes to the real quality of our lives and that consumerism is a danger to the planet"* (Wilkinson and Pickett, 2010 p269).

From an ecological perspective, Daly (1993) has noted that the term 'sustainable growth' is an oxymoron when applied to the economy, "self-*contradictory as prose, and unevocative as poetry*". The obsession with economic growth as the pre-requisite for future well-being (Anderson, 2009; UNEP, 2011) displays a staggering degree of cognitive dissonance (bias towards a certain decision even though other factors favour an alternative) as it actually risks achieving the opposite. So long as economic growth is crucially dependent on continued consumption of fossil fuels, it can only hasten the crossing of climate thresholds predicted by recent climate science, beyond which the preservation of current planetary conditions will be beyond our control. Capra and Henderson (2009) suggest that the notion of indefinite (quantitative) economic growth needs to be replaced by sustainable (qualitative) economic development:

> *"our key challenge is how to shift from an economic system based on the notion of unlimited growth to one that is both ecologically sustainable and socially just. "No growth" is not the answer. Growth is a central characteristic of all life; a society, or economy, that does not grow will die sooner or later. Growth in nature, however, is not linear and unlimited. While certain parts of organisms, or ecosystems, grow, others decline, releasing and recycling their components which become resources for new growth"* (Capra and Henderson, 2009 p.4).

Politicians appear unable to assimilate the implications of the latest climate research:

> *"Policy makers refuse stubbornly to contemplate mechanisms for mitigating CO_2 emissions that cannot be demonstrated to, at best, not threaten short-term economic competitiveness and preferably offer early monetary returns….."* (Anderson, 2009).

Anderson concludes that if we are prepared to genuinely rise to the challenge we have brought upon ourselves, then we need to redesign the financial accounting model that dominates our lives, and "*re-establish society's dominance over economics*".

In the continuing global economic crisis now focused on the Eurozone, Governments appear to be desperate to preserve the existing financial system and aim for a return to economic growth, rather than grasp the opportunity to transform the economy as a whole onto a sustainable path.

The clear need to transform the global financial system has in fact been emphasised by the Bank of England since the 2008 crisis (Alessandri and Haldane, 2009; King, 2009). Alessandri and Haldane (2009) explained the case for transformation of the financial system via change in the regulation of banking risk and change in state support for banks in crisis, as the current certainty of state support encourages the tendency for banks to take excessive risks. They concluded:

> "*Reversing direction will not be easy. It is likely to require a financial sector reform effort every bit as radical as followed the Great Depression*" (p19).

3.2 Institutionalised Inequality

In 1991 Margaret Thatcher explained:

"It is our job to glory in inequality and see that talents and abilities are given vent and expression for the benefit of us all" (Thomas, 1998 p165).

Thomas (1998) states that the occasion was the Royal Geographical Society's presidential dinner. This now-infamous statement represented, along with the emphasis on competition, the central rationale for Thatcherite policies that were also adopted by US President Ronald Reagan and exported to the rest of the world (Lean and Cooper, 1996). In fact income inequality increased greatly during the Thatcher era, but the benefits failed to 'trickle down' to the lower end of the income scale (George, 2008b; Wilkinson and Pickett, 2010; Stiglitz, 2012).

The IPCC (2012) notes that inequality in wealth and education, disability, health status, gender, age, class, and other social and cultural characteristics determine how individuals and communities are vulnerable to, and affected by, the impacts of anthropogenic global warming. The nature of anthropogenic global warming means that a global response in the common interest is appropriate.

Wilkinson *et al.* (2010) concluded that reducing income inequality would likely be a pre-requisite for marshalling the sense of community and common purpose necessary to embrace effective measures and address the challenge of global warming. Business leaders will be crucial for delivering transformation, and business leaders in more equal societies were more likely to agree with governmental participation in international environmental agreements (Figure 9) than those in more unequal societies such as the UK (Wilkinson *et al.,* 2010).

The evidence suggests that reducing income inequality leads to a reduction in consumerism and status competition, as well as development of more social cohesion, all of which are needed to tackle global warming (Wilkinson *et al.,* 2010). The disconnect between individual self-interest and society is reduced in more equal societies, so people are more public spirited and trust each other more. More equal societies also have smaller ecological footprints, people consume less water, eat less meat, recycle more and produce less waste (Wilkinson *et al.,* 2010).

