

TOTAL CAPITAL EFFICIENCY: AN ECONOMIC THEORY OF SUSTAINABLE DEVELOPMENT

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ABSTRACT

The emerging discipline of sustainability management is subject to a number of critiques. These range from challenges to its ideological alignment with different conceptions of sustainable development, to skepticism about the significance of its economic value add. This essay takes the view that at their core these critiques stem from deep and unresolved conceptual challenges in the relationship between economic science and sustainable development discourse. The essay reviews the emergence of sustainable development discourse in the context of the evolution of economic conceptions of value and market behavior. In so doing it unearths the marginal theory of value and dominance of monetary valuation and exchange in economics as key obstacles to market mechanisms that take cognizance of the 'sustainable development value' of goods and services for which the perceived monetary value might be low.

By relaxing certain key assumptions in the neoclassical growth model, a revised sustainable development model is proposed in which the role of the sustainability management toolkit can be understood as an important component of a mechanism for realizing a practicable and iterative evolution in the economic theory of sustainable development.

KEYWORDS

Sustainable development economics, sustainability measurement, sustainability management.

In general equilibrium everything depends upon everything else.

(Léon Walras 1834-1910)

INTRODUCTION

Economic production affects the lives of every inhabitant of the Earth. This is because the planet is ecologically and economically closed or cut off from external economic and ecological systems. Ultimately we are all interdependent. Economic theory is sometimes used to describe or explain production and consumption decisions and how these relate to the broader materially closed economy in which they are made. Increased cognizance of the closed nature of the earth's biosphere has led to greater inquiry in recent decades into the relationship between economic production and the ecosystem in which it takes place.

These inquiries have observed significant interconnectedness of economic, social and ecological systems within our closed *ecosystem*. This has in turn contributed to the emergence of sustainable development as an economic concept. While progress has been made in some areas, economics and sustainable development currently have serious practical and conceptual disconnects that inhibit the establishment of a cogent *economic theory of sustainable development*. The term 'economic theory of sustainable development' is used here to distinguish from theories of sustainable development that might at their heart, focus on ecological, social or ethical aspects rather than focusing on what this essay views as intrinsic and inevitable economic foundations.

The development of an economic theory of sustainable development fundamentally challenges the current format of economics through requiring new ways of thinking about economic constructs that have become deeply embedded in economics' discourse during its evolution. Sustainable development theory on the other hand is in a very nascent form with numerous ideological and conceptual tributaries, many of which appear only to diverge in the very long run. These apparently divergent views give rise to great uncertainty about both the meaning of the concept and the nature of its underlying causal processes.

In the light of this immense uncertainty it seems reasonable that economics as a broad body of theory only touches selectively on sustainable development issues, rather than ingesting sustainable development propositions into the mainstream of economic thought. However economic production remains, and shall remain, constrained by its relationship with ultimately scarce ecological and social goods and services. The consequences of this, for our ability to use economics' tools to guide production and consumption decisions towards sustainable improvements in the human condition, cannot be overstated.

Given the immense and ongoing uncertainty around sustainable development this essay does not attempt to clearly define sustainable development, nor to provide a linear blue print for how it should be achieved. Rather it focuses on identifying the key issues affecting the realization of sustainable development and, through a process of conceptual analysis, offers a series of theoretical tools that can help to determine a course of action for enhancing our understanding of the concept and aligning production processes with this evolving understanding on an ongoing and iterative basis. The methodology employed aims to achieve this through conceptually integrating some key elements of neoclassical growth theory and market theory with the main cornerstones of sustainable development theory.

Given the evolving nature of sustainable development discourse the essay focuses on the least frequently disputed characteristics of sustainable development rather than basing its contribution on any particular

definitions. These characteristics have been identified during a focused literature review relating to the economic dimensions of sustainable development, and through insights gained in the practice of sustainability management, with a particular focus on its application to the financial services industry.

A review of sustainable development discourse identifies four cornerstones across what is a diverse and sometimes contradicting body of knowledge. These are: 1. Sustainable development is usually understood to engender sustainable improvements in the human condition; 2. Economic manifestations of sustainable development recognize the significance of a broad set of ecological, societal and economic capital types as inputs into economic development; 3. The substitutability of these capital types is not fully understood; and 4. The concept of sustainable development is itself in a state of continual and profound evolution.

A review of economic theory subsequently traces two main hallmarks in the evolution of economics that inhibit the integration of the four cornerstones for sustainable development into mainstream economics. These are: 1. The use of financial indicators or monetary units as the principal means of measuring and exchanging economic value; and 2. The reliance of the neoclassical paradigm on marginal utility as the main determinant of economic value in market systems.

Overlaying the cornerstones for sustainable development with these two aspects of economic theory allows us to identify the separate but interdependent characteristics of economic theory that could more meaningfully accommodate the main criteria for an economic theory of sustainable development.

Based on observations made in the conceptual analysis described above, the essay asserts first that the dominance of monetary valuation is an impediment to integrating or internalizing the significance to sustainable development of non-monetized goods and services into economic production decisions; and second, that the dominance of the marginal theory of value precludes market theory in its present form from meaningfully accommodating integration into consumption and production choices, the use value of goods for which the perceived value might be low. The interconnections between these deep seated characteristics of mainstream economics are sometimes circular and confusing from a sustainable development standpoint.

The study offers a solution to this complexity through integrating sustainable development criteria into a revised economic growth model that incorporates the cornerstones for sustainable development. It subsequently integrates the same criteria into the concept of externalities and assesses the conceptual implications of this new formulation of externalities for the new model for economic development.

The proposed models, although based on well-established economic principles, engender a shift towards viewing sustainable development as a process rather than a particular end state in aggregate economic production. In terms of this view, emphasis is placed on employing measurement tools and economic mechanisms for achieving the most sustainable configurations of the broader capital portfolio through iterations of economic production, rather than focusing on development ultimately being a function of capital accumulation as posited in the Neoclassical Growth Model.

