Global 4C: World Monetary Union for Climate Change Mitigation

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Abstract—The future viability of our civilization is in serious doubt because of *Anthropogenic Global Warming* (AGW) [3][5][6], chronic degradation of ecosystems [9][30][45], and risk of nuclear war [64]. These harms and risks are related to unchecked economic growth, fossil fuel usage, resource consumption, and militarization. Civilization is evidently in need of systemic change to avoid collapse and to build restorative networks [50][52].

We submit that a public policy has been overlooked that could facilitate a socio-economic transformation for stabilizing the climate. We call the policy *Global 4C Mitigation*, but because it is historically unprecedented, a new theoretical framework is derived to rationalize money-and-markets and to describe the policy. The framework recognizes that there are three primary currency options: *commodity, fiat,* and *service currencies* [10]. The framework also groups market-based environmental policies into *Pigovian Families* that have a common unit-of-account. Each family includes taxes (*Father),* tradable permits (*Son*), standard subsidy/reward schemes (*Daughter*), and 'reward and service currencies' (*Mother*).

Global 4C Mitigation is the *Pigovian Mother* of climate mitigation policy because it invokes the reward and service currency option for greenhouse gases. Recommended is a parallel world currency based on a *Carbon Monetary Standard* to create a truly global price. The new currency system is termed *Complementary Currencies for Climate Change* (4C), and 4C is to be issued for greenhouse mitigation and sequestration in a global reward scheme. 4C prices are to be scheduled to rise under monetary protocols that incentivize greenhouse gas mitigation in concert with carbon tax and cap-andtrade schemes. Rising 4C prices should be arranged with international *Green Quantitative Easing (GQE)* [21] and guaranteed by a *World Monetary Union for Climate Change Mitigation*.

A roadmap is available to fast-track 4C implementation. The first stage, called the 'Seed', requires raising financial capital to develop a secure Global 4C Digital Network for issuing and trading 4C over the Internet and mobile phones. This network should be decentralized, trusted, scalable, international, and available to enterprises and citizens in urban and remote regions. The roadmap involves a global social-and-environmental movement with a novel political pathway to initiate negotiations for the World Monetary Union. Global 4C Mitigation may well lead to genuine Earth System Governance [18] and a self-regulating economy that can lessen poverty, inequity, and debt over the long run.

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I. INTRODUCTION

Environmental policies that were developed during the 20th Century provide the basis of most greenhouse mitigation policies negotiated under the United Nations Framework Convention on Climate Change (UNFCCC). In the post-COP21 period we should question the efficacy of standard climate mitigation policies because they will probably fail to limit global warming to 2°C above the pre-industrial baseline [29]. Strong climate mitigation is difficult because (a) vested interests create political delay [46] over taxes and regulations; (b) greenhouse gas (GHG) emissions are strongly coupled to economic growth [22]; (c) most national governments and firms target economic growth; and (d) the climate system is sensitive to cumulative GHG emissions and is susceptible to abrupt change due to amplifying feedbacks [7][24][39][40] [41][51].

According to reviews of the Intentional Nationally Determined Contributions (INDC) submitted at COP21, Anthropogenic Global Warming (AGW) could exceed +3°C by 2100 with disastrous consequences [27][29]. Another problem is freeriding. For example a significant amount of carbon offsets traded under the Kyoto Protocol have succumbed to freeriding [31]. We assert that, despite the challenges, a novel public policy called *Global 4C Mitigation* could effectively finance and manage deep decarbonization and long-term drawdown of atmospheric GHGs.

II. GLOBAL 4C

Global 4C Mitigation is a policy based on a new framework for money-and-markets [8][10][11][12][15]. *Global 4C* (or *Global Foresee*) is the name given to the initiative [23]. The objective of Global 4C is to achieve decarbonization across all sectors of the global economy, protect biodiversity, preserve agricultural capacity, and enhance public education. The policy follows a trend in monetary innovation that is espoused by Lietaer et al. [33] but it is significantly different to standard climate policies because it can create macro-economic selfregulation and socio-economic feedbacks for stronger climate mitigation. The economic instrument is a new world currency system called *Complementary Currencies for Climate Change* (4C). 4C may be given an official ISO4217 trading name, and we suggest the '*Solar Dollar*' (SON) is culturally appropriate. 4C will be a currency system based on a *Carbon Monetary Standard* for greenhouse mitigation (i.e. a unit of account of 100 kg of CO₂-e verifiably mitigated). An administrative system will be needed to ensure that the 4C currency supply is pegged to the mass of CO₂-e emissions abated and sequestered. Auditing will require universal assessment rules for statistical certainty. 4C will be issued debt-free as a reward to enterprises for their voluntary GHG mitigation, and 4C will circulate in the global economy to parallel the existing fiat system and reform the global economy (i.e. 4C is a *complementary* world currency system).

Global 4C Mitigation will involve a monetary protocol that can transfer purchasing power from a basket of fiat currencies into the 4C to raise the 4C price and incentivize greenhouse mitigation. When the transfer of purchasing power is financed with *Green Quantitative Easing* (GQE) [21], the approach may be described as 'debt deleveraging' [16] [17] whereby the 'debt' is the greenhouse pollution potential of the economy.

