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New financing for sustainable development: The case for NNP- or inclusive wealth-linked bonds*

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New financing for sustainable development:

The case for green NNP- or inclusive wealth-linked bonds

Abstract

We propose that national governments could issue bonds whose interest payments are linked to green net national product (gNNP) or, almost equivalently, to inclusive wealth. The main intention of this new financial instrument is to entice investors and the national government to invest in human and natural capital, for which the corresponding financial assets currently do not exist. As the concept of wealth expands to include human and natural capital, so should the corresponding assets side in the balance sheet of nations. While the argument for gross national product (GNP)-linked bonds focuses on trimming public debt toward fiscal sustainability, the proposed bonds aim to ensure long-term sustainability. The theoretical link associated with welfare economics is also more plausible. Moreover, it could lead to the virtuous cycle of increased government expenditure directed toward inclusive wealth, expanding tax revenue, increased coupon payment to investors, and increased social well-being.

Keywords: inclusive wealth, genuine savings, sustainable development, GDP-linked bond

1. Introduction

Many attempts have been made lately to assess sustainable development of nations by indicators of broadened notion of wealth. Wealth in common parlance refers to financial assets, but in the burgeoning literature of sustainable development, it is inclusive of all capital stocks that are of relevance to human well-being, from present to future generations. This would include not only manufactured capital (physical infrastructure, houses, plant, machinery), human capital (educational attainment and health embodied in each individual), and natural capital (forests, agricultural land, fishery), but could be extended at least conceptually to social capital (trust, networks) and institutions (transparent and democratic politics), in line with debates on sustainable development in general (Clémençon 2012). Whether wealth in this sense is to be recognized to a larger audience hinges on to what extent macroeconomic policymakers would strike a balance between short-term economic performance and long-term sustainability. Indeed, the authors of a recent report on using an inclusive wealth index as an indicator of sustainability suggested that such indicators should be "mainstreamed" in the discussion on macroeconomic policymaking (UNU-IHDP and UNEP 2012).

However, such mainstreaming looks unlikely at present. One reason for this neglect of sustainability in the macroeconomic policymaking community is that, on the one hand, the latter targets traditional economic indices such as interest rates, inflation, unemployment, and gross national product (GNP), all of which do not seem to have much to do with the environment. On the other hand, the literature on sustainable development is focused on non-declining social well-being in the long run and thus the trend in wealth in a broad sense. As elaborated later, this wealth in a broad sense is often referred to as inclusive wealth[1], and made up basically of manufactured, human, and

[1] By the qualifier, we do not intend to imply any equity concerns.

natural capital. Given that macroeconomic policymakers and sustainability proponents have different objectives and time scales, it is no wonder that sustainability indicators are not mainstreamed in macroeconomics.

A next natural question is that, if, as a thought experiment, policymakers also cared about non-declining social well-being and sustainability, what should they do to achieve their goals? Obviously, increasing public and private projects in manufactured, human, and natural capital is a proximate answer to this question, but we immediately face the question of "how".

Given that inclusive wealth (and hence manufactured, human, and natural capital) is a stock concept, unlike interest rates, inflation, unemployment, and GNP, one aspect to consider is to think of a country's balance sheet, which is a snapshot of stock of assets and liabilities of that nation. The liabilities side represents how the assets side has been financed. For example, conventional manufactured capital employed in private firms is usually financed by corporate debt or shareholders' equity. On the contrary, public infrastructure and other physical capital are financed by public debt or tax revenue. As this balance sheet is expanded to include human and natural capital, along with manufactured capital, a problem arises: financial assets are still few and far between that correspond to human and natural capital in the balance sheet of nations. Put differently, financial portfolio investors still have limited access to invest in the development of human and natural capital in the current financial asset market. Moreover, even if there exists such a financial asset, the current general lack of a framework for valuing human and natural capital causes regulatory risk, which in turn drives heightened investor uncertainty. This partially explains why such assets are still niche.

Against this backdrop, in the current study we aim to mainstream sustainability in macroeconomics by focusing on the financial assets side of the economy in line with welfare economic theory. Specifically, we argue that national governments can issue

bonds that are linked to green net national product (gNNP) or, almost equivalently, to inclusive wealth, an index increasingly recognized as an indicator of sustainability[2]. On the supply side of the bond, this approach would enable the government to raise additional financial resources toward investment in human and natural capital. On the demand side, not only would investors then benefit from the increase in the inclusive wealth of an economy, but they would also be able to diversify their portfolios and have a stake in a much wider base of capital assets, most of which are untapped in terms of financial investment. This would also benefit society at large, since it could share the downside risk of non-conventional capital assets such as human and natural capital. Moreover, this would also be more plausible than interesting proposals to create GDP-linked bonds, because flow-stock relationship is more evident in the gNNP-wealth nexus, as we will demonstrate.

The rest of the paper is structured as follows. Section 2 reviews developments in the literature on green national accounting and sustainability to provide a simple explanation of gNNP and inclusive wealth. Section 3 introduces the design of the two variants in our proposal. Section 4 discusses the strengths and weaknesses of the proposed debt compared with GDP-linked bonds and other initiatives. Section 5 presents a numerical example applied to Japan. Section 6 concludes. Since we do not focus on open economies, we use GDP and GNP interchangeably throughout.