SUSTAINABLE DEVELOPMENT

Linguistically the term sustainable development is a relatively modern formulation, although the conceptual foundations of the idea may be much older. The word sustainable derives from the Latin word *sustinere*, which simply means to 'uphold' (www.thefreedictionary.com). Thus in modern use the formulation 'sustainable' means 'capable of being upheld or continued'. 'Development' is thought to have first been used towards the end of the 18th century and is derived from the old French word 'desvoluper' meaning to 'de-envelop' or unwrap (www.merriam-webster.com). In modern use the term development can mean a broad range of things including 'to bring from latency to or toward fulfilment,' 'to expand or enlarge', 'to aid in the growth of', 'to improve the quality of' or 'to cause to become more complex or intricate' (www.thefreedictionary.com).

Arguably the broad interpretations of the word 'develop' have contributed to the very different conceptions of sustainable development today, with authors such as Christen and Schmidt (2011) recently finding "great arbitrariness in the understanding of this idea and in the attempts to answer its 'principal organizing question': What is to be sustained?"

One of the most commonly accepted definitions of the term is that of the Brundtland Report. In 1982, ten years after the Stockholm Conference on the Human Environment, the United Nations General Assembly established an independent commission on sustainable development, today known as the Brundtland Commission, which provided the following definition: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987).

In 1990, David Pearce, Edward Barbier and Anil Markandya suggested that:

The use of the term 'development', rather than 'economic growth', implies acceptance of the limitations of the use of measures such as gross national product (GNP) to measure the well-being of nations. Instead development embraces wider concerns of the quality of life – educational attainment, nutritional status, access to basic freedoms and spiritual welfare. The emphasis on sustainability suggests that what is needed is a policy effort aimed at making these developmental achievements last well into the future (Pearce et al., 1990).

Later, and although this interpretation of the term had been popular, it was argued that the political confusion emerging as a result of its looseness has led to its abuse. James Connely and Graham Smith suggest that although in its original usage the term sustainable development challenged orthodox political and economic views; its use has been broadened to the extent that it has subsequently been used simply to defend mainstream patterns of industrialization and economic growth (Connely and Smith, 1999).

Daly had presented a similar view, noting that at the time of the Brundtland Report its definition was sufficiently vague to facilitate general agreement, suggesting that by 1995 its vagueness had become "a breeding ground for disagreement" with some arguing that the term was so vague that it was of no use to standard economics (Daly, 1996).

Commentary on the disagreements and disconnects within what we describe as the *popular sustainability movement* has found deep ideological foundations for the many different streams of thought with Springett (2005) likening sustainable development discourse to a 'site of political contest'.

The struggle between discursivity and control is an inherently ideological process (Redclift, 1996), and one that is sometimes overlooked, or taken for granted. A critical perspective views sustainable development as a political project - a 'site of political contest' akin to Gramsci's 'wars of positions' (Gramsci, 1988), with the potential for bringing about political or structural change (Springett; p 1 2005).

Evidence of political and ideological contest is commonplace in the sustainability literature. Harvey (1996) for example describes the voracious inclusiveness of the discourse as the trademark of a rapidly evolving line of thinking. Others, such as Beder (1997) and Luke (2013) echo Springett's views suggesting that organised business has co-opted sustainable development as a means to favourably engineer public perceptions towards the ethical desirability of big business, with Sunderlin (1995) observing its power as a vehicle for perpetuating the capitalist means of production. However others, including O'Connor (1998), have viewed sustainable development as a useful conceptual tool for thinking about economic and social activity in a manner that could result in greater harmony between human beings and the natural world.

Although this essay decouples these popular accounts of sustainable development discourse from the focus of our literature review, they cannot be completely abstracted from the establishment of the sustainable development paradigm. On the one hand the lack of a cogent theory of sustainable development creates a vacuum within which strongly divergent views can exist and be contested. On the other hand, and as we shall see when we explore the implications of market economics for the discourse, it may well be that these divergent perspectives and tensions can ultimately solidify the practical realisation of sustainable development through a process of conceptual, ontological, anthropological, political and economic attrition.

Before reaching this conclusion it is crucial to explore the more scientific origins of what could one day become a unified economic theory of sustainable development.

EMERGING THEORY

The power of the concept of sustainable development is that it both reflects and evokes a latent shift in our vision of how the economic activities of human beings are related to the natural world – an ecosystem which is finite, non-growing and materially closed. The demands of these activities on the containing ecosystem for regeneration of raw material “inputs” and absorption of waste “outputs” must, I will argue, be kept at ecologically sustainable levels as a condition of sustainable development (Daly, 1996; p 2).

Pezzy and Toman (2002) describe the period shortly following the publication of *The Limits to Growth* (Meadows *et al.*, 1972) as being a foundational period in sustainable development theory. The authors cite *The Optimal Depletion of Exhaustible Resources* (Dasgupta and Heal, 1974), *Growth with Exhaustible Natural Resources: Efficient and Optimal Growth Paths* (Stiglitz, 1974), and *Intergenerational Equity and Exhaustible Resources* (Solow, 1974) as seminal works in sustainable development theory. Although they do not use the term sustainability very frequently, their analysis on the nature of economic growth when a non-renewable natural resource is “...a significant input to aggregate production” makes them important formative references in the sustainability literature (Pezzy and Toman, 2002).

The authors note that the early work on sustainable development focused on utility optimisation as the principal characteristic or unifying common objective for sustained human improvement. Dasgupta and Heal (1974) viewed society's objective as being to maximize present value (PV) of individuals' utility using a

constant discount rate relative to the ‘using up’ of natural capital and the use of man-made capital as an input. However it was later observed that in the long run these assumptions led to a situation where consumption and utility approached zero in the long run, notwithstanding an initial peak during the period of relative abundance.