Central banks will be instructed by the protocol to buy 4C using fiat created with GQE. This will transfer resources from the global economy into mitigation whilst also stimulating real economic growth and creating 'green' jobs. Under this system, the worldwide mitigation market can be recast as a borderless economy that generates its own world currency.

The new theory and philosophy that is presented begins with a review of civilization as a 'heat engine' and a description of money and currencies. The *service currency* [10] is then defined as a bridge between two fundamentally important economic instruments: (a) Pigovian¹ subsidies and (b) currencies. *Market policy dualism* is introduced to explain why Pigovian taxes and Pigovian subsidies are complementary and can be aggregated to improve social welfare.

III. CIVILIZATION AS A HEAT ENGINE

Economic growth is strongly coupled to GHG emissions mainly because we are heavily reliant on coal, oil and gas for primary energy. Garrett [22] examined this coupling at the global scale by modeling civilization as a 'heat engine'. Garrett [22] concludes that, because of Jevons Paradox, extremely dangerous AGW will not be prevented unless significant economic de-growth occurs in conjunction with a clean energy revolution. Jevons Paradox is the proposition that a more efficient use of a resource, such as fossil fuels, can lead to increased (rather than decreased) consumption of the resource over the long-term. A separate study that looks at the solar energy in biomass and fossil fuels shows that civilization is energetically unsustainable in its current form [50]. Garrett's [22] analysis of economic and energy data shows that national currencies have purchasing power that is strongly correlated to primary energy use. This correlation is estimated to be 9.7 ± 0.3 mW of primary power for each US dollar equivalent when inflation adjusted to 1990. This ratio is the average of all currencies because it describes the average power generated to create civilization's wealth (i.e. all goods, services, and social networks).

IV. WHAT IS MONEY?

A key limitation of the standard economic worldview is a monetary 'blind spot'. We believe that monetary theory provides the most holistic theoretical framework for mitigating climate change and correcting market failures because it engages the four major domains of civilization: (i) economic, (ii) physical, (iii) social, and (iv) political. We begin by defining precisely what we mean by 'money' and 'currency'.

A. Logos of Money

Money is vital for efficient trade and social complexity [20]. Strictly speaking, 'money' is a conceptual model (i.e. an idea) whereas 'currencies' are tools that apply the idea of money. The *logos of money* is presented below as a new triadic frame model (or symbol) that describes all currency systems (see Fig. 1). The triangle's apices represent the three elementary mathematical concepts that comprise 'accounting' (i.e. unit of account, addition, and subtraction). The triangle's sides represent the multi-dimensional features that are essential to currency in the real world. These are its *medium of exchange* (what is it?), its *store of value* (why is it?), and its *social agreement* (how is it?).



Figure 1. The *logos of money* is a triadic frame comprising an accounting system (apices) and three tangible dimensions (sides).

For a currency to be useful as an accounting tool, it needs a standardized unit of account so that credits and debits can be reconciled. The medium of exchange is the physical manifestation of a currency, and it can be any technology that effectively regulates possession. The store of value denotes that a currency's price (i.e. value) is reasonably stable and predictable. Currencies have social value if they overcome the 'double coincidence of wants' that makes bartering

¹ Arthur Cecil Pigou (1877-1959)

inconvenient. The social agreement refers to the laws, rules, and guidelines that society adopts for issuing, trading, and managing a currency.

B. Commodity Currency

The literature often classifies national currencies by their unit of account, and the two primary types of currency are *commodity currency* and *fiat currency*. By definition, a commodity currency has a unit of account that is a quantum of 'good' (e.g. shell, salt, silver, gold). A practical feature of commodity currencies is that their medium of exchange has intrinsic value and doubles as the unit of account. For example, the Spanish dollar (*real de a ocho*) was traded internationally for more than two centuries [20]. If a commodity currency has a medium of exchange that differs from the commodity, then it is a *representative currency*.

C. Fiat Currency

National fiat currencies have an intangible unit of account and are decreed by government. At the time of writing, all national currencies were fiat (USD, YEN, EUR, etc.) and their prices were established in a floating exchange rate system. A practical feature of national fiat for a sovereign nation is the ability to manage its fiat by political means (e.g. monetary policy). Fiat creation by fractional reserve banking (i.e. most commercial banking) can facilitate and encourage economic growth by issuing new fiat as interest bearing debt. Growth is stimulated because the interest charged on outstanding debt increases demand for new fiat in the marketplace.

D.Service Currency

The new framework of Global 4C Mitigation expands on the above two-currency paradigm by introducing a third primary currency type called the *service currency* [10] (see Fig. 2c). Service currencies are proposed to have a unit of account defined by a quantum of service (e.g. mitigation, education, security). This three-currency paradigm invites governments and economists to consider using service currencies to better manage economies.