2. Literature review

2.1. Theoretical underpinnings of gNNP and inclusive wealth

Here, we review the relevant literature on green national accounting to provide the

[2] Seminal works include Hamilton and Clemens (1999), Asheim (2000), Dasgupta and Mäler (2000), and Arrow et al. (2012). Aside from UNU-IHDP and UNEP (2012; 2014), case studies include Mota et al. (2010) for Portugal, Ollivier and Giraud (2010) for Madagascar, Ferreira and Moro (2011) for Ireland, Yamaguchi et al. (2016) for a disaster-hit area in Japan, and Acar and Gultekin-Karakas (2016) for Turkey.

rationale for our main argument, focusing on the relevant ideas underlying our proposal. (see, e.g., Heal and Kriström 2002; Weitzman 2003; Dasgupta 2009; Aronsson and Löfgren 2010 for excellent reviews). It was Weitzman (1976) who found a linear relationship between *green net national product (gNNP)* and social well-being. We can define gNNP as

gNNP = GNP – depreciation of manufactured capital

+ increase in natural and human capital, (1)

where

GNP = consumption + investment in manufactured capital (2)

and *social well-being* at time t as

$$V(t) = U\big(C(t)\big) + \frac{U(C(t+1))}{1+\delta} + \frac{U(C(t+2))}{(1+\delta)^2} + \cdots, \quad (3)$$

which means the sum of discounted utility of consumption $C(s)$ for the present to (infinite) future generations. $U(C(t))$ is utility derived from consumption at t, $C(t)$, and δ is the social discount rate. Under particular conditions, social well-being is equated with current *inclusive wealth* in society, if all the relevant capital stocks relevant to future generations (manufactured, human, and natural capital) are captured in that inclusive wealth. If we define *sustainable development* as non-declining social well-being, sustainable development can be measured by non-declining inclusive wealth. There are now two camps famous for publishing sustainability indicators based on this idea: genuine savings (GS) of World Bank (2012) and inclusive wealth (IW) of UNU-IHDP and UNEP (2012). Following the first measurement by Pearce and Atkinson (1993), Hamilton and Clemens (1999) assume optimal economy and show that the increase in inclusive wealth – which they call (GS) ---, opening an avenue for the annually published figures in *World Development Indicators*. Dasgupta and Mäler (2000) show that, by properly defining shadow prices, the framework can be applied to imperfect economies as well, leading to IW. Theoretical adjustments have also been made for population,

technology, and trade[3], and specific applications now abound.

We go on to define several other terms. We write the current net increase in manufactured capital and natural capital as $\Delta K(t) \equiv K(t+1) - K(t)$ and $\Delta N(t) \equiv N(t+1) - N(t)$, respectively[4]. For ease of exposition, we assume only manufactured and natural capital as components of inclusive wealth. Assuming that the dynamics of manufactured and natural capital can be described by the levels of these capital stocks, and that they are the only ones relevant to social well-being, social well-being as in (3) can also be written as a function of capital stocks, $V(K(t), N(t))$. In other words, we have an equivalence of inclusive wealth and social well-being. Now, in order to see the relationship between gNNP and inclusive wealth, let us define the *current-value Hamiltonian* as

$$H(t) = U(C(t)) + p_K \Delta K(t) + p_N \Delta N(t), \qquad (4)$$

where p_K and p_N are the *shadow prices* of manufactured and natural capital in utility terms, respectively. Shadow price of a capital asset can be defined as its marginal contribution to social well-being under specific conditions. To have an idea of what the current-value Hamiltonian (4) virtually means, we note that gNNP in (1) and (2) can be rewritten as

$$gNNP(t) = C(t) + \Delta K(t) + q_N \Delta N(t), \qquad (5)$$

where q_N is the shadow price of natural capital in monetary terms[5]. Hence, comparing (4) and (5), the current-value Hamiltonian can be regarded as an equivalent of gNNP in utility terms. It can also be shown that this current-value Hamiltonian is proportional

[3] Related work includes Pezzey (2004), Arrow et al. (2004) and Ferreira et al. (2008) for population growth, Arrow et al. (2003) and Asheim (2004) for the value of population, and Yamaguchi (2014) for the value of population composition. Atkinson and Hamilton (2002) and Oleson (2011) note the relevance of including international trade.

[4] Both manufactured and natural capital change are subject to certain dynamics, which need not be specified.