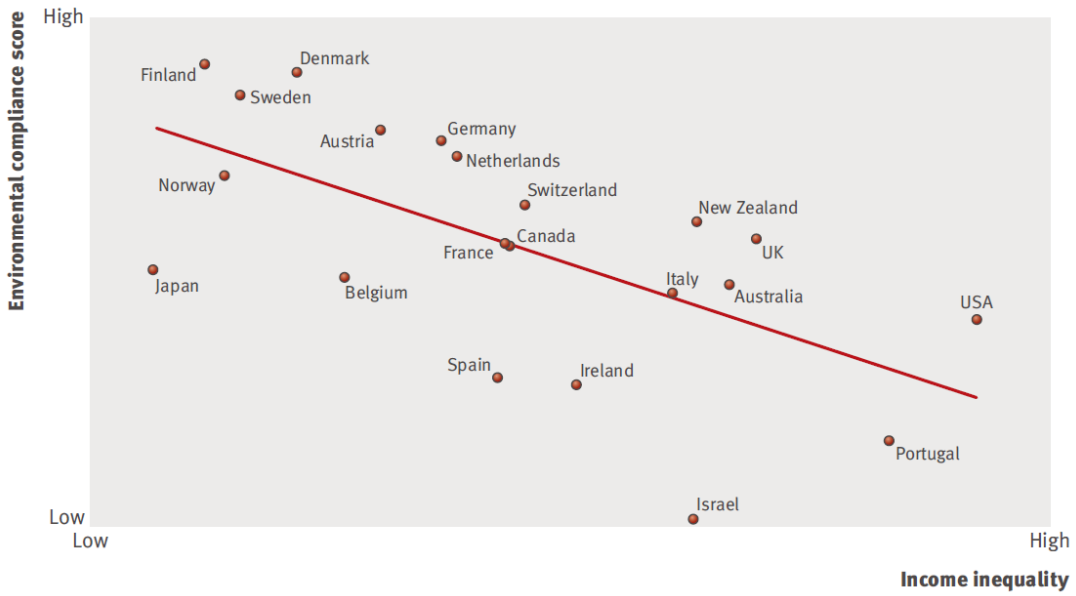


Figure 9 Importance business leaders give to their governments complying with international environmental agreements, and inequality of income (Source: Wilkinson *et al*., 2010)

Stiglitz (2012) points out that neoliberal policies have shaped market forces so that inequality has greatly increased through the pursuit of self-interest. The growth that has occurred has resulted in increased concentration of wealth at the top and increased poverty at the bottom of the wealth pyramid. Stiglitz argues that growing inequality was at the root of the 2008 recession. Economic inequality leads to political inequality that leads to more economic inequality in a positive feedback loop. Democracy suffers because policy becomes based on 'one dollar, one vote' rather than 'one person, one vote'. Stiglitz (2012) emphasises that this inequality is manmade, and calls for a change in politics and economics to create a more shared prosperity.

Wilkinson and Pickett (2010) used available data from 23 of the world's richer countries to show that increasing income inequality *within* a particular country, rather than *between* countries, was in fact significantly correlated with a wide range of negative social outcomes. Countries where the ratio of the top 20% to the bottom 20% of incomes was lower (more equal societies) actually performed better across the range of measures of societal well-being (Figure 10). Reducing income inequality can therefore be expected to facilitate real improvement in the quality of life.

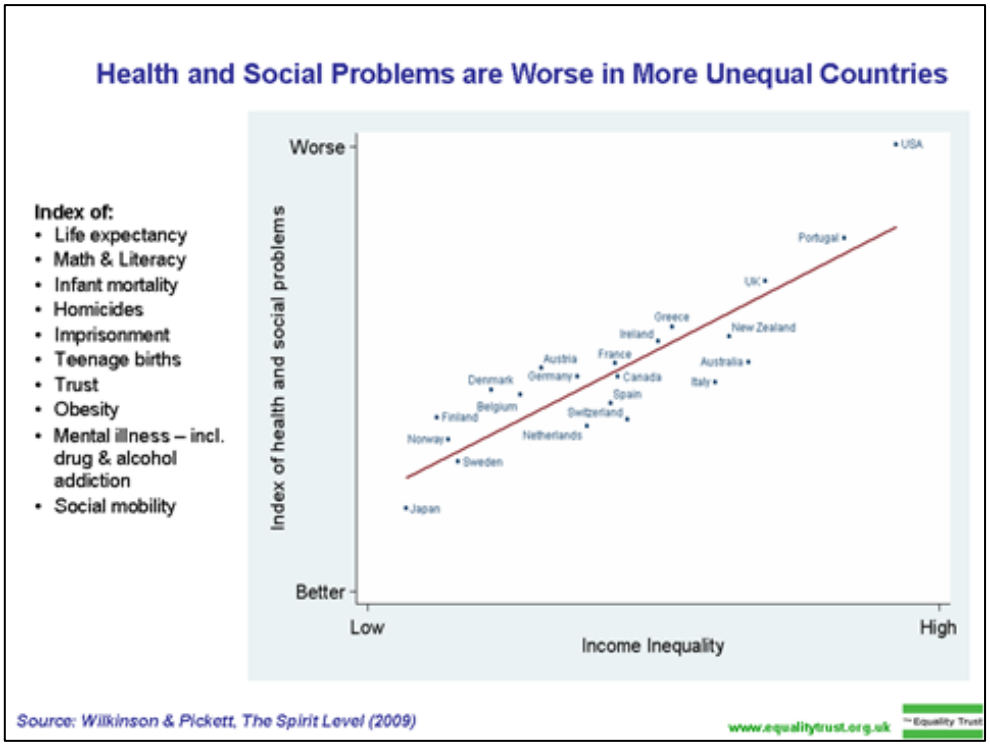


Figure 10 Association between income inequality and health/social outcomes within rich countries ($p<0.01$)