Stiglitz (1974) postulated that the rate of exogenous technical progress would be large enough to offset the effects of resource depletion and thus circumvent PV optimality inevitably reaching zero in the very long run. Simultaneously Solow (1974) proposed that constant consumption could be sustained provided that the depletion of natural resources was accompanied by an appropriate program of accumulating other economic capital. Solow’s contribution is seen by Pezzy and Toman to be the prequel to Hartwick’s (1977) “Intergenerational Equity and the Investing of Rents from Exhaustible Resources.” This gave birth to what has become known as the *weak sustainability approach*, which assumes that different forms of capital are perfectly substitutable for one another in aggregate production, thus “Zero net investment results in constant consumption forever.” This principle later became known as Hartwick’s rule.

Notwithstanding the notoriety of Hartwick’s rule, at the heart of sustainable development theory today still lies the unresolved debate about the inter-temporal substitutability of different capital types in the course of economic growth, which has given rise to the ‘weak’ vs ‘strong’ sustainability debate. Kavi Kumar of the Madras School of Economics describes the weak versus strong sustainability debate succinctly:

..weak sustainability can be defined as the maintenance of the value of the aggregated stock of capital and strong sustainability requires that each type of capital stock should be maintained in its own right, at least above some minimum level (Kumar, 2012; p.1).

In 1990, Olivier Godard brought attention to the uncertainties surrounding the weak versus strong debate, suggesting that a political process towards sustainable development can neither be derived directly from an inter temporal economic optimisation informed by market prices, nor from scientific understandings of biophysical processes upon which the regeneration of natural resources depends. He argued this on the basis that imperfect understandings of the complexity of each of these two fields, and the relationships between them, dictate an element of uncertainty regarding policy processes towards sustainable development. For his reason, the author gives importance to the precautionary principle as a means to tempering decision processes that may lead to ecologically unsustainable economic activities (Godard, 1990; p. 22).

In 2002 however, Pezzy and Toman observed that, despite the warnings of Godard, Daly and others, the Hartwick rule had been implemented by numerous government and multilateral organisations when choosing to invest “rents from natural resource depletion in building up capital in the rest of the economy”, highlighting the practical bearing that the present state of sustainable development theory has for practical economic decision making (Pezzy and Toman, 2002). The risk in assuming perfect substitutability between heterogeneous capital types was further crystallised by Laloë (2007) who noted that the definitions of capital are themselves in a state of continual evolution, giving insight into sustainable development as a concept that can never be perfectly defined but only progressed in parallel with our ontology of it.

While in absolute terms the precautionary principle suggests that one cannot assume perfect substitution under conditions of uncertainty the debate could become infinitely more nuanced at the margin where cause might exist to believe in partial substitutability or differing rates of fungibility relative to changes in other factors. It is worth noting at this point that the principal logic within sustainable development theory today

has been to explore the configuration of capital and production in the pursuit of greater utility. Here the focus has been on the reorganisation of production, and its underlying forces of demand and supply, as a key theme.

During the 1850s however John Stuart Mill outlined in his Principles of Political Economy the idea of a 'stationary state' economy in which population growth and capital accumulation would both reach zero. He reasoned that zero growth in population or capital accumulation would not necessarily imply a stationary state in human improvement (Mill, 1909), as opportunities for qualitative growth in the human condition were not necessarily always linked to accumulation of capital.²

After reflecting on Mill's thought process this essay questions whether sustainable development discourse has been focused on only one side of the economic equation: the reorganisation of production in order to sustain utility. Here the challenge is compounded by uncertainty around what form of utility is to be sustained. It appears the second side of this equation is to explore whether and how conceptions of utility could be reorganised, and what implications this would have on forces of supply and demand informing production.

These musings form an important part of the conclusion for this essay, however it is necessary first to unwrap, or de-envelop, the economics' discourse in which conceptions of sustainable development have struggled to exist.

ECONOMICS

Economics is the social science that analyzes the production, distribution, and consumption of goods and services. The term *economics* comes from the Ancient Greek *oikonomia* for "management of a household" (Harper, 2001). Although economic analyses are often used in economic decision making to determine the most desirable course of action relative to the alternatives, economics does not concern itself with value judgments – rather it is objective within certain assumptions (Kirzner, 1963; p. 8).

Economic reasoning throws light, for example, on situations that human beings associate with specific sensations. The demand for food has to do with feelings of hunger or of satiety; the demand for reading material has to do with the thrills of exploration, suspense, or learning; the supply of labor has to do with feelings of weariness and fatigue. It is emphasised that economic theory does not refer to these specific sensations. Economic theory abstracts the element of preference - bare and colorless - that emerges in each of these situations. In geometry a proposition may throw light on properties of rectangular objects, including restaurant tables, milk cartons, and billboards. Geometry, however, has nothing essentially to do with eating in restaurants, drinking milk, or advertising (Kirzner, 1963; p. 8).

This section traces the evolution of economic science from some of its first formal constructs to the present day. The review is punctuated with some objective reflections on the relationship between formal economics and the cornerstones for sustainable development identified in the previous section.

We accordingly begin with the first formal school in economics and work systematically towards the present day, focusing on elements in the evolution of formal economics that have a material bearing on our ability to achieve harmony between economic science and the cornerstones for sustainable development. In so doing we will observe structural dislocation between what are largely perceived to be the scientific truths about the

² For a detailed discussion see Edwards, AR. 2010.

functioning of the physical world and the perceived realities of our porous economic interface with it. In so doing the meaningfulness of economic objectivity, when it is based on certain fundamental assumptions, is brought into question.

The gravity of these observations inspires an excavation of the bedrock of economic theory to reveal the causes of some of these surprising structural inconsistencies, with the first formal school in economic thought forming a logical starting point.