[5] In equation (5), we assume an efficient economy where the marginal utility of consumption is equated with the marginal return of manufactured capital ($U'(C) = p_K$). Then, it also holds that $q_N = p_N / p_K$.

to social well-being:

$$H(t) = \delta V(t), \qquad (6)$$

implying that this represents the return on social well-being, with δ as an interest rate (see, e.g., Weitzman 1976; Dasgupta 2009). This approach makes social well-being seem more like another class of asset, in much the same way as typical financial assets that earn interest. Dasgupta and Mäler (2000) and Fenichel and Abbott (2014) also clarified that the above argument holds in imperfect economies as well. All in all, linking equations (4), (5) and (6), gNNP in monetary terms can be expressed in the following way[6]:

$$gNNP(t) = C(t) + \Delta K(t) + q_N \Delta N(t) = \frac{H(t)}{U'(C(t))} = \frac{\delta V(t)}{U'(C(t))}. \qquad (7)$$

The denominator in the final term in equation (7) is the marginal utility of consumption, which just transforms utility terms into monetary terms. Thus, this equation shows that gNNP is proportional to social well-being, if we assume that marginal utility of consumption is constant, regardless of income levels. While acknowledging some criticism (Dasgupta and Mäler 2000), in the following we employ this gNNP interpretation of the current-value Hamiltonian for simplicity.

2.2. GNP-linked bonds

The current proposal is inspired by a similar, but completely differently motivated, proposal to issue a government bond linked with GNP. The idea appeared first in Shiller (1993), which is enhanced with more recent data and simulations (Kamstra and Shiller 2009). In particular, they propose that the national government sell a share of GNP, just like a share of corporate stock, that pays a dividend each year of one-trillionth of GNP. As elaborated in section 4, the main argument for such issuance is that, at the time of economic crisis, the government only has to pay a share of GNP, rather than the

[6] In addition to the previous endnote, we also assume that utility is proportional to consumption ($U'(C)C = U(C)$).

conventional interest rate that arises from huge government budget deficit. The latter interest rate goes up in crisis, whereas the share of GNP goes down. Moreover, investors would get access to investment into human capital, which is a large portion of GNP.

Rather than linking a bond's payment to the *level* of GNP, another camp argues for payment associated with the *growth rate* of GNP. Borensztein and Mauro (2004) estimate how much should be paid to investors for a GNP-linked bond, as a premium on risk-free government bond. They have also raised such challenges as data verifiability, moral hazard, and liquidity. In a similar vein, Chamon and Mauro (2005) and Barr et al. (2014) argue for linking government debt to GNP growth rate, on the grounds that it proves to lead to reducing the incidence of default and enhancing national welfare in their own simulations.

In practice, however, there are only a few applications (Kamstra and Shiller 2009). Bulgaria, Costa Rica and Bosnia and Herzegovina have issued bonds which increased their payments provided that gross domestic product (GDP) reached a certain level, but neither of the two kinds discussed above. Singapore issued a new bond which pays a return of 3 percent plus the economic growth rate. Argentina issued a conditional bond whose payments are linked to the growth rate of the country. The latter two examples can be seen as a realization of the second proposal.

To the best of our knowledge, there is no previous proposal to link the performance of green NNP or other sustainability indicators to a bond return. We will discuss comparison with other instruments in general in Section 4.

3. Bond design

In this section, we propose two alternative ways of designing gNNP- or inclusive wealth-linked bonds. Specifically, the coupons of the possible bonds in question may be linked to either the *level* or the *growth rate* of gNNP or of inclusive wealth. Each design has a plausible theoretical foundation in welfare economics.

3.1. Coupons linked to the level of gNNP or inclusive wealth

The first form is simply a bond that annually pays a share of gNNP, in line with the proposal of Kamstra and Shiller (2009). Specifically, if current gNNP in monetary terms is considered to be \$1 trillion, the coupon payment could become \$α this year, where $0 < \alpha < 1$ is a constant. If the bond in question is a consol bond, which pays coupons permanently, the bond price in the perfect market should be[7]

$$P_B = \alpha \frac{gNNP}{r}, \tag{8}$$

where r is the consumption discount rate, or the risk-free interest rate usually linked to (normal) government bonds. Plugging gNNP in equation (7) into (8), we obtain

$$P_B = \frac{\alpha \delta V}{rU'(C)}. \tag{9}$$

This implies—plausibly—that the bond price is proportional to the social well-being (or inclusive wealth)[8]. This is not a surprising result, since the bond payment is designed to be proportional to gNNP, which, in turn, is assumed to be proportional to social well-being. Thus, this bond represents a share of gNNP and a share of inclusive wealth (hence we may call this bond "inclusive bills").

3.2. Coupons linked to growth in gNNP or inclusive wealth

The second class of possible bonds is linked to the growth rate, not the level, of gNNP. This variant is analogous to the major body of the current literature on GDP-linked bonds. Moreover, it also has a plausible feature in terms of welfare economic theory. We continue to assume that gNNP can be proxied by the current-value Hamiltonian. Taking the time derivative of both sides on equation (7), it holds that

$$\frac{\Delta gNNP}{gNNP} = \frac{\Delta V}{V} - \frac{\Delta U'(C)}{U'(C)} = \frac{\Delta V}{V} + \eta(C)\frac{\Delta C}{C}. \tag{10}$$

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[7] From this section onward, we drop the time subscript.

[8] In addition, we also assume that the consumption discount rate can be approximated by the pure rate of time preference (i.e., $r = \delta$).

That is, the growth rate of gNNP in monetary terms is composed of social well-being growth effect and consumption growth effect[9]. Thus, a bond with coupons linked to the growth rate of gNNP is equivalent to those linked to the growth rate of social well-being, if the level of consumption does not change[10].