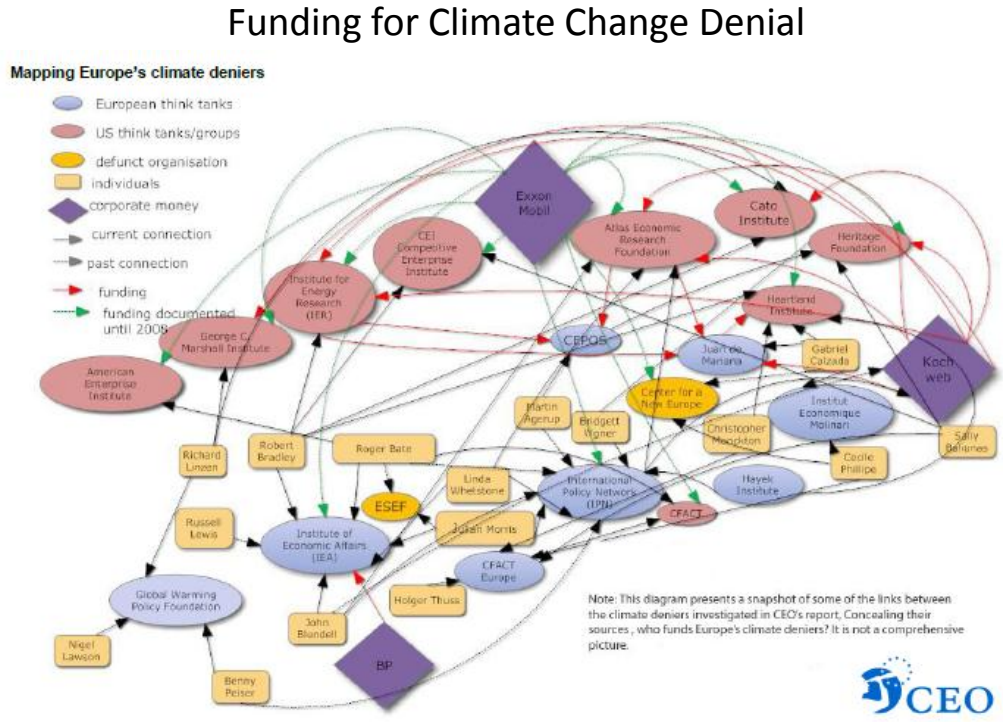
3.3 Climate change denial

Just as 'Big Tobacco' (Ong and Glantz, 2001) and 'Big Food' (Brownell and Warner, 2009) have sought to maintain corporate profits by dismissing inconvenient scientific findings and manufacturing doubt about the need for regulation, so 'Big Energy' has successfully used lobbying and funding of the global warming denial industry to prevent meaningful action on climate change (Hansen, 2009; Oreskes and Conway, 2010a and 2010b; CEO, 2010; Greenpeace, 2010; Dunlap and McCright 2011; Mann 2012; UCS, 2012). The tactics used include manufacturing uncertainty about the scientific consensus and attacking scientists who publish inconvenient findings, through all forms of media.

There was a significant decline in public concern about global warming in 2009-2010. The financial crisis of 2008 served to divert attention away from global warming, but the reduced concern was not driven by increasing scientific uncertainty. Rather, the *perception* of doubt was successfully insinuated into the public mind (Dunlap and McCright, 2011). By exerting disproportionate influence on the ruling powers, Transnational Corporations (TNCs) are in a position to "*force their own preferred dynamics of development on the whole world*" (Wohlmeyer, 2002 p21). They are able to do this through the shared values of opposition to regulation and commitment to 'free' markets embodied in the political ideology of neoliberalism (Dunlap and McCright, 2011).

An investigation by Corporate Europe Observatory (CEO, 2010) into the funding of global warming denial found a web of funding relationships between fossil fuel corporations and think tanks opposing action on global warming (Figure 11).

The 15th session of the Conference of the Parties to the UNFCCC (the Copenhagen Climate Change Conference) took place from 7-19th December 2009 and offered the leaders of the world their best opportunity to live up to their obligations under the UNFCCC. During the course of that year scientists had made valiant efforts to impress the urgency of the situation on world leaders (Richardson *et al.*, 2009; Sokolov *et al.*, 2009; UNEP, 2009). In the event the politicians completely failed to display the ecological literacy and wisdom that would 'protect the climate system for present and future generations'. The illegal hacking of climate scientists emails from the University of East Anglia had provided a convenient and timely opportunity for the climate denial machine to derail the talks (Dunlap and McCright, 2011) by casting doubt on the integrity of climate change researchers and the reliability of their findings.



Corporate Europe Observatory (2010)

Figure 11 Funding of Europe's global warming denial industry (Source: CEO, 2010).

One climate scientist well known for downplaying the risks of global warming took such an opportunity in the Wall Street Journal (Michaels, 2009), using the hacked emails to try to also discredit the US Environmental Protection Agency finding that carbon dioxide is a pollutant and can therefore be regulated.

A revealing example of how other scientists have been co-opted to trade scientific integrity for financial support from the fossil fuel industry, in respect of 'fracking' to extract shale gas, is given by Efstathiou (2012).

Dunlap and McCright (2011) and McCright and Dunlap (2011a) point out that since anthropogenic climate change is a serious unintended consequence of fossil fuel use, the industrial capitalist economic system as a whole is fundamentally threatened merely by acknowledging the reality of anthropogenic climate change. Dunlap and McCright (2011) note that organised global warming denial has increasingly been driven by conservative think tanks and front groups (Figure 12).

In March 2001, George W. Bush rejected the Kyoto Protocol on greenhouse gas emission reduction on the spurious grounds that 80% of the world was exempt from compliance; that it would cause serious harm to the U.S. economy; and that the science of global climate change was uncertain. He preferred instead, in the tradition of neoliberal capitalism, to focus on the development of "*technologies, market incentives, and other creative ways to address global climate change*" (Bush, 2001). Subsequently, a Strategic Plan for Climate Change was launched in December 2002, to provide "*more scientific information to define a clearly articulated regulatory policy that's practical, affordable and doesn't put the economy at risk*" (Blanchard, 2003 p18).