Physiocracy

We can trace the genesis of formal economic theory to the French Physiocratic tradition. Arguably this was the first formal school of economic thought, immediately preceding classical economics, and immediately preceded by a mixture of semi organised mercantile and agrarian economics.

Physiocracy (from the Greek for "Government of Nature") (www.policonomics.com) posited that the wealth of nations was derived from the value of "land agriculture" or "land development." The most significant contribution of the Physiocrats was their emphasis on productive agrarian work as the source of national wealth, which was in contrast to the emerging schools of thought that focused on the ruler's accumulation of gold and the balance of trade as the source of wealth (Charbit and [Virmani](#), 2002).

Although the Physiocrats placed great emphasis on the significance of natural capital in the creation of economic value, or surplus, the economic value of this capital was ultimately translated into a monetary measure. This is a very important point because monetary valuation and exchange has accompanied some notable obstacles for a more harmonious relationship between economic science and sustainable development.

The first of these obstacles is the implicit assumption that money is fungible with natural capital – which, as we have seen, is an unresolved question at the heart of the great works in sustainable development economics of 1974 around PV optimisation theory. Second is the estrangement of money from the thermodynamic properties of matter and energy (goods and services). Soddy (1922) posited that this dislocation is caused by the fact that money can be created and destroyed, while the first two laws of thermodynamics state that matter and energy can neither be created nor destroyed. Soddy suggests that monetary exchange inevitably leads to the accumulation of physical debt, as monetary wealth by altering the physical integrity of goods and services through the generation of entropy in the production of a monetary surplus:

Debts are subject to the laws of mathematics rather than physics. Unlike wealth which is subject to the laws of thermodynamics, debts do not rot with old age and are not consumed in the process of living (Soddy, 1926; p.178).

Daly elaborates:

The fundamental error of economics is the confusion of wealth, a magnitude with an irreducible physical dimension, with debt, a purely mathematical or imaginary quantity. The positive physical quantity, two pigs, represents wealth and can be seen and touched. But minus two pigs, debt, is an imaginary magnitude with no physical dimension (Daly, 1996).

Daly's example demonstrates that the exchange of physical goods and services, in this case two pigs, for money results in the seller holding a financial instrument which itself has no physical usefulness, or physical use value. The seller has exchanged something that has physical use value for something that does not. The example crystallises the importance of the quality of money circulating in the economy and how its creation is linked to economic value creation and its implications for the underlying capital stocks.

These points are key because they allow us to couple our first cornerstone of sustainable development with its first obstacle in economics. This pairing is that of the need for economic calculus to be inclusive of the heterogeneity of the different forms of capital required for sustainable development with the prominence of monetary valuation and exchange as the principal means of measuring, communicating and exchanging economic value.

Although already evident in the physiocratic tradition this issue becomes even more profound when the marginal theory of value that began to emerge in classical economics, later takes centre court in the neoclassical paradigm.

Classical Economics

Classical economists are credited with further reorienting economics away from an analysis of the ruler's personal interests to broader national interests. Adam Smith identified the wealth of a nation with the yearly national income, instead of the king's treasury. Smith saw this income as produced by labour, land, and capital. With property rights to land and capital held by individuals, the national income is divided up between labourers, landlords, and capitalists in the form of wages, rent, and interest or profits (Smith, 1776).

These changes increased the significance of individuals representing different interests as market participants and accompanied inquiry into how society could be organized where individuals are driven by personal monetary gain. This inquiry later led to the broad and sophisticated body of knowledge comprising market theory. Adam Smith's *The Wealth of Nations*, in which he refers to an 'invisible hand' that moves market forces towards their natural equilibrium without the aid of external forces, is usually considered as marking the beginning of classical economics (Smith, 1776).

This essay suggests that sustainable development presents a new set of variables that can be integrated into market dynamics which, crucially, can provide the basis for market configurations that are as conducive to any particular conception of sustainable development as they are to any particular conception of utility – provided the appropriate variables are appropriately integrated, or internalised into decision making processes. This brings into question theories of value and their bearing on market equilibrium. Here again the contributions of classical economists are crucial.

Classical economists developed a theory of value and how this relates to price in order to investigate economic dynamics. During this period a fundamental distinction between market price and natural price was introduced in order to facilitate the portrayal of regularities in prices. In terms of his view market prices would always oscillate around the natural price subject to many transient influences. Natural prices, according to Petty, and Smith for example, capture systematic and persistent forces operating at a point in time (Fogarty, 1996). Market prices always tend towards natural prices in a process that Smith described as being similar to gravitational attraction.

When the price of any commodity is neither more nor less than what is sufficient to pay the rent of the land, the wages of the labour, and the profits of the stock employed in raising, preparing, and bringing it to market, according to their natural rates, the commodity is then sold for what may be called its natural price. The commodity is sold for what it is worth (Smith, 1776; p.51- 52).

Notwithstanding Smith's work on natural prices, some economists gradually began emphasizing the perceived value of a good to the consumer. They proposed a theory that the value of a product was to be explained with differences in utility (usefulness) to the consumer (Atkinson, 1982; p. 286).

This led to the establishment of the marginal theory of value, which is today the dominant theory of value, and can be seen to have buried what might have been a productive debate on the difference between natural and market prices. Fogarty eloquently captures the essence of the paradox of value and its deep historical origins:

For medieval theorists, value depended not on any intrinsic value but on utility and scarcity. Shakespeare's Richard III's battle plea "A horse, a horse, my kingdom for a horse" epitomises the subjective approach to value of this era (Fogarty, 1996; p. 2).

Marginalism raises important questions about the nature of production when demand and price are driven principally by market participants' perceptions of value. Indeed it places great weight on the validity of these perceptions, which as John Law had already found during the 17th century using thought experiments such as the water/diamond paradox, to be based on perceptions of value above intrinsic value or economic usefulness (Law, 1994).