One feature to note about this specific design is that the coupon rate could be negative in theory in contrast to the first design where the coupon is equal to a share of gNNP or inclusive wealth, which is non-negative by definition. In corporate finance, dividends to equity investors can easily be zero when the business is performing poorly. In any case, this second class can be said to be a riskier asset for investors.

3.3. Revenue and fund

The current proposal is meant to create a theoretically sound financial asset that is consistent with green accounting theory and risk sharing by portfolio adjustment, so that it may be revenue-neutral. In debt-accumulating developed countries, it would be realistic to gradually substitute a proportion of current public debt that has matured so that the total debt outstanding does not increase. It would then follow that there is no net increase in the government revenue.

However, when the budget deficit is not large, or at least fiscal sustainability seems within reach, an alternative would be to separate the proceeds from the general budget and set up a bond revenue fund to be used for investment in inclusive wealth. This would be a desirable move in that the object of investment would be consistent with the source of the return, i.e., it would be a re-investment. The idea of funds from the proposed bond revenue may be somewhat reminiscent of the sovereign wealth funds (SWFs). SWFs are created mainly to manage volatile natural resource revenues to be invested in non-

[9] The elasticity of marginal utility is defined by $\eta(C) \equiv \frac{-U''(C)C}{U'(C)}$.

[10] Asheim and Weitzman (2001) showed that growth in gNNP can be regarded as growth in well-being if Divisia price index is used.

resource capital in resource-rich nations like Norway or Kuwait (see, e.g., Collier et al. 2010). The difference between our bond revenue fund and SWFs is that, while the latter focuses on coping with volatility in commodity prices and proceeds, the bond revenue fund is meant to set aside financial resources for investment in human and natural capital, as well as to make the fund-investment accounting and procedure more transparent to citizens.

In this net revenue-raising case, investment strategies have to be determined. The government assesses the current portfolio of inclusive wealth on a regular basis and prioritizes capital assets to which high marginal shadow prices are attached. For example, under rampant deforestation, as the forest shadow price rises, revenue from inclusive bonds is diverted to afforestation or reforestation, or more importantly, projects to slow deforestation. Alternatively, if the growth in the educational component of human capital is sluggish, the social planner would like to expend to enhance educational attainment nationwide provided that the marginal shadow price of human capital remains high (i.e., it pays off to improve educational attainment).

As a further option for the institutional design, in analogy with shareholders' equity in companies, the bond may come with a voting right related to investment projects. A problem with this scheme is that "shareholders" may not necessarily vote for inclusive investment projects and merely cling to their vested interests. The scheme should thus be designed in two stages. First, the social planner shows potential capital investment projects with (relatively) high shadow prices. Second, bondholders vote for candidate projects, perhaps according to the amount of their total investment. This approach would serve as a complement to the usual democratic decision-making of government investment.

In either case, it is vital to make the whole process transparent and objective. As a bureaucrat, the social planner in the government may not have perfect information about inclusive wealth. What's worse, they may even be corrupt. All the data on inclusive

wealth and their shadow prices and potential projects should thus be open to the public and subject to close examination anytime. In order to ensure that the government would invest in those areas that are manufactured/natural/human capital enhancing, it is vital to monitor the whole process from accounting to investment. Thus, it could be an idea to establish a neutral monitoring and regulating body to make sure that all the relevant pieces of information are disclosed and that investment strategies are followed in a way consistent with the list of candidate projects with high shadow prices.

4. Strengths and weaknesses

4.1. Advantages of gNNP- or inclusive wealth-linked bonds

Designing and issuing bonds whose interest payments are linked to gNNP or inclusive wealth in the way described in Section 3 has many advantages. First, as mentioned in the Introduction, it contributes to "mainstreaming" inclusive wealth as an index of sustainability, from the corresponding financial assets side of the nation's balance sheet. When the proposed bond is issued and circulated, the concept and index of gNNP or inclusive wealth is likely to catch on among citizens, if the price of the bond is regularly announced in newspapers or other media, along with other bond and equity market updates.

Second, the proposed bond could lead us one step closer to create the "perfect capital market" internalizing true income (Weitzman 2003). This point can be understood by the balance sheet of a nation in Figure 1, which shows that currently existent assets cover the inclusive wealth of nations only partially; indeed, no financial claim exists to cover human and natural capital. Corporate bonds (D), government bonds (GB), and shareholders' equity (E) are employed to produce physical capital in the private and public sectors. In this regard, "[i]n the language of financial economists, the current menu of available assets is incomplete" (Kamstra and Shiller 2009). Kamstra and Shiller made the case for shares in GDP, which would allegedly cover returns on a wider list of

assets, primarily human capital. As the wealth of nations is increasingly being recognized as including non-conventional stocks such as human and natural capital, it is important to "internalize" them in the asset market as well. Nevertheless, as shown in equation (6), the return on such broader wealth is gNNP. It is then not only reasonable but also more plausible to establish financial assets associated with gNNP—not GNP—and inclusive wealth, to diversify risk and investors' resources.