Standard public/environmental policies are based on existing fiat systems, whereas policies that employ service currencies represent a paradigm shift because they could systemically improve economic systems. Service currencies cannot be issued under a fractional reserve banking system because the unit of account is a tangible service. The service currency requires a new kind of administrative system that pegs the currency supply to services that can be recorded and audited. This will require rules for assessing the amount of currency to be issued, and social agreements for deciding the conditions of issuance. A practical feature of service currencies is that they are inherently suitable for implementing reward-based schemes. We conjecture that a lack of experience with service currencies creates a social bias that retards society's ability to mitigate climate change and address other global environmental problems.

V.MARKET POLICY DUALISM

The term '*dualism*' is used sparingly in economics. It is mainly associated with the concept of *economic dualism* that refers to two economic groups, within one country, that have different market behavior and different levels of development, wealth, and technology. It is reasoned here that the term 'dualism' can have specific meaning for market economics and can be used to justify complementary market policies. We propose two primary forms of market policy dualism. The first form is the '*complementary pair*', and the second is the '*polarizing opposite*'. These terms are explained below with examples.

A. Complementary Pairs

The complementary pair is defined here as any two features of a system that have opposing character but can interact and produce emergent system behavior. Examples in socioeconomic systems include two policies that promote: (i) rewarding and penalizing, (ii) decentralization and centralization, (iii) diversification and streamlining, (iv) imagination and automation, (v) cooperation and competition, or (vi) socialism and capitalism.

Example 1: It is generally agreed that investment in research promotes innovation. Innovation is the result of applying imagination and logic to solving problems. Therefore two policies that promote a balance of imagination and logic are complementary and can improve social welfare.

Example 2: Social experiments have shown that people tend to cooperate more when given a combination of rewards and penalties (rather than only rewards or only penalties) [4]. Therefore two policies that offer a balance of rewards and penalties are complementary and can improve social welfare.

B. Polarizing Opposites

Polarizing opposites are system features that have opposing character and cannot co-exist in the same instance (i.e. they are mutually exclusive). General examples include: 0 and 1 in digital binary code, good and evil in religious theology, and matter and anti-matter in quantum physics. Examples in socioeconomic systems include two policies that promote (i) legality and illegality, (ii) peace and war, (iii) health and disease, or (iv) learning and illiteracy.

C. Potential for Dysfunction

If two market-based policies are natural complements but are treated as polar opposites then some social welfare could be lost. It is proffered here that social and political polarization of complementary policies is a cause of socio-economic dysfunction. A classic example is the political polarization of capitalism and socialism during the Cold War: a political clash that resulted the Cuban Missile Crisis and a nuclear standoff.

Political polarization of complementary policies can be expressed through a debating style called the Hegelian dialectic. Typically this involves a thesis and an anti-thesis. An example is when the U.S. President G. W. Bush (September 20, 2001) famously said: "*Either you are with us, or you are with the terrorists*".

Although it is unlikely to be intentional, it appears that the modern narrative on climate change and economics typically presents Pigovian taxes and Pigovian subsidies as alternatives - not complements. This bias may emerge from a tradition of using *efficiency* (e.g. cost vs. benefit) for making quantitative policy decisions. Subsidies inherently favor *diversity*, innovation, and decentralized authority and networks (refer next section). We claim that a balance of economic efficiency and diversity is not readily translated into metrics or fiscal statements for decision-makers. Lietaer et al. [33][63] similarly advise that ecosystems and economies require a balance of efficiency, diversity, and interconnectivity to avoid fragility/collapse and to improve sustainability.

D.Potential for Regeneration

Market policy dualism advocates that complementary policies (e.g. penalties and rewards) be combined to improve social welfare. Key advantages of Global 4C are assumed to be (a) an aggregation of complementary price signals, and (b) emergence of dynamic feedbacks in terms of reduced political delay, improved cooperation, greater innovation, more fluid financial planning, global participation, decentralization of networks, social transformation, and improved market efficiency.

VI. DUALISM OF PIGOVIAN TAXES AND SUBSIDIES

A Pigovian tax is a tax that is imposed on a market that is creating negative externalities (e.g. pollution). Conversely, a Pigovian subsidy is a reward that is offered to a market that can create positive externalities (e.g. mitigation). Important to the theory of policy dualism is that the 'logos of money' is applicable to both Pigovian taxes and Pigovian subsidies (see Fig. 3). A key difference between Pigovian taxes and Pigovian subsidies is that their units-of-account are for *disservices* and *services* respectively, and their stores of value are *negative* and *positive*, respectively. Of these two instruments, only the Pigovian subsidy can be issued as a currency because its store of value is positive. The Pigovian tax is inherently punitive and cannot be issued as a currency.



Figure 3. The logos of money as applied to (a) Pigovian taxes, and (b) Pigovian subsidies/rewards. Subsidies/rewards have a positive store of value and so can be used as currency.