If a precautionary approach had instead been taken towards the low-probability, but high risk impacts of scientific warnings about anthropogenic climate change available at the time (Hansen *et al*., 1981; Schneider, 1989; Mann *et al*., 1998; Hansen *et al*., 1998) it is likely that the current challenge would have been significantly reduced in scale and cost. Blanchard (2003) suggests that the Bush approach to tackling global warming can be explained by:

- the weight of interest groups in policy-making, especially the energy industry;
- the historical reticence for government intervention by US corporations;
- the confidence that technology can tackle any problem and drive US economic growth.

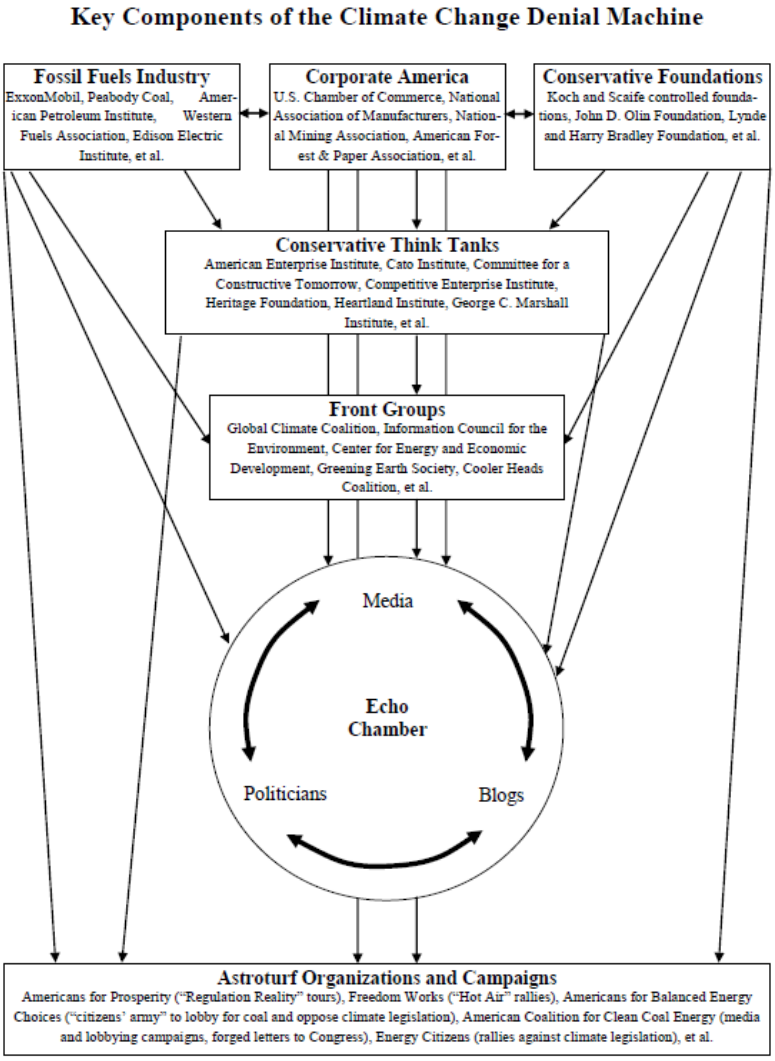


Figure 12 Structure of global warming denial in the US (Source: Dunlap and McCright, 2011)

The US non-governmental organisation Environmental Working Group obtained part of a briefing book for lobbyists and Republican politicians (Luntz, 2002) written by public opinion researcher Frank Luntz, who had offered his clients some revealing advice about how to address global warming:

- "*You need to continue to make the lack of scientific certainty a primary issue in the debate*" and "*emphasise the importance of acting only with <u>all</u> the facts in hand*"
- "*we need to emphasise how voluntary innovation and experimentation are preferable to bureaucratic or international intervention and regulation*"
- "*the most important principle in any discussion of global warming is your commitment to sound science*"… "*Similarly, our confidence in the ability of science and technology to solve our nation's ills is second to none*"
- "*the scientific debate is closing [against us] but not yet closed. There is still a window of opportunity to challenge the science*"

- "*you need to be even more active in recruiting experts who are sympathetic to your view, and much more active in making them part of your message*"… "*People are willing to trust scientists ... and less willing to trust politicians. If you wish to challenge the prevailing wisdom about global warming, it is more effective to have professionals making the case than politicians*"
- "*Climate change'' is less frightening than "global warming.*" "*While global warming has catastrophic connotations attached to it, climate change suggests a more controllable and less emotional challenge*" (Luntz, 2002).

It would appear that this advice was carefully heeded. Regarding 'sound science', similar tactics employed by the tobacco industry are described by Ong and Glantz (2001):

> "*Public health professionals need to be aware that the sound science movement is not an indigenous effort from within the profession to improve the quality of scientific discourse, but reflects sophisticated public relations campaigns controlled by industry executives and lawyers whose aim is to manipulate the standards of scientific proof to serve the corporate interests of their clients*" (p1749).

At the annual meeting of the American Association for the Advancement of Science (AAAS) in February 2012, AAAS President Nina Fedoroff noted that university and government researchers are hounded for publishing their findings on climate change. Emails are hacked and facebook campaigns call for scientists to be dismissed, often supported by right-wing politicians (McKie, 2012). McKie also points out that Republican Presidential candidate Rick Santorum insisted he is the right candidate because he had "*cottoned on earlier than his rivals Newt Gingrich or Mitt Romney to the 'hoax' of global warming"*. McKie (2012) quotes Professor Naomi Oreskes, a University of California science historian, observing that we:

> "*now have to watch as every Republican candidate for this year's presidential election denies the science behind climate change and evolution. That is a staggering state of affairs and it is very worrying"*.