Figure 1. About Here

Suppose that the government has "discovered" a new component of inclusive wealth, say natural capital, whose value was found to be ΔN. The acquisition or maintenance of that capital comes with a cost. If a bond is issued at the amount that matches a portion of this increase in natural capital, ΔIB, and if the firm sector purchases all the bond, which is in turn financed by corporate retained earnings (cash), the resulting balance sheet would become Figure 2. All the other capital assets are assumed to be unchanged. Now the firm has a stake in the increased natural capital by way of the bond, ΔIB. In a closed economy with no international transfer of goods or money, all the financial assets cancel each other domestically and thus do not appear in the aggregated lower panel of Figure 2, since they are claims to real assets. In the end, set against this increase in inclusive wealth, ΔN, is the increase in net wealth, ΔW_G, and the privately owned net wealth, W_P, which partly finance the acquisition of the increase in inclusive wealth.

Figure 2. About here

Investment opportunities in human and natural capital imply more than just internalizing or expanding non-conventional capital. If conventional capital faces a declining rate of return in the future, as Kamstra and Shiller (2009) argued, it is of

utmost importance to shift resources gradually to categories of human and natural capital that are relatively scarce, as "investors could insulate themselves from the risk of declining returns to capital."

Third, related to the second point, the bond in question would also be beneficial for investors, partly because they can now diversify their investments through this equity-like vehicle. On the one hand, since gNNP and inclusive wealth is not considered to highly correlate with GNP or other market commodities[11], let alone individual bonds or equities, this would contribute to asset diversification and risk reduction significantly. On the other hand, as will be discussed in section 4.2, incorporating human and natural capital in investment portfolio would pose a significant challenge of measuring shadow prices as well as quantities, thus raising regulatory risk and uncertainty. The net effect is ambiguous, but as regulations are gradually to be in place, the former risk reduction could dominate in the long run. Further, investors would be exposed to less volatility than to shares in corporations. Moreover, this would be a departure from traditional policy instruments in environmental economics such as Pigouvian taxes, subsidies, and tradable permits or quotas in that stakeholders now have an incentive to invest in natural and human capital in a proactive way, rather than correcting their behavior, sometimes being penalized, and internalizing the environmental consequences. This aspect may appeal to previously inactive investors who are, however, conscious about social issues.

Fourth, when inclusive wealth or gNNP is declining, investors may erode their asset value; however, this should be seen as a sound move in light of intergenerational risk-sharing. The decline in inclusive wealth is a prediction of unsustainability, implying that well-being may decrease at some point in the future. As it stands, no mechanism exists to share this burden with future generations. The bond we propose would thus share

[11] Manufactured capital may correlate with GNP, but including human as well as natural capital would attenuate the correlation.

with current investors the risk of a decline in future well-being, while the current government is encouraged to invest in inclusive wealth that benefits future generations.

Fifth, from the standpoint of the government, interest payments linked to inclusive wealth or gNNP may place pressure on the budget deficit, particularly when inclusive wealth or gNNP is increasing at a rate faster than GNP as this would raise the debt-GNP ratio, a typical indicator of national debt sustainability. While this is a possible weakness of the bond in question, it is essentially a short-run argument. If inclusive wealth or gNNP is indeed increasing, it implies that the future productive base is becoming more stable, leading to enhanced tax revenue in the future. However, this is only valid when future taxes are imposed on returns from wealth, inclusive of human and natural capital. Thus, the government also has an incentive to mainstream the return on inclusive wealth, especially natural capital, in terms of the tax base. Conversely, if GNP is increasing faster than inclusive wealth or gNNP, less pressure is placed on the budget deficit; however, this GNP growth is unsustainable in the long run simply because inclusive wealth, the very source of future well-being, is relatively degrading. In either case, fiscal problems arise only in the short run because of the gap between inclusive wealth and taxable income and capital assets. A "good" equilibrium is the virtuous cycle of increased government expenditure toward inclusive wealth, expanding tax revenue, increased coupon payment to investors, and increased social well-being.

Finally, traditional market-based instruments in environmental economics such as taxes, subsidies, and tradable permits have their own advantages. What is distinctive about the proposed bonds compared with these familiar instruments is that those who want to invest in previously unnoticed capital can do so voluntarily. By contrast, taxes or subsidies are financial resources collected either from those responsible for the emissions of unwanted materials or from general taxpayers. Pigouvian taxes, which are levied on pollution-emitting production to shift it from a privately optimal to a socially

optimal level, are collected from those who produce or consume goods with negative externalities. Hence, as those externalities diminish, so does tax revenue. Subsidies are usually financed from the general budget, which is traceable to (unwilling) taxpayers. Tradable permits are issued to cap the total emission of externalities, implying that the buyers of permits have no choice but to produce those goods with external effects. It is also increasingly claimed that levying taxes on financial transaction on bads. In particular, Tobin tax, which is claimed to be set aside for natural capital conservation, was originally proposed to be imposed on international currency transactions (ul Haq et al. 1996). In terms of possible revenue raised, taxes hold most promise, in contrast to funds or markets (Barbier 2012). While the suggestion is comprehensible and may be supported politically, little reasoning can be found to link the tax base (financial transaction) and the expenditure (social inequality; nature conservation), let alone a sound welfare economic theory. Bonds, in turn, could be another market-based instrument for sustainable development by diverting the money of investors with forward-looking attitudes toward a broader productive base of nations.