The well-known paradox of diamonds and water questions why a desert traveler might find a cup of water infinitely more valuable than she would a cup of diamonds. The paradox signifies that under normal market conditions, use value and exchange value do not necessarily coincide (Smith, 1776; p. 30).

This thought experiment exemplifies the dominance of marginalism in economic life today, which is significant for sustainable development discourse because it means that markets will tend towards resource allocation in line with market participants' perceptions of value, whether or not these perceptions are conducive to the realisation of sustainable development in the long run.

Neoclassical economics

Neoclassical economics is today a dominant school in economic thought focusing on the determining of process, outputs and income distribution in markets resulting from their interdependencies with the forces of supply and demand. At its center neoclassical economics relies on rational choice theory and the assumption that income-constrained individuals will seek to optimize their own utility, while cost-constrained firms employ available information and factors of production to maximize profits (Campus, 1987; p. 323).

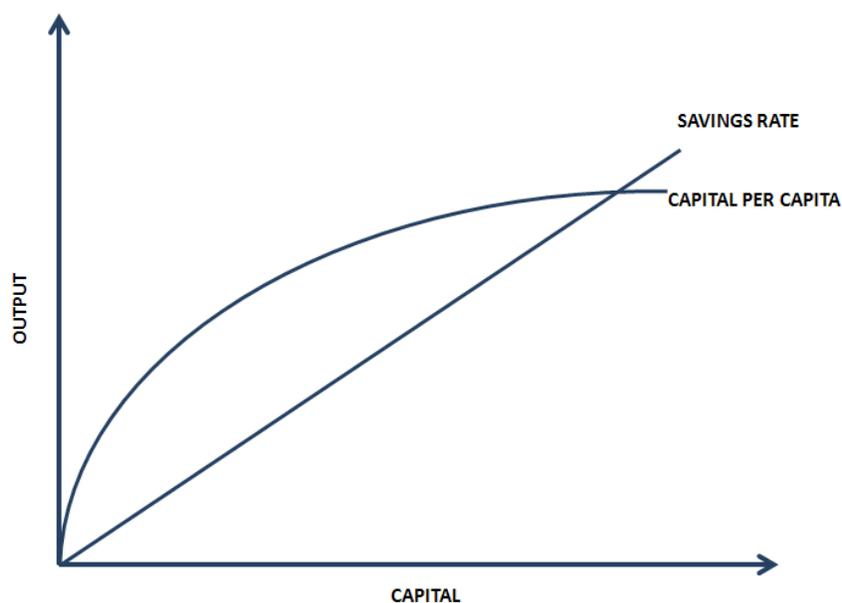
Weintraub observes that despite certain minor variations, neoclassical economics is generally based on three underlying assumptions:

1. Consumers have rational preferences based on perceptions of value;
2. Consumers maximize utility and firms maximize profits; and
3. People's activities are independent and informed by 'full and relevant information' (Weintraub, 2007).

These assumptions have formed the theoretical foundation on which economists Robert Solow and Trevor Swan developed the neoclassical economic growth model which contributed significantly to the formative thinking on sustainable development. The neoclassical growth model, or Solow-Swan growth model aims to explain long run economic growth through examining its interdependencies with labor productivity, capital accumulation, population growth and technological progress. Robert Solow is widely credited as being the first economist to formally distinguish between ‘vintages’ of capital in modeling economic growth. He argues that new capital is more valuable than old capital because technology improves over time and that new capital benefits from new, better, technology (Harris, 2006).

The model is formulated on the basis of a neoclassical production function where output per worker is a function of capital per worker and assumes diminishing marginal returns to capital. The model posits that capital per worker is determined by population growth, depreciation, savings and investment (Harris, 2006). In terms of Diagram 1 below, capital per worker increases when the savings rate is greater than the population growth rate plus the depreciation rate. This is known as ‘capital deepening’. ‘Capital widening’ however occurs when capital increases at an equivalent rate to population growth, plus depreciation (Acemoglu, 2011).

Diagram 1. Neoclassical Economic Growth Model



An important corollary of Solow’s growth model, particularly when considered in tandem to Stiglitz’s 1974 contribution on the role of technology in sustaining production, is the implicit assumption that substituting natural resources for economic capital in production can support continually growing consumption (Petith, 1999). Perhaps even more important is the scientifically flawed assumption that substituting natural resources for economic capital inevitably leads to net capital accumulation. Here we do not challenge the possibility of this, only its inevitability.

When we consider the implications of these assumptions for sustainable development three principal issues emerge. First is that the econometric methodologies supporting such microeconomic hypotheses are not able to explain the fungibility of natural capital for other forms of capital, at the high rates of substitution that the

hypothesis supposes because the information lies outside of the econometrically measurable range. In simple terms, the interdependencies between capital types are too complex to explain using empirical tools. This also opens up such hypotheses to criticism by proponents of Soddy's perspective, in that economic production often engenders the substituting of monetary wealth for physical debt, thus potentially structurally decoupling the creation of economic capital from the ability of natural and social capital to sustain it. The second issue is that the forces of demand and supply informing the accumulation and distribution of capital are based on market participants' perceptions of value rather than the use value of the capital used up in economic production. The third key issue which has been comprehensively addressed in the context of the Georgescu Rogen versus Solow/Stiglitz debate, is that the materials balance of these systems indicate that technical progress will be insufficient to substitute for resource usage. In other words technology would not be able to adequately compensate for the 'using up' of natural capital in the production process (Petith, 1999).