Dunlap and McCright (2011) explain that global warming denial is part of an effort to preserve the existing social order built on industrial capitalism and powered by fossil fuels. Deference to such figures of 'authority' is clearly unwarranted.

3.4 Faith in technology

The more time passes without credible climate policies, the more the world is forced to depend on technology as a last resort to solve climate problems. The economic system depends on technology to drive economic growth (Jackson, 2009). Technological innovation will be crucial in solving the challenges of global warming and enabling future economic development, but it must be sustainable technology that serves a common purpose, rather than unsustainable technology enriching a narrow minority focused on short term profits. Instead of making a priority of *mitigation* policies (New *et al.*, 2011), that would constrain fossil-fuel dependent economic growth and corporate-driven technological determinism, the response is to emphasise the potential for *adaptation* that allows 'business as usual' technology-driven economic growth to continue (Wimbush, 2011).

Unfortunately there appears to be much blind faith in technological innovation to provide solutions such as carbon capture and storage; and various geoengineering technologies. Growth-driven technological solutions do not appear to be sustainable.

Given the apparent need to remove CO_2 from the air to restore the energy balance of Earth, an assessment was made of the likely cost of direct air capture (DAC) of CO_2 (APS, 2011). The cost of DAC using today's technology was estimated at around \$600/t CO_2 compared to \$80/t CO_2 for carbon capture and storage (CCS). Hansen *et al.*, (2012c) point out that DAC would therefore cost \$2200/t C (\$294/t C for CCS), and that removing 50ppm CO_2 from the atmosphere would cost over \$230 trillion. It is also worth noting that the cost of CCS using today's technology is unlikely to be economically viable. Deutsche Bank Research (Heymann, 2011) notes that the additional cost of CCS compared to conventional power plants is between 40% and 75%. The technology also reduces the efficiency of coal-fired plants by 10-50%, so more coal is needed to produce the same amount of energy. Heymann (2011) suggests a carbon price of €35-50/t CO_2 would be needed for CCS to make financial sense, whereas the EU carbon price is well below that figure.

For fossil-fuel dependent economic growth to be sustainable, increasing technological efficiency is very unlikely to be sufficient. Technological efficiency can result in lower CO_2 emissions per dollar of GDP and therefore achieve relative decoupling. However, continued economic growth and increasing population would ensure that overall emissions continue to increase, failing to achieve the absolute decoupling necessary (Jackson, 2009). Technological efficiency would need to improve by more than an order of magnitude by 2050 to bring about the absolute emission reductions that are needed to stabilise CO_2 emissions at 450 parts per million, a concentration of CO_2 that is itself now seen to be on the verge of 'very dangerous' climate change (Anderson and Bows, 2011). Reliance on technological solutions is not likely to produce the absolute emission reduction that is essential for future human welfare.

3.5 Cultural cognition of climate risk

Since 1979, the cultural values of neoliberalism have permeated into the consciousness of ordinary people and at all levels of (non-existent) society, so allegiance to values of individualism and deference to authority is likely to be strong. Individual preference for instant over delayed reward means people will likely be reluctant to sacrifice elements of today's materialistic lifestyle for the promise of a better quality of life later on.

Kahan and Braman (2006) found evidence that people perceive societal risks according to their individual cultural allegiances, rather than according to the best evidence on how to pursue common interests at the collective level. The authors refer to this phenomenon as 'the tragedy of the risk-perception commons' (Kahan *et al*., 2011). People formed factual beliefs that reflected and reinforced competing cultural beliefs along the cross-cutting axes of (i) hierarchical vs. egalitarian, and (ii) individualistic vs. communitarian (Figure 13).

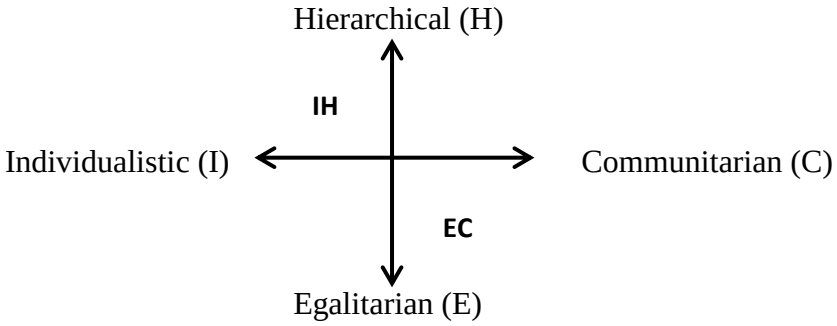


Figure 13 A framework for categorising public perception of risk (Source: adapted from Kahan *et al.*, 2011)

Interestingly, individuals categorised as IH were found to be less concerned about the risk of global warming as their level of scientific literacy increased, while those categorised as EC became more concerned as scientific literacy increased (Kahan *et al.*, 2011).

Although the association was not strong between these attributes and political leanings, the combination IH was loosely aligned with the political right (Kahan *et al.*, 2012).

Individuals categorised as EC were found to be loosely aligned with the political left (Kahan *et al.*, 2012). Perhaps more appropriately in the circumstances of 2012, the EC position would hold that social cohesion is vitally important if life is to be tolerable, and that limits to economic freedom are essential for genuine democracy. If economic freedom is the overriding priority, society will be fragmented and citizens will become just individual consumers (George, 2008a).