One may wonder if conventional environmental or human capital policy would be more natural and direct instruments than the proposed bond. It is true that conventional instruments can address specific problems, such as mitigation of pollutant emissions or funding for basic education, when markets for externality or educational loans fail to function or even exist. However, we still think a case can be made for new bonds that complement existing instruments for several reasons. First, they are not designed for investors to bet on sustainable development on the whole, or "macro markets" in the language of Shiller (1992). Second, neither are they designed to enable policymakers to have revenues to be invested across sustainable projects in general. In the case of our proposed instruments, the relevant market failure is not only the absence of markets for unaccounted-for natural capital but also the absence of "macro markets" in the language

of Shiller (1993)[12]. Third, it would enable the government to partly address scale mismatches between ecology and institutions prevalent in ecosystem services (Cumming et al. 2006; Duraiappah et al. 2014).

4.2. Drawbacks

First, as already mentioned, the government budget deficit risks growing in the short run when GNP increases slower than gNNP or inclusive wealth does. This is simply because budget deficit as measured by debt/GNP ratio increases as interest payment grows and GNP is sluggish. Hence, gradually replacing conventional public debt with our proposed bond may be a sensible strategy in order to improve fiscal sustainability, as is also proposed by Kamstra and Shiller (2009). Of course, even if the total debt outstanding is unchanged, interest payments may be larger than the return on conventional government bonds in the short run. In the long run, however, the problem may be resolved by expanding the tax base to include inclusive wealth, along with a more stable inclusive wealth base because of gNNP growth.

Under the proposed bond scheme, the government would have an incentive to internalize previously unaccounted for capital as a tax base. When gNNP or inclusive wealth is increasing faster than GNP, the tax revenue increase does not catch up with the rise in interest payments and thus the government would have to bridge the gap. In fact, this policy reform to broaden tax base to include human and natural capital should be in place, even in the absence of the current proposed bond, as those capital assets are to be mainstreamed in the economy. In most countries, private manufactured capital such as plants, property, land, and houses are already taxable. The return on human capital, in the form of wages and salaries, is also captured for income taxes. What remains is the return on natural capital. Some classes of natural capital, particularly

[12] Of course, our notion of macro markets now includes the return from human and natural capital.

exhaustible resources, mineral resources, and forest resources, are counted as taxable assets; however, taxes should ideally cover all classes of natural capital that have externalities, including those related to the ecosystem. Potential examples of taxation or fees on natural capital may include, among others, tourism operator permits, recreation fees, or fishing and hunting licenses, for typically ecosystems in national parks.

Second, unless a benevolent government is assumed, moral hazard may occur. In particular, in the absence of close monitoring, government bureaucrats may have an incentive to divert investment away from inclusive wealth to restrain interest payments, particularly when the government is pressured to cut down on budget deficits. While this is a theoretical possibility, it is neither a necessity nor a long-run consequence. In the future, inclusive wealth growth, combined with internalizing the resource allocation, will enhance tax revenue. Moreover, the moral hazard problem can be mitigated by making the investment decision-making process transparent and democratic. It should also be noted that other proposals to link a financial instrument with GNP have the same issue, and, for that matter, that the current system of national accounts is not totally immune to the manipulability problem.

In addition, the government is not the exclusive investor in inclusive wealth. A large proportion of manufactured capital (plants, houses, private schools, etc.) is formed by firms. Although the government is responsible for meeting basic needs in the formation of human capital, other aspects of human and health capital are often built privately, such as higher education, vocational training, healthy eating, and regular exercise. Of the three capital assets comprising inclusive wealth, it is natural capital where the government plays the biggest role; however, many classes of natural capital are still managed by the private sector (oil, gas, and mineral resources) or by the public sector (common-pool resources). This fact implies that even if the government suffers moral hazard, our proposed bond should still work to incentivize the private sector to invest in inclusive wealth.

The third concern comes from a practical standpoint: the measurement of gNNP and inclusive wealth. They include assets that are not traded in markets, or whose market prices do not reflect their real contribution to human well-being, which makes it particularly difficult to establish how to attach shadow prices to human and natural capital. However, case studies are increasingly being shared and guidelines established to address this issue. A gradual and conservative approach is suggested, starting from subclasses whose shadow prices are easily estimated. For example, timber value can be integrated easier than non-timber forest benefits. The former can be estimated from traded wood products, while the latter include those by regulating services (improving air quality, pollination), habitat services (genepool), and cultural services (recreation) (van der Ploeg and de Groot 2010). One way to obtain shadow prices in a consistent manner is to resort to computable general equilibrium models (Arrow et al. 2013), where human and natural capital are increasingly incorporated (see, e.g., Wittwer and Dixon 2015).