 TABLE 1

 MARKET POLICY DUALISM: COMPLEMENTARY MARKET-BASED

 POLICIES FOR CLIMATE CHANGE MITIGATION

	'Pigovian Father'	'Pigovian Mother'
Policy Name:	Standard Carbon Tax	Global 4C Mitigation
Financial Incentive:	Tax (Penalty)	Subsidy (Reward)
Instrument:	Pigovian Tax	Service Currency
Unit of Account:	1000 kg of CO ₂ -e Verifiably Polluted	100 kg of CO ₂ -e Verifiably Mitigated
Store of Value:	Negative	Positive
Social Engagement:	Compulsory	Voluntary
Social Agreement:	Established by Law	Established by Social Manifesto & Monetary Union
Administrator:	Government	Shareholders
Social Authority:	Centralized in Government	Decentralized in Markets
Socio- Economic Principle:	Polluter Pays Principle (PPP)	Beneficiary Pays Principle (BPP)
Upstream Finance:	Tax Revenue	Monetary Policy (Quantitative Easing) & Market Sentiment
Downstream Finance:	Fiscal Spending	Currency Issuance (Subsidy Payments)
Information Sharing:	Minimal (Governmental)	Maximal (Public Domain)

Footnot

For simplicity the tax is assumed to be for pollution at the 'chimneystack'.

(2) Subsidies and rewards can be issued for industrial decarbonization, clean energy supply, sequestration, and education.

The dual implementation of the standard carbon tax (Pigovian tax) and Global 4C Mitigation (Pigovian subsidy and service currency) is the chief example of policy dualism for climate change mitigation (see Table 1). In this approach, there is a policy for centralized authority (to impose taxes) and a policy for decentralized authority (to offer rewards). The new approach is to consider that there will be interactions between the centralized and decentralized networks of these policies resulting in synergetic benefits that transcend the theoretical aggregate of benefits.

A. Centralization and Decentralization

The management of national fiat currencies involves centralized authority because sovereign governments use the fiat to manage and protect the nation state. Essential to this arrangement is the legal tender status assigned to national fiat so that the payment of taxes is with the national fiat. Taxes are punitive by nature, and so centralization of authority is necessary for tax collection. This centralization may obscure the fact that currency issuance is inherently a reward-based process and decentralized. The potential to maximally decentralize currency issuance has enormous implications for policies based on the aforementioned service currency, because a great number of firms and citizens can be invited to issue service currencies (i.e. for commissions) thereby expanding the supply of service currency.

A balance between centralization and decentralization could be vitally important to reforming the global economy and mitigating greenhouse emissions. Two examples are given below to illustrate how currency issuance is reward-based and inherently decentralized.

Example 1: In the fractional reserve banking system, fiat issuance by commercial banks is reward-based because lenders receive interest payments as a reward for finding borrowers. The authority of issuance is decentralized because the decision to lend is consigned to the bank, and the decision to borrow is given to the borrower.

Example 2: Bitcoin [38] is an unofficial supranational currency that provides newly issued Bitcoin as a reward for managing a public digital ledger, called the Bitcoin blockchain, which prevents double spending. Anybody can offer computing power to update the digital ledger in return for newly issued Bitcoin - thereby becoming a Bitcoin 'miner'. Bitcoin issuance is maximally decentralized because it has removed the need for trusted institutions.

VII. THE PIGOVIAN FAMILY

The Global 4C Mitigation framework is a revision of market-based environmental policy by introducing '*Pigovian Families*' (see Fig. 4). This new framework embraces market policy dualism by assigning masculine/feminine archetypes to taxes/subsidies, respectively (refer Table 1). Each Pigovian Family is identified by a pair of (polar opposite) units-of-

account. For example, the following units are practical for a Pigovian Family that mitigates greenhouse pollution: (a) a mass of CO_2 -e pollution, and (b) a mass of CO_2 -e mitigation (refer Table 1, Fig. 3).

The Pigovian Family of market-based policies is comprised of a 'Father', 'Son', 'Mother', and 'Daughter' (refer Fig. 4). The Father and Son are taxes on ecosystem *disservices* (an externalized cost), and the Mother and Daughter are subsidies/rewards for ecosystem *services*. The Mother is, by definition, a service currency. The enunciation of the Father and Mother as a complementary pair of policies is the new framework for market-based environmental policy. Each member of a Pigovian Family that mitigates pollution is described below.



Figure 4. The Pigovian Family for market-based environmental policy is comprised of a Father, Son, Mother and Daughter. The Mother is a service currency.

A. Pigovian Father

The archetypal 'Father' is a standard tax on pollution and is the principal 'masculine' policy of the Pigovian Family. A typical social agreement is that a quantum of pollution will attract a tax, and the amount of pollution will be discovered in the marketplace. The tax revenue is spent through fiscal policy.

B. Pigovian Son

The archetypal 'Son' is similar to the Father, but the amount of pollution is capped and the price of polluting is discovered in the marketplace by trading pollution permits (e.g. carbon credits). Permits satisfy the logos of money (Fig. 3) but they have a negative store of value and have social agreements that do not support them as a general currency. Citizens may buy permits to reduce pollution, but this requires citizens to pay the social cost of pollution. The tax revenue is spent through fiscal policy.