Perceptions of global warming risk have become increasingly polarised politically since the 1992 Rio Earth Summit (McCright and Dunlap, 2011a). These authors studied this phenomenon among members of the US public, noting that such understanding is crucial to developing effective policy responses. They found that people towards the left of the political spectrum were more likely to accept the scientific consensus on anthropogenic climate change and be concerned than those towards the right. Again, the strength of these respective convictions increased with increasing understanding of global warming, indicating that education alone is not sufficient to develop the sense of common purpose needed to forge a sustainable path for humanity in the 21st Century. McCright and Dunlap (2011b) concluded that the views of conservative white males contribute disproportionately to the high level of global warming denial in the United States.

The extent to which the cultural beliefs of the American people have been manipulated by the secular and religious Right is explored by George (2008c).

3.6 Scientific reticence

One of the reasons for public confusion over the clear threat of global warming may be that scientists are reluctant to announce findings until they are supported by other evidence gradually over time. This natural reticence is good science under normal circumstances but may not be so appropriate if serious harm results from undue delay, as may be the case with climate science (Hansen 2007). Scientists may also be reluctant to speak out due to the risk of being attacked by political and industry opponents of climate regulation. Following publication of his 1981 paper in *Science*, Hansen's research suffered when the Department of Energy withdrew it's decision to fund his research (Hansen, 2007). Scientists like James Hansen (Hansen, 2009) and Michael Mann (Mann, 2012) are confident enough in their position to focus on the need to communicate the implications of their findings to the world and defend science from corporate and political interests. The onslaught against palaeoclimatologist Mann following publication of the famous 'hockey stick' graph showing the late 20th Century temperature rise in an historical context, is recounted by Mann (2012) and by Clynes (2012). Such ideologically and financially motivated reactions may mean that many other scientists are deterred from publishing 'inconvenient' findings. Political support for the corporate-funded climate denial industry merely emphasises the need to reclaim the democratic process from such narrow interests motivated by power and profits.

All of the above factors are likely to be involved in explaining the dire situation the world is now in. The overriding influence can be seen to be the culture of neoliberal ideology that has dominated our lives for the last thirty years. Effective responses to the perfect storm of crises cannot be introduced until society is motivated by a new set of values more conducive to ecological sustainability.

4. Solutions

It is clear that the rules governing the economy, and the national and international institutions promoting them, have failed to represent the interests of the environment or human society. Instead they have resulted in the perfect storm of crises that threaten to make human existence much more onerous in the near future.

Facing down this perfect storm of environmental, social and economic crises requires a paradigm shift (Gilbertson and Reyes, 2009; Wood, 2012), away from the dominant culture of consumption, aggressive competition, individualism, inequality and undue respect for hierarchy towards a more egalitarian and communitarian culture (Wilkinson *et al*, 2010).
This fundamental change in our cultural paradigm is illustrated simply in Figure 14.

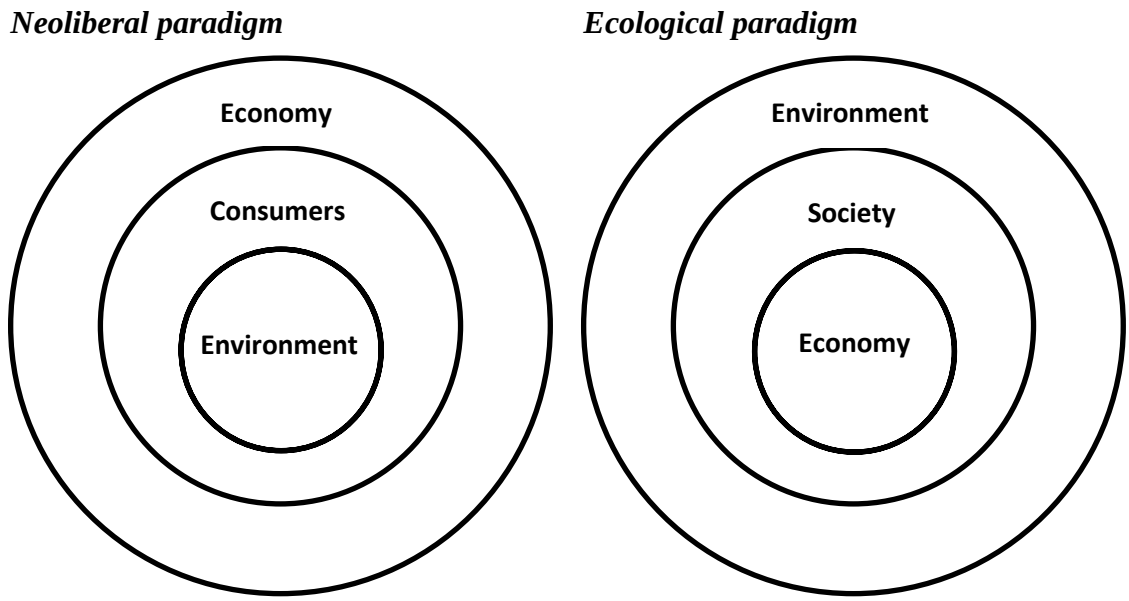


Figure 14 The Challenge of Cultural Transformation.

In the neoliberal world, the economy has subsumed the environment, which linearly serves the economy as a source of raw materials to be processed, and a sink for it's waste products. Society is demoted to a collection of individual consumers. Nation states are in service to the market, whose existence depends on unsustainable quantitative growth. In a sustainable world, human society is organised to live within ecological constraints, and the economy develops qualitatively to serve the needs of the population while respecting environmental limits.