Fourth, the market may risk becoming thin if incentives are insufficient for investors to join the market. This possibility hinges on the supply and demand of the asset market in general as well as the fundamentals and investor confidence in the economy. The "global saving glut" in developed countries (Bernanke 2005) is fueled by recent quantitative easing in high-income countries, some of which even experience negative interbank interest rates. While this means that the government of these nations can already borrow resources cheaply in the market, there is always the risk of rising interest rates in the future, partly in response to debt accumulation and default risk. In addition, there is a stronger case for the current bond we discuss for developing and emerging countries: in those regions, there is a general lack of infrastructure, so that the rate of return on manufactured capital is high. It cannot be generally stated whether this rate of return on manufactured capital is higher than the share or growth rate of gNNP or inclusive wealth; however, assuming that natural capital is being degraded, the share or

growth rate of gNNP or inclusive wealth can easily be below the high opportunity cost of capital in developing countries. All this means that governments in these economies could have an incentive to issue bonds that may enable them to obtain another source of revenue at a lower cost than elsewhere.

4.3. Comparison with GNP-linked bonds

Table 1 compares the advantages and drawbacks of GNP- and gNNP- or inclusive wealth-linked bonds. GNP-linked bonds are primarily designed to reduce the interest payments of the issuing government and to diversify risks. In times of sluggish growth, interest payments to the bond also slow, mitigating the pressure on the budget deficit. Moreover, since interest payments are not consumed quickly by households, the seeming procyclicality does not bite seriously (Kamstra and Shiller 2009); that is to say, when the GNP growth is high, so are the interest payments, but at least some of them are saved by households, hence there is a pressure to slow GNP growth. Reducing the debt/service ratio would also reduce the likelihood of extreme events such as country default or currency or financial crisis, benefitting the economy in question as well as the international community. Governments which have heavily leveraged themselves could issue GNP-linked bonds, in the same way as corporations sell equity and manage their debt (Shiller 2013). From the perspective of investors, the bond could thus work as equity securities to the country as a whole by covering the return on human capital as well.

Table 1. About here

By contrast, gNNP- or inclusive wealth-linked bonds aim to ensure the long-term sustainability of an economy, rather than fiscal sustainability. A corollary is that they may worsen fiscal sustainability defined by the debt/GNP ratio, particularly when GNP grows slower than inclusive wealth. The procyclicality of GNP-linked bonds we

mentioned above does not generally apply to our proposed bonds, however, since GNP and inclusive wealth growth are not considered to be correlated.

By comparison, gNNP or inclusive wealth-linked bonds are more plausible than their GNP counterparts for ensuring sustainable development. GNP typically outweighs gNNP, which is the return on the inclusive wealth of nations (see equation (1)), meaning that GNP does not indicate sustainability of an economy if inclusive wealth is being depreciated without being explicitly accounted for. The theoretical nexus between stock and return is much more straightforward in inclusive wealth and gNNP than (partial) wealth and GNP, as shown in Section 2.1.

4.4. Comparison and complementarity with other initiatives

It is useful to compare with other initiatives aim to direct financial resources toward natural and human capital in a global context, if not explicitly stated that way. First, Stiglitz (2002) proposed that the special drawing rights (SDRs) issued by the International Monetary Fund be used to enhance investment in environmentally friendly infrastructure, especially global public goods in developing countries. One new type of SDR is global greenbacks, or "green paper gold." Second, payment for ecosystem services (PES) is designed to internalize local environmental amenities that offer benefits globally but for which local citizens lack sufficient incentives to preserve (Engel et al. 2008). It is a direct income transfer to the often poor or marginalized owners of specific natural capital and as such does not fit with the macroeconomic scale addressed in the present study.

Third, socially responsible investment (SRI) is growing and, as of March 2010, more than 700 entities signed the United Nations Principles for Responsible Investment, with around US$18 trillion in assets under management (Capelle-Blancard and Monjon 2012). Typically, SRI applies environmental, social, and governance (ESG) criteria in investment strategies. While SRI does work to divert money away from unsustainable

activities, as the name “divestment” suggests, it is less proactive and less direct than investing in sustainable activities. In addition, by nature, it focuses on publicly traded companies, which comprise only the minority of the holders of inclusive wealth.

Fourth, social impact bonds (SIBs) are a vehicle to gather money from investors with a return contingent on the outcome of the associated project, such as prisoner rehabilitation, childhood education, and homelessness (Warner 2013). This relatively new scheme could also be applied in principle to environmental conservation, although only a few examples have thus far been presented. SIBs are conceptually similar to the current bond we propose, in that if invested in natural capital they are creating a corresponding financial asset on the liabilities side to the natural capital. The latter two financial vehicles address a portfolio of individual companies (in the case of SRI) or projects (in the case of SIBs) in contrast to our bonds that cover the macroeconomy. Thus, again, they complement each other.

Although not financial securities, one may also come up with other examples of more direct investment into human capital by investors. A prominent example is found in venture capital firms (VCs) which invest equities into business ventures with alliance capital, intellectual capital, and human capital (Baum and Silverman 2004). Another example of direct human capital investment into the educational component in today’s internet-dominated age is a peer-to-peer investment platform such as Upstart.