I propose here that a holistic sustainable development perspective on long run economic growth should be based on new assumptions, starting with the behavioural assumptions on the economic decisions of market participants. Here I suggest that the following assumptions should form the conceptual bedrock for the development of a cogent economic theory of sustainable development:

1. Consumers have preferences based on perceptions of value;
2. Consumers maximize utility and firms maximize profits;
3. People's activities are interdependent and informed by incomplete information.

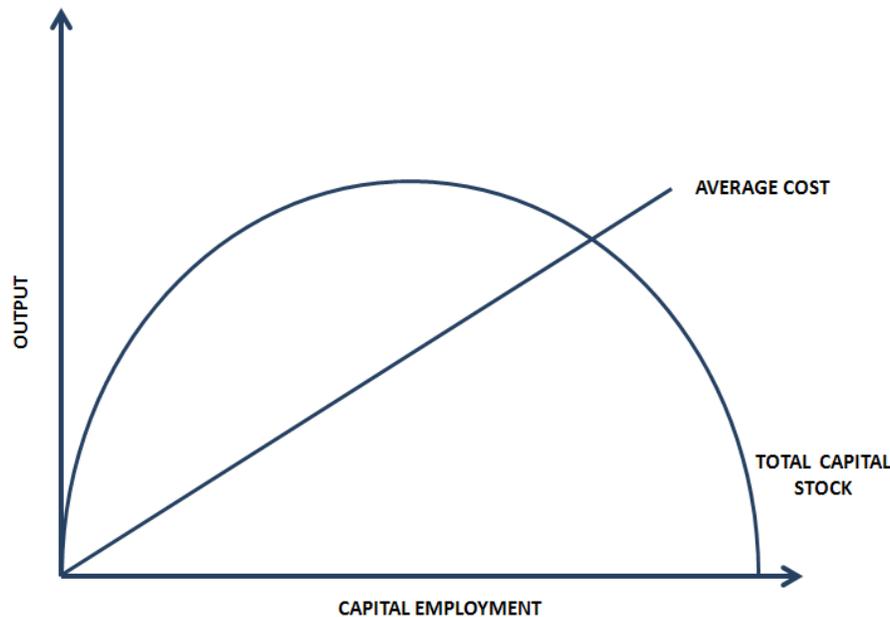
With these foundations in place I suggest that the challenges presented by sustainable development discourse to the neoclassical growth model could be overcome with a revised formulation based on two new assumptions. These are:

1. The capital stock employed in economic production is heterogeneous and may not be fungible;
2. The yield of economic production from the heterogeneous capital stock is subject to increases in the rate of capital employment being positively correlated with the generation of thermodynamic throughput or entropy, regardless of the concomitant level of economic production.

Based on these assumptions I introduce the model below which is inspired by the Gordon- Schaefer model for depletable renewable resource extraction³, depicting output, or economic production relative to capital employment. The integrity of the capital stock is represented as an upside down parabola demonstrating the phenomenon of diminishing marginal returns to capital employment. The right hand side of the graph represents an important departure from the Solow model by making provision for net decreases in the integrity of the total capital stock, where the Solow model assumes fundamentally that capital is accumulated through the course of economic production, albeit subject to diminishing returns. The model also includes an average cost (AC) function to provide a mechanism for linking the monetary cost of production with the integrity of the heterogeneous capital stock. The intention with the introduction of the AC function is to circumvent what can be referred to as the *Soddy problem*, which posits material inversion between economic capital accumulation and physical capital accumulation. The average cost function provides a means for achieving this provided that costs and benefits potentially having an impact on the *thermodynamic integrity* of the *total capital stock* can be internalized by the decisions of market participants.

³ For a full discussion see: Schaefer, MD. 1957; pp 669-681; Kompas, T. 2005; p 1.

Diagram 2. Sustainable Economic Development Model



This proposal is a defining part of this essay's contribution which simultaneously relies on the individual discretions of economic decision makers and William Kapp's notion that non monetized economic costs ultimately influence monetary values and thus market forces (Kapp, 1975; p. 229).

The potential for the dynamics proposed above to meaningfully link non market forces with the thermodynamic properties of the total capital stock requires a deeper understanding, and broader definition of the concept of economic externalities.

Externalities

In economics an externality is defined as a cost or benefit resulting from an activity or transaction which affects a third party who did not choose to incur that cost or benefit (Buchanan and Stubblebine, 1962; p. 371-384).

The concept of externalities is profound in neoclassical economics which understands voluntary exchange to be mutually beneficial to the parties involved (because in terms of the neoclassical view, economic decision makers are motivated by rational self-interest and would not trade if they believed that it would be detrimental to their interests). In contrast, and from the perspective of those affected by externalities, the unintended impacts of economic activity could either be positive or negative, and importantly, beyond the rational choice of the affected decision makers.

In neoclassical welfare economics the existence of externalities is seen to result in socially sub-optimal outcomes since those who suffer negative externalities do so involuntarily while those who benefit do so without cost. The overall cost or benefit to society of externalities is generally defined as the net monetary cost or benefit after summing the imputed costs and benefits for all involved (Arrow, 1969; p. 1-16).

This definition of externalities raises several important issues on the character of different manifestations of externalities in market systems. Here Kapp (1975) notes:

.. whereas some of the social costs of private production could be traced to particular production practices (or neglect of preventative measures) in specific industries, other social losses were seen to arise rather as a result of the workings of the competitive process within the prevailing framework of existing legal and economic institutions (Kapp,1975; p. 229).

Kapp's observations highlight two essential qualities of externalities under the neoclassical paradigm. The first is an unintended cost or benefit that is not internalised into the firm's production function. The second is an unintended impact of an individual externality event on the interests/welfare of society as a whole. The work of Sidgwick (1887) and Moss (1995; p. 201), along with that of Hardin (1968), Ostrom (1990) and others deals primarily with the latter; all note however that the latter phenomenon is a consequence of unintended cost or benefit that is not internalised or taken into account in the entity or individual's decision making.