Global warming policy based on ecological principles is urgently needed, so some kind of merger between the two paradigms illustrated in Figure 14 is all that time will allow in the short term. Porritt (2005) has pointed to the need to change today's version of capitalism to embrace different values that allow real solutions to the worsening crises. A starting point would be to acknowledge that Margaret Thatcher was wrong on all three counts cited here: There *is* such a thing as Society; There *is* an alternative to free market economic theory; and institutionalised inequality is *not* a good thing. This means acknowledging that the neoliberal project was a poorly conceived path to human development.

4.1 Reclaiming democracy

The implications of this transformation for all areas of human activity are as profound as those of the Industrial Revolution, and it is not realistic that subservience of politics to the market could effect such radical change. Free market industrial capitalism, with its ecologically destructive technologies, is incapable of providing effective leadership. Cultural and regulatory capture of 'democratic' institutions by the proponents of neoliberal capitalism prevents appropriate political responses to the challenges we face. The driver for change, if hope is to be realised, must be the demand for action expressed democratically by the public.

According to George (2008b) the trick to introducing ecological literacy into decision-making is to:

"*convince politicians that ecological transformation and environmental practices can pay off politically*".

Once the political will to respond effectively to global warming reality is recruited, the existing values that dictate policy and in turn govern institutional behaviour could be relatively easy to revise, despite expected resistance from proponents of the *status quo*.

4.2 Raising awareness

For this to happen, a clear message needs to be communicated about the prospects of continuing fossil fuel use for our children and future generations. When the public realise the scale of the threat from global warming and the urgency of taking radical action to stabilise the climate, they will be able to decide rationally where their true interests lie. There are enormous opportunities to deal with the problem in a way that leads to real improvement in the quality of their lives. Young people in particular need to view the consequences of global warming as unacceptable before their voices are added to calls for change in behaviour and values. They may now be able to perceive global warming personally, and be able to place political calls for deregulation and increased competition in their proper ideological context.

The media will also need to play an important role in raising awareness of global warming reality, but have failed so far, with some exceptions, to display any sign of ecological literacy in the face of the 'perfect storm'.

The internet offers almost universal and ready access to information that would provide the basis for cultural transformation. The familiarity of young people with this powerful medium for change offers great potential for understanding the complexities of the world we live in. The sources used to construct the narrative of the present paper are virtually all available to anyone with internet access. Book contents can often be browsed online via Google books (e.g. see Wood, 2012). YouTube videos bring the perspectives of prominent natural and social scientists direct to digital screens.

Education has an important role in culturing the curiosity in students that leads to understanding of the world. Overcoming cultural influence on the perception of risk is a particular challenge to development of ecological literacy in students.

Scientists are also people with families and children. There are increasingly examples of scientists willing to face the wrath of a power structure that believes 'freedom' and 'competition' are the answers. It may help to remember, as Capra (2008) observes: "*life did not take over the planet by combat, but through cooperation, partnership and networking*". Society would be well served if many more scientists would view their work in the context of the Precautionary Principle, as the UNFCCC (1992) intended, and publicly communicate findings that may be inconvenient to the 'masters of mankind', as Adam Smith called them. The pressing urgency of global warming means the time is right for more scientists to consider the policy implications of their work and communicate their understanding of the science, rather than being cowed by the deniers of global warming.

4.3 Leadership

It is clear that a new kind of leadership will be essential at all levels of community, education, industry and public service. The pressing need is for such leaders to step up without delay and apply ecologically literate values in the solution of the perfect storm of crises. If future disaster is to be avoided, a wartime mentality of common purpose may be needed to counter the threat of global warming. According to Porritt (2009) the obvious remedy for the economic and environmental crises lies in massive investment in sustainable infrastructure and technologies to help '*avoid the infinitely worse calamity that is looming'*. Such investment could offer the opportunity for the qualitative form of economic growth advocated by Capra and Henderson (2009).

4.4 Science based energy policy

Adaptation to unavoidable global warming will be essential, but the overriding need is to restore the energy balance of Earth through mitigation of global warming caused by human activity. A suitably cautious policy would be to limit eventual warming to no more than 1°C above the global mean temperature in 2000 (Hansen, 2007), although even this may be too much to prevent ice sheet disintegration leading to multi-metre sea level rise in the 21st Century.

Hansen *et al.* (2012c) conclude that the immediate need is to change energy policy and embark on a radical reduction in fossil fuel use. If energy balance is to be restored to preserve a climate adapted for life as we know it, atmospheric concentration of CO_2 must be reduced to around 350ppm by the end of this century. Emission reductions of 6% per year starting now are required to achieve this target (Hansen *et al.,* 2012c), a reduction not even achieved during the collapse of the Soviet Union (Jackson, 2009). In addition, under this scenario a massive reforestation program would be required, essentially restoring biospheric carbon content to its natural level. Delay would certainly make the transition to a new energy future even more painful. If emissions reductions had begun in 2005, the required rate of reduction would have been 3% per year. If reductions are delayed until 2020, the required reductions will be 15% per year (Hansen *et al.,* 2012c).