C. Pigovian Daughter

The archetypal 'Daughter' is the standard subsidy/reward that is paid in national currency for a quantum of pollution that is mitigated. The total amount mitigated is discovered in the marketplace based on the subsidy/reward price. In practice, most subsidies tend to be technology specific. Financing is provided by fiscal policy (e.g. taxes or budget cuts).

D.Pigovian Mother

The archetypal 'Mother' is the principal 'feminine' policy of the Pigovian Family, but she missing in the standard literature on market-based environmental policy. The Mother is similar to the Daughter, but with two key differences. Firstly, the economic instrument is an official service currency. Secondly, financing is achieved with monetary policy (not fiscal policy) that can transfer purchasing power from other currencies into the service currency. Financing can be managed with *Quantitative Easing* (QE) [1][21] to spread the costs and to avoid new taxes and budget cuts.

E. Policy Implications

The Pigovian Family has far reaching policy consequences because the service currency (Mother) is acknowledged as the principal complement to the Pigovian tax (Father) as shown in Table 1. The Pigovian Family concept can be used to classify all market-based policies and policy combinations. Three examples are given below.

Example 1: Fee-and-dividend is a market-based policy. The fee can be the Father of a Pigovian Family for greenhouse mitigation, but the dividend is issued with fiscal policy based on the national fiat. Hence the combination of the fee and the dividend does not qualify as a complementary pair.

Example 2: The UNFCCC's program called *Reducing Emissions from Deforestation and forest Degradation* (REDD) is an incentive scheme for forest owners in developing countries, with the aim of reducing GHG emissions. REDD incentives can be the Daughter of a Pigovian Family if the finance is provided by fiscal policy.

Example 3: When REDD incentives are financed with carbon offsets from a cap-and-trade market the incentives create zerosum mitigation by 'offsetting' pollution that occurs elsewhere. This offset trading is not a mitigation policy *per se*, because it only lowers the cost of pollution in a specific market. This type of REDD scheme is not itself a member of a Pigovian Family, although it is attached to a Pigovian Son.

VIII. CARBON MONETARY STANDARD

Global 4C Mitigation is the Pigovian Mother for GHG mitigation and is based on a *Carbon Monetary Standard* (see Table 2) with a unit of account defined as 100 kg of CO_2 -e

verifiably mitigated. Note that 100 kg of CO₂-e, rather than 1 tonne of CO₂-e, is adopted for the unit of account because it upholds the tradition of centennial subdivision of currencies and will generate exchange rates that will be more convenient. The proposed trading name of the 4C currency is the '*Solar Dollar*' (SOL).

TABLE 2	
CARBON MONETARY STANDARD (PROPOSED)	

Item	Description
Monetary System	Global Complementary Currencies for Climate Change Mitigation (Global 4C Mitigation)
ISO4217 Currency Trading Name	Solar Dollar
ISO4217 Tickers	SOL, SUN, SAM, SON, YAN
Unit of Account	100 kg of CO ₂ -e Verifiably Mitigated
Medium of Exchange	Digital networks over the internet, mobile phones, and banking systems.
Store of Value (Pre- Ratification)	A floating Solar Dollar price will be the result of supply-demand in open markets. The currency supply is coupled to the audited mitigation rate, and currency demand reflects social preferences and market sentiment.
Store of Value (Post- Ratification)	A scheduled Solar Dollar price will be the result of central bank purchases with a comprehensive basket of fiat currencies under an international monetary protocol for <i>Green Quantitative Easing</i> (GQE). Market actors will trade in Solar Dollars in foreign exchange markets, and investors will take advantage of the rising price in a scheduled multi-decade 'bull market'.
Social Agreement (Pre- Ratification)	The Solar Dollar will be issued to firms and private actors as a reward for mitigating GHG emissions (incl. industrial de-carbonization, clean energy, sequestration, and education). Solar Dollar issuance will be managed under transparent assessor-mitigator contractual relationships. Citizens will be invited to purchase Solar Dollars as a petition to political leaders and central banks for the policy. Citizens may trade with and invest in Solar Dollars.
Social Agreement (Post- Ratification)	The social agreement is similar to that for pre- ratification, but a specific mitigation objective needs to be defined. After ratification the cost of Solar Dollar financing will be guaranteed by Central bank trading using fiat created with Green Quantitative Easing (GQE). Costs will be spread across the global economy and further absorbed by currency markets. The social agreement will involve new institutions, including a World Monetary Union for Climate Change Mitigation, a monetary protocol, an expert panel for price scheduling, mitigation auditing, verification, and currency issuance and trading. GQE will be justified under the Beneficiary Pays Principle (BPP).

4C can be used to incentivize decarbonization in all sectors of the economy, including industrial de-carbonization, clean energy, and sequestration, and also with educational programs. The rules for assessing mitigation are beyond the scope of this paper, but draft rules are presented in Chen et al. [10].

The social agreement described in Table 2 includes a protocol for raising the value of 4C to meet a specific climate stabilization objective. This objective can be fixed *a priori* as a 'guardrail'. With an established guardrail, the price of 4C can respond autonomously to meet a prognostic multi-decade price schedule that addresses the guardrail. It is therefore feasible to present the 4C price as a schedule that is adjusted periodically and autonomously in response to observed changes in the economy and climate system.