The work of Arthur Pigou aimed to bridge the interconnections between the microeconomic origins and macroeconomic implications of externalities by imposing what subsequently became known as Pigovian or 'sin' taxes. This served to recover monetary values of societal externalities via the tax system (Pigou, 1970). Notwithstanding the many successes of this approach it suffers two main challenges from a sustainable development standpoint. The first is that although, as Kapp points out, externalities ultimately have financial implications, assuming monetary valuations for externalities could perpetuate the *Soddy problem*. Paying for externalities would not necessarily remedy the misallocation of resources catalysed by the dislocation between the financial system and the integrity of the total capital stock.

The second and profoundly related issue is that of assuming fungibility between financial compensation for externalities and their implications for the long term productivity of the economy's underlying heterogeneous capital stock. This assumption could be an acutely unscientific one in the light of the present status of the weak versus strong sustainability debate.

It is arguable therefore that the development of an economic theory of sustainable development must cater for a broader interpretation and economics treatment of externalities than that currently provided for in either neoclassical economics or the sustainable development literature. This essay aims to contribute here by providing a conceptual orientation to the notion of a *sustainable development externality*, which can be defined as a departure from the total capital configuration that is most conducive to the realisation of sustainable development based on the best available information. A sustainable development externality is therefore an opportunity cost to the realisation of sustainable development, and only ever based on best information because the concept and definition of sustainable development are still evolving.

The practical implications of the concept of sustainable development externalities, although imprecise by necessity, have potentially meaningful implications for the ability of market forces to enable a *total capital allocation* that is conducive to the long run realisation of sustainable development. Here the total capital allocation is defined as the distribution of the entire heterogeneous capital portfolio relied upon for economic production relative to variations in supply of and demand for these capital types. The meaningfulness of this concept is dependent upon the ability of market participants to align their perceptions of value, and thus their productive and consumptive decisions, with the criteria for sustainable development.

This brings into sharp focus the necessity for reliable sustainable development assessment tools.

THE ROLE OF THE MARKET

The sustainability movements described in the first part of this essay are today characterised by a growing array of sustainable development measurement tools and assessment devices. These range from composite indices such as Net National Product (NNP), (Messinger, 1997), Green National Product (NNP*) and genuine Savings (Sg) (Pearce and Barbier, 2000) to multicriterion assessments aiming to capture the heterogeneity of interdependent capital types in ecological, social and economic systems. Examples within the proliferation of multicriterion assessments include new corporate reporting standards such as those advocated by the Global Reporting Initiative (GRI) (www.globalreporting.org), the International Integrated Reporting Council (IIRC) (www.iirc.org), the Equator Principles (www.equator-principles.com), the International Institute for Sustainable Development, BellagioSTAMP (www.iisd.org) and The Economics of Ecosystems and Biodiversity (TEEB) project currently progressing under the leadership of Pavan Sukhdev (www.teebforbusiness.org). All of these increasingly coordinated efforts aim to provide greater relevance to information supporting economic decision making by capturing the status or change in status of heterogeneous capital types relied upon in economic production.

A founding premise on which this toolkit is evolving, is that the usage of these tools by resource owners, entrepreneurs, consumers and regulators can accompany the implicit internalisation of non-monetised externalities into the production process via their impact on the perceptions and economic decisions of market participants. The linking of these tools with the state of the art, albeit evolving, conceptions of sustainable development provide a practical avenue for the widespread internalisation of sustainable development externalities into economic production processes. Here non-monetizable sustainability cost can be internalised by economic decision making without ever embarking on the impossible exercise of accurately assigning monetary values to such costs.

The equipping of economic decision makers at all levels of the market system with tools for a better understanding of the implications of their decisions for the sustainability of their production processes based on a broader, more scientific set of indicators can ultimately allow for sustainable development decision making to take root beyond and below the domain of economic planning or academic conjecture.

This economic shift would not bring about a departure from the individualism or marginalism that dominated the neoclassical period as much as it would be characterised by the emergence of a more scientific and objective approach to measuring and perceiving value among market participants at all interdependent levels of market activity. The diagram below illustrates this interdependence by describing total capital distribution as the aggregation of productive and consumptive decisions made by three levels of market participants within a market system. These are resource owners, entrepreneurs and consumers. This essay has adapted Kirzner's model to incorporate a capital as the foundational resource for market activity (Kirzner, 1963; p. 19). Importantly, the supply of capital at each level of market activity is informed by demand and scarcity while demand is informed by information and perceptions of value.