4.5 Ecological reform of economics

Neoliberal market solutions like carbon trading are inadequate for the task ahead. There is a pressing need to reform the dominant accounting model so that the environmental and social costs of fossil fuel use are completely internalised into the price of their continued use. The implications of internalising the costs of global warming into national and business accounts pose a serious threat to the economic system of free-market capitalism and those who seek to sustain it beyond any usefulness to society. Therefore it is crucial to place a realistic price on the 'social cost of carbon' (SCC). The SCC represents the estimated cost of damage caused by each additional tonne of carbon dioxide, and also represents the value of benefits achieved by reducing those emissions. It can also be seen as the cost of doing nothing (Ackerman and Stanton, 2012). Official US estimates of the SCC appear likely to seriously undervalue the cost of future global warming damage. If the evidence suggesting non-linear dynamics of global warming impacts on land and sea ice (Velicogna, 2009; Rignot *et al.,* 2011; Stroeve *et*

al., 2012) is correct, then surely the impacts on future economic output will be similiarly non-linear, implying much greater future economic damage.

The social cost of carbon was estimated at $21/t for 2010 (in 2007 dollars) rising to $136 in 2050 by the US Interagency Working Group (IWG, 2010). According to Ackerman and Stanton (2012), many of the biggest risks of global warming were not considered by the IWG, who downplayed the future impact of current emission levels. They note that such a low cost estimate suggests climate risks can be addressed gradually without great expense. A realistic estimate depends on assessment of:

1. climate sensitivity (the temperature response to a doubling of CO_2, which is around 3°C (IPCC, 2007). This value only includes the fast feedbacks of water vapour, clouds, aerosols and sea ice extent. Changes in high latitude vegetation, continental ice sheets and persistent GHGs are slow feedbacks that would increase the eventual equilibrium climate sensitivity (Hansen,2007).
2. the estimate of damage per unit of CO_2 (the reduction in global economic output resulting from increased temperature).
3. the discount rate used (long term considerations make this crucial for estimating the cost of future impacts. The higher the rate used, the less important long term estimates of damage are considered to be) (Ackerman and Stanton, 2012).

Ackerman and Stanton (2012) state that in all cases the IWG chose options that minimised estimated risks and damages. They concluded that more likely impacts of global warming result in estimates for the social cost of carbon that are higher than IWG estimates by an order of magnitude, thus exceeding the cost of the radical emissions reduction that are needed:

> *"Once the SCC is high enough to justify maximum feasible abatement in cost-benefit terms, then cost-benefit analysis becomes functionally equivalent to a precautionary approach to carbon emissions. All that remains for economic analysis of climate policy is to determine the cost-minimising strategy for eliminating emissions as quickly as possible"* (Ackerman and Stanton, 2012 p20).

This assessment shows that there is no economic argument for further delay in transforming energy policy. If fossil fuels had to pay their full costs to society through taxes, levies etc. and were no longer subsidised, clean energy technologies could rapidly reach their full potential. A realistic price of carbon, rising over decades, would enable people and businesses to change lifestyles and investments to minimize costs (Hansen *et al*., 2012c). Overall energy demand would also need to be constrained rather than increase greatly as currently predicted.

4.6 Legal

As a result of political inertia in the face of the perfect storm of crises, legal experts are now exploring the possibility of legal redress under the Public Trust Doctrine to oblige governments to develop appropriate policies in line with global warming science, in order to protect the future of young people and Nature (Wood, 2012). The commitments made by signatories to the UNFCCC may offer the best hope, short of a western-style 'arab spring', of forcing governments to protect the biosphere for the young and for future generations. In several States of the US, young people are currently trying, with the help of ecologically

literate legal experts, to sue the State, as well as Federal Government, to bring about change to appropriate energy and global warming policies (Wood, 2012; iMatter March; Our Children's Trust).

5. Conclusion

Global warming appears to be the 'killer' issue that will dramatically change our world for the worse or for the better, depending on which option we choose. Either way, the implications for our way of life are enormous, and it seems we have very little time to make our own decision before the choice is taken from us.

Scientific evidence suggests the likelihood of increasingly severe and frequent extreme weather events in the short term, and severe social, economic and environmental disruption in a matter of decades due to rising seas and increasingly catastrophic storms. There are indications of non-linear dynamics at work in accelerating loss of continental ice sheets and Arctic sea ice. Positive feedbacks mean 'tipping points' in the climate system could be passed very soon, leading to irreversible global warming. A precautionary approach should be evident in climate policy as intended by the UNFCCC. However, a "raw and dispassionate" assessment of climate reality poses an existential threat to the prevailing political and economic culture of neoliberal capitalism. The market based 'solution' of carbon trading makes profit from pollution but fails to effectively address the problem of how to end it. Preservation of neoliberal ideology requires manipulation of the public perception of the risks, and threatens the prospects of our children and future generations.

There are natural and anthropogenic barriers to achieving the public awareness needed to demand cultural change. People will be loath to give up any of today's fossil-fuel dependent comforts for the promise of future improvement in quality of life unless they perceive an unacceptable threat on a personal level. The culture of neoliberal capitalism appeals particularly to the egoistic tendencies of individuals. To surmount this barrier, a clear message needs to be communicated to the public about the prospects of continuing fossil fuel use for their children and future generations. The role of neoliberal capitalism in creating the perfect storm of crises is also emphasised.

Public demand for change, allied with appeals for legal redress, may be the only way to achieve a change in energy policy in the limited time available.

Stabilising the climate has to take priority over economic growth to preserve tolerable living conditions for humanity, implying the need for the biggest transformation in human history.

We all have a choice to make, and it needs to be considered without delay. If we care about the short-term prospects for our families and our children; if we care about the long-term prospects for the survival of human civilisation, the choice of an ecologically sustainable future, and the cultural transformation it entails, seems like an obvious choice to make while there is still time.

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