Global 4C brings to the negotiating table the concept of a bullmarket that is scheduled by central bank protocols. This possibility deserves careful attention because the social psychology of bull-markets is missing in standard climate policy and theory. The Global Financial Crisis (GFC) of 2007-9 was fueled by a bull-market in U.S. subprime housing. This is an example of the enormous socio-economic momentum that can be generated by a bull market. The essential idea is that Global 4C can use the 'profit motive' to facilitate strong climate mitigation.

IX. MACRO-ECONOMIC MANAGEMENT

A. Supply and Demand

4C will be issued as a proportional subsidy or reward to enterprises that successfully mitigate or sequester greenhouse pollution. The rules for assessing mitigation are outlined by Chen et al. [10]. At the macro-economical level, the total rate of decarbonization can be managed through the 4C price. By raising the 4C price, the supply-demand equilibrium will shift in favor of more mitigation, and the 4C supply will also increase.

To raise the 4C price, central banks will need to buy 4C with fiat that they will create via international GQE [1][21]. GQE is similar to the concept of debt deleveraging [16][17][47]. A noteworthy example of debt deleveraging is the economic stimulus coordinated by the U.S. Government and U.S. Federal Reserve in response to the 2007-9 global financial crisis [58].

B. Floor Prices

The operational objective is to ensure that the 4C price exceeds a floor price (see Fig. 5) that guarantees a specific climate stabilization objective, such as the Copenhagen Accord. [57] An official panel of scientists and economists will define the 4C floor price based on the mitigation objective. A strategic advantage is that the 4C floor price can adjust to emerging climate science, INDCs, and any other physical, economic, social, or political variable. A sophisticated monetary protocol will be needed to coordinate central bank trading of 4C in order to achieve the 4C floor price. Central banks will keep 4C in reserve and will use their reserves to stabilize the 4C market.

To achieve 'least cost mitigation' the 4C price will rise from a base of zero (see A to E in Fig. 5). Prior to the protocol's ratification (see B in Fig. 5), demand for 4C will be created by social preference and petitioning. After the protocol's ratification (see C, D, and E in Fig. 5) central banks will trade 4C to ensure that the 4C price meets the floor price. The 4C price vs. mitigation rate relationship will be revealed during policy implementation (see Fig. 6). 4C prices may fall after climate change is ameliorated (see D in Fig. 5). Climate stabilization will inevitably require continued sequestration of atmospheric GHGs to counter any man-made GHG emissions over the long-term (see E in Fig. 5).

C.Negative Feedback

Market actors will consider the 4C price schedule and will trade accordingly to maximize profits (refer C in Fig. 5). This will result in bull market sentiment, thus creating a 'negative social feedback' on greenhouse emissions (refer C in Fig. 5). The negative feedback may include shifting social and political attitudes that favor higher carbon taxes and decarbonization generally.

D.Macro-Economic Metrics

Emerging from the policy theory are new macro-economic metrics [10]. Two common metrics are the *Gross World Product* (GWP) and *Gross Domestic Product* (GDP). It is possible to assess the global decarbonization trend by dividing GWP into two parts: GWP_{fiat} for fiat economies, and GWP_{4C} for the 4C economy (see Eq. 1 and Fig. 7). GWP_{4C} will increase when the 4C price and supply increase. The policy does not include targets for global economic growth because total growth is treated as an independent variable. If the global economy has a growth bias [42] and decarbonization is challenging, then 4C prices should adjust higher under the monetary protocol and GWP_{4C} will likely increase relative to GWP_{fiat} (and GWP). The GWP_{4C} to GWP ratio is termed the *Gross Service Ratio* (GSR_{4C}) as defined in Equation 2.

The GSR_{4C} characterizes the degree of economic difficulty when attempting to decarbonize the economy. Figure 7 shows three hypothetical scenarios: (a) high difficulty, (b) medium difficulty, and (c) low difficulty. The GSR_{4C} will mimic Figure 7(a) if economic de-growth is needed to limit global warming (e.g. significant de-growth is essential to limit warming to 2°C above baseline according to [22]). GSR_{4C} has a maximum value of unity that would occur if 100% of the purchasing power of national currencies is transferred into 4C – effectively transforming 4C into a one world currency.



Figure 5. A hypothetical 4C floor price schedule with five major policy phases: (A) pre-policy; (B) pre-protocol; (C) protocol for a rising mitigation challenge, (D) protocol for a falling mitigation challenge, and (E) protocol for quasi-steady mitigation [10].



Figure 6. A hypothetical price-quantity relationship for total mitigation that receives 4C subsidies and rewards [10].



(a) High Difficulty: the global economy degrows with decarbonization. $\mathrm{GSR}_{4\mathrm{C}}$ is relatively high as trade conducted in 4C is relatively large.

(b) Medium Difficulty: the global economy grows moderately with decarbonization. ${\rm GSR}_{4{\rm C}}$ is moderate as trade in 4C is moderate.