Diagram 3. Market Interdependency

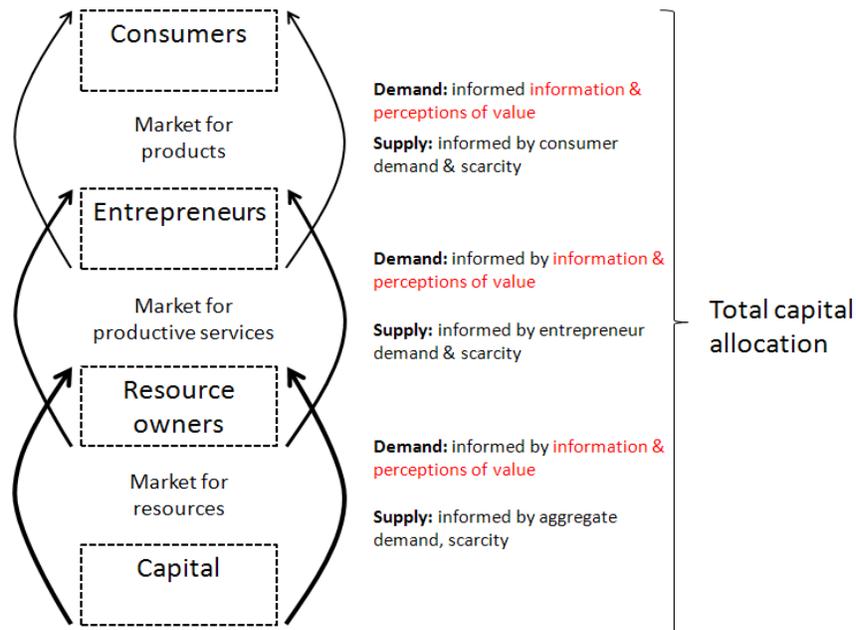
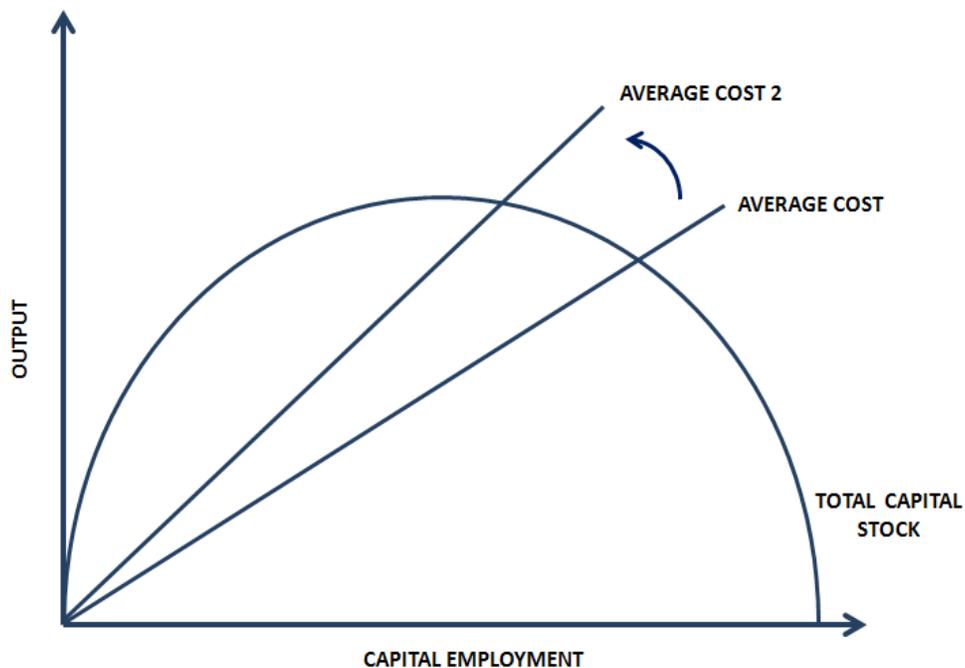


Diagram 4 below attempts to describe how the internalisation of sustainable development externalities into the economic decision making of market participants by adjusting their available information and thus perceptions of value, can impact on the consumption of the total capital stock, resulting in an upward shift in the AC function and a concomitant reduction in the level of capital employment.

Diagram 4. Sustainable Economic Development Model: Sustainable Development Externalities



In terms of this model, sustainable development externalities could be offset by developments in the sustainable development knowledge base and the development of substitution processes, perhaps characterised by technological change. These internalisation processes could encourage greater innovation and development of substitutes in seeking new, more capital efficient means of production, which may ultimately provoke a systemic shift in the sustainability of economic production. Whether this means the implementation of a weak, strong or a *mixed sustainability approach*, the important contribution of the above model is that it does not assume one or the other, and creates space for the ambiguity necessitated by the on-going evolution of the concept.

This shift represents a nuanced view on the Solow Growth Model in that capital accumulation is more fundamentally subject to the thermodynamic properties of the total capital stock. The accumulation of better quality capital is both a function of the nature of production and the perceptions of value informing demand.

Perhaps ironically the inclusiveness initiated by the classical movement and its implications for the emergence of the marginal theory within the neoclassical paradigm could, in a more evolved and economically objective state, metamorphose into a system of decision making that more appropriately mimics the natural forces of selection, attrition and entropy that characterise ecosystem dynamics.

Here one might be forgiven for wondering whether the apparently haphazard groundswell of sustainability movements, for all of their aforementioned deficiencies, are evidence of an economy that is incubating a new kind of economic order where the next step in economic evolution is led as much by changes in conceptions of utility (as conceived by Mill in the 1850s), as by attempts to reorganise production and capital distribution.

CONCLUSION

As is frequently the case with academic adventures, this essay and its underlying research endeavour probably raise more important questions than are answered.

The essay has aimed to conceptualise some of the criteria for sustainable development relative to some of the main hallmarks of economic science. Overlaying this theoretical offering with insights gained from the emerging discipline of sustainability management, has sparked the possibility of a new economic formulation which provides the basis for progressing both economic and sustainable development theory to constructive practical ends.

Perhaps unsurprisingly, the biggest question presented by this study stems from its most severe limitation. What are the empirical methodologies that could be used to substantiate the practicability of its theoretical contributions?

The question has, I hope understandably, transcended the scope of this contribution. However its linkages with the life and times of the practice of sustainability management give new import to enduring suspicions that the empirical meaning of sustainable development theory lies in the relationship between its empirical tools and the financial income statements and balance sheets in the service of which they find themselves. Here it is my intention that future work should focus on the functioning of sustainable development measurement and assessment devices in the context of financial institutions, as important entities influencing

the level of financial capital applied to different production processes.

It is in the interface between the provision of economic capital and the broader sustainable development credentials of production that lie deep and potentially unsettling insights into questions around variations in the quality of economic value creation, from one production process to the next.

Economic value is not homogeneous or without form and the unearthing of its secrets is undoubtedly the most challenging economic project of our time, with innumerable (and many will say insurmountable) obstacles at every level. However this project remains one for a species that still has everything to gain, or lose, from the crucial next steps in its economic evolution.

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