(c) Low Difficulty: the global economic grows strongly with decarbonization. The GSR_{4C} is relatively low as trade conducted in 4C relatively low.

Figure 7. Gross World Product (GWP) and Gross Service Ratio (GSR_{4C}) as key metrics for evaluating global decarbonization and economic growth or de-growth during the 21st century and beyond [10].

Equation 1. Gross World Product

 $GWP\{\$\} = GWP_{fiat}\{\$\} + GWP_{4C}\{\$\}$

Where,

\$	= Reference fiat currency
4C	= Complementary Currencies for Climate Change
GWP	= Gross World Product valued in \$
GWP_{fiat}	= Total GWP of fiat economies and valued in \$
GWP_{4C}	= Total GWP of the 4C economy and valued in \$

Equation 2. Gross Service Ratio for 4C

 $GSR_{4C} = GWP_{4C}\{\$\} / GWP\{\$\}$

Where,

 GSR_{4C} = Gross Service Ration for 4C

X. THE WAY FORWARD

A. Fast-Track Roadmap

Global 4C Mitigation has no historic precedent to guide the way forward. The policy is novel because it bridges the monetary system with global environmental governance. From a bottom-up perspective, the policy is already believed feasible because it can be based on existing models for digital communications, digital social networking, digital currencies, carbon trading, and subsidy/reward schemes. The policy also appears consistent with the key criteria of market-based policies as described by Nordhaus [39] and Stavins [53].

From a top-down perspective, the Global 4C has yet to be assessed in terms of its quantitative macroeconomics, monetary protocols for GQE and 4C trade, and pathways to a world monetary union. Despite this knowledge gap, a fasttrack roadmap is recommended so that the policy has a chance of being implemented within years rather than decades because of time constraints posed by AGW. If there were to be a 'Manhattan Project' for decarbonization, we argue that Global 4C should be placed at the top of the list to provide a global system of accounting, value, information sharing, and social agreements for effective climate mitigation.

B. Digital Administrative System

A fully functioning Global 4C system is called the 'World Tree', and it may also be called a 'Tree of Knowledge' because it will share mitigation data. The World Tree will have three major components, as follows:

(i) **Global 4C Digital Network**: administrative systems, 4C digital currency trading platform, public domain databases, collaborative networks, programmable digital contracts, and interfacing with banking, communications networks, and the *Internet of Things*.

(ii) **Global 4C Currency Market**: an international agreement, monetary protocols, Integrated Assessment Models (IAM), floor price schedules, and international trading.

(iii) **Global 4C Mitigation Market**: subsidy scheme, reward scheme, administration, data collection, mitigation auditing, verification, contracts, and 4C issuance.

C. Project Investors – Sowing the Seed

The Global 4C Digital Network can be developed and deployed relatively quickly if it is established as a profitable commercial project. The business model can include multilevel commissions for administrators (i.e. shareholders) and auditors. A consortium of investors with a pioneering mindset is needed to design and build the Global 4C Digital Network. Financial returns for investors are potentially much larger than for other digital currency projects, because 4C should become an official world currency and should be issued at the rate of roughly \$1 trillion USD per year to strongly mitigate climate change. As a rough estimate, the policy could generate commissions for shareholders and auditors in the range \$10-100 billion USD per year over many decades. We therefore describe the Global 4C Digital Network as a 'Seed', and 4C is the 'DNA' of this seed.

D. Concerned Citizens – Growing the Tree

The Global 4C roadmap requires citizens and firms to audit mitigation and trade 4C over the Internet and mobile phones. To achieve exponentially rising patronage, qualified citizens and firms will be eligible for certification as mitigation auditors. The long-term goal is to enable the auditing of mitigation for any technology, in any sector, and in any location (assuming that the mitigation is legal). Pilot projects can be used to test rules, methods, and software for mitigation assessments. A social network for auditors that offers multilevel 4C commissions may be adopted to grow the network more quickly.

International 4C trading will be encouraged to give 4C a market price, however the initial focus will be a digital 4C petition that accompanies trading. The 4C petition will aim for wide and massive public support, from many millions of citizens. The 4C petition will provide a focal point for a global social-environmental movement, attract media coverage, public debate, and a response from the academic and political elite. The 4C petition will request world leaders and bankers to address the proposal with a sense of urgency - and to open a door to official discussions, meetings, and then negotiations. We compare this policy phase with the growth of a 'Tree'.

E. World Leaders – The World Tree

The Global 4C roadmap circumvents the 'body politic' to engage directly with the elites of politics and banking: whom we assume will have sufficient political sway to establish the World Monetary Union for Climate Change Mitigation. A trustworthy Global 4C digital network and a massive citizen petition will be the 'vehicle' that diplomats and leaders can endorse. If leaders, politicians, and experts align their views, then the World Monetary Union for Climate Change Mitigation could be settled by agreement. We may describe this World Monetary Union as the arrival of the 'World Tree' and a possible *axis mundi* for civilization.

F. World Monetary Union

The historical discourse on international monetary agreements has focused on reserve currencies, exchange standards (e.g. Bretton Woods), and single-currency unions (e.g. Maastricht Treaty); and since the Global Financial Crisis of 2007-9 the discourse has focused on economic recovery [62]. Global 4C offers a new option: a parallel world currency for mutual climate stabilization. The World Monetary Union for Climate Change Mitigation will require national governments to exchange some monetary sovereignty for mutual climate stabilization. Certain items, such as administration, currency convertibility, and trade rules, may

be negotiated to achieve the accord. The World Monetary Union should emerge as a stable institution for *Earth System Governance* [18] and a *Third Industrial Revolution* [43].

G.Digital Currency Technology

There are numerous digital currency platforms in the marketplace. Examples include *Bitcoin* [38], *Litecoin* [61], *Ethereum* [19], and *Solarcoin* [61]. These technologies use peer-to-peer (P2P) data exchanges for low-cost transactions. Solarcoin is an unofficial digital currency and a solar energy incentive. It may be considered a Global 4C prototype, but it cannot address the climate mitigation objectives of Global 4C because the unit of account of Solarcoin is 1 MWh of solar derived electricity. The unit of account of Global 4C is 100 kg CO₂-e verifiably mitigated, and this is essential to couple the 4C price and supply to the actual greenhouse mitigation rate.

XI. DISCUSSION

A. Climate Mitigation Policy

A common worldview is that carbon taxes and cap-andtrade schemes are superlative market-based policies because of their 'efficiency'. We assert that these policies are only effective if they can be implemented within the available timewindow. Orthodox regulations, policies, and INDC's agreed at COP21 might not address some decisive features of AGW such as the rebound effect (Jevons paradox) [2][22][25][56]. Unlike standard policies, Global 4C could provide *strong negative feedbacks* on climate change, and this offers a new kind of economic self-regulation that may be analogous to the self-regulation described by *Gaia theory* [37].

B. Growing Global Debt

McKinsey Global Institute [17] estimated that global debt surpassed \$199 trillion in 2014 - about 2.5 times global GDP. Servicing this debt will become increasingly difficult if growth is weak, interest rates rise, trade stagnates, or if markets crash [32]. Rising debt may pressure politicians to limit taxes and encourage unsustainable growth. These issues could impact climate mitigation efforts worldwide.

C. Communities and Indigenous People

UN-REDD and UN-REDD+ schemes present problems for indigenous peoples and communities when they are not given authority over their land or do not receive their fair share of benefits. Global 4C may solve these problems by issuing micro-payments to individuals over the Internet and mobile phones [13]. The technicalities of issuing micro-payments in remote/rural regions can be solved with digital technologies, geo-statistical assessment methods, and decentralization.

D. Acting on Expert Recommendations

Global 4C Mitigation could, in theory, address all of the eight climate actions recommended in *The Earth Statement* by Stern et al. [55]. It could also address eight of the ten action

items recommended by *The Global Commission on Economy and Climate* [60], as follows:

1. Accelerating a low-carbon transformation by integrating climate into central bank macro-economic decision-making processes.

2. Creating a strong, lasting and equitable international climate agreement with a World Monetary Union for Climate Change Mitigation based on a Carbon Monetary Standard.

3. Introducing strong, predictable carbon prices through a world currency system, global reward scheme, and transparent assessment rules.

4. Substantially reduce capital costs for low-carbon infrastructure investments with a fully-funded debt-free global reward scheme.

5. Scale-up innovation in key low-carbon and climate resilient technologies with a fully-funded debt-free global reward scheme and public mitigation database.

6. Prevent deforestation of natural forests by rewarding avoided deforestation with a fully-funded global reward scheme and using statistical assessment rules.

7. Providing debt-free reward-based financing for the restoration of lost or degraded forests and agricultural lands, and using statistical assessment rules.

8. Accelerating the shift away from polluting coal-fired power generation to cleaner energy sources with a fully-funded debt-free global reward scheme and statistical assessment rules for clean energy.

XII. CONCLUSION

The Global 4C Mitigation policy presents a new approach for more strongly mitigating anthropogenic global warming whilst also reforming the economy with the 4C parallel world currency system. The policy theory is founded on a new framework for money-and-markets that places emphasis on using a parallel world currency and GQE to establish a safe level of global economic growth or de-growth. This could address shortfalls in the INDC's agreed at COP21 under the UNFCCC, and it could address some key needs of the 'financial system we need' according to a UNEP inquiry [59].

The Global 4C Mitigation policy brings to the narrative a conversation about service currencies that can act as a global reward and a parallel world currency. This new narrative advocates complementary market-based policies for triggering a social transformation. Whilst Global 4C Mitigation does not yet include an exact blueprint, it does offer a roadmap and an opportunity to reform the economy with regenerative networks – and in the most uncertain of times.

XIII. RECOMMENDATIONS

Due to the critical nature of climate change, we recommend that this work-in-progress be disseminated for comment. New collaborations and sponsorship for Global 4C are needed to continue the project. Academics are cordially invited to coauthor papers for peer-reviewed journals (see contact list).

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DECLARATION

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