5. Example

5.1. The place and challenges of natural capital in Japan

As shown in Table 2, the latest *Inclusive Wealth Report* (UNU-IHDP and UNEP 2014) reported that inclusive wealth in Japan increased from $44,161 billion in 1990 to $54,693 billion in 2010, in constant US$ of 2005. Manufactured, human, and natural capitals comprise around 38%, 62%, and 1%, respectively, of inclusive wealth in 2010. In many high-income countries, the composition of natural capital in inclusive wealth falls

somewhere from 1 to 10%, as opposed to human capital representing over 60%, and Japan is no exception in this regard.

As can be seen from Figure 3, agricultural land is steadily on the decline because both paddy fields and others are shrinking on a moderate pace, in line with the number of agricultural farms (MAFF 2016), whilst forest resources are increasing. As a result, natural capital on the whole is slightly decreasing.

Table 2. About here

Figure 3. About here

There has been a debate, however, that the forestland quality is being degraded as forestry has been shrinking in Japan (Forestry Agency 2015) and it has become difficult even to maintain forests intact. Moreover, the forest landscape called Satoyama has become run down partly due to the privatization of land at the local scale and the erosion of the communal rules overseeing the maintenance of the commons (Duraiappah et al. 2014). Reflecting bottom-up quality into shadow prices is thus one of the future challenges of forest accounting. There are some initiatives to raise productivity of agricultural land and forestry (MAFF 2016), but they face the challenge of labor shortage and capacity building with an aging and falling population.

Regarding human capital, average years of schooling for total population older than 15 years old is 11.6 years (Barro and Lee 2013). The situation of course differs for each and every cohort. For example, female population experiences slightly less years of schooling (11.45 years) than male counterparts on the average.

5.2. Numerical example: Application of gNNP- or inclusive wealth-linked bonds

Let us apply numerically a possible bond whose coupons are linked to the level of

gNNP or inclusive wealth. As laid out in Section 3, the interest payment would be a share of gNNP fixed before the issuance of the bond. Suppose that this constant, α, is 100 billionth of the current gNNP and that the social discount rate (pure rate of time preference) is δ =2%.

Using the inclusive wealth figure of $54,693 billion in in monetary units in 2010 (corresponding to $\frac{V(t)}{U'(C(t))}$) to equation (7), which shows that gNNP is proportional to inclusive wealth, so that

$$gNNP(t) = \frac{\delta V(t)}{U'(C(t))} = \$1{,}093 \ \ billion,$$

implying that gNNP is estimated to be less than one fourth of GDP, $4,579b, in 2010. Next, applying $\alpha = \frac{1}{100\text{b}}$ to gNNP, the annual coupon payment would be

$$\alpha * gNNP(t) = \$10.93.$$

Finally, employing equation (8) and the interest rate being assumed as $r = \delta = 2\%$, the theoretical bond price would be

$$P_B = \alpha \frac{gNNP}{r} = \$547.$$

if the current level of gNNP is expected to continue. If we employ lower interest rates plugged into r, as reflects recent interest rates in some developed economies, the bond price would be higher, due to the lower opportunity cost of holding this bond. The government can in principle issue as many bonds as it would like to invest; however, it is sensible to put a ceiling on the total amount of issuance, such that it does not surpass the net wealth (i.e., using the terminology in section 4.1, $\Delta IB \leq \Delta N$).

For the second class of the proposal, we present the case of the bond associated with the growth rate of gNNP or inclusive wealth. Based on the same Japanese data (see Table 2), inclusive wealth has grown 1.08% annually in the past two decades. Manufactured, human, and natural capitals comprise around 0.736%, 0.351%, and -0.002%, respectively, of inclusive wealth change. This figure (1.08%), or the most recent annual change rate of inclusive wealth if available, can be used as a direct reference for

the interest payments. Recall from equation (10) that this change rate in inclusive wealth would be equal to the change rate in gNNP, if we ignore consumption growth.

Alternatively, the difference between the growth rate of inclusive wealth and some benchmark growth rate can be set as the interest payment of this bond. Long-term interest rates of government bonds maturing in ten years have been constantly on the decline for the past decade in most advanced economies (OECD 2016). If the Japanese government sets the benchmark as, say, 0.35%, which is the yearly average of the interest rate for the 10-year government bond in 2015, the interest payment investors obtain from the proposed bond would be 0.73% (=1.08 - 0.35) of the amount issued.

5.3. Revenues and prospective investment projects

How should this revenue be spent? We argued that it could be revenue-neutral, while alternatively the proceeds from issuing bonds can be set aside to establish funds to be invested in prospective projects, in accordance with the trend of shadow prices of individual capital assets. This task is daunting because the current dataset of shadow prices has only begun to be collected and is still far from real shadow value. Having noted this reservation, the following are examples of the direction in which the argument may proceed in Japan, which is by no means meant to be an exhaustive overview of prospective projects.

Regarding natural capital, just because agricultural land has been on the decline does not mean that it should be reinvested. If its shadow prices (computed as the present value of future rent flows from agricultural products) are deemed to be decreasing, the government may not include investment in the expansion of the volume of agricultural land. Instead it could be more straightforward to raise shadow price of the average agricultural land, by taking such measures as consolidating dispersed land plots, intensifying cultivation methods, streamlining logistics, incentivizing conversion to high value-added crops and products, among others. Subsidizing projects of clearing forests

into more efficient land use for the sake of revitalizing local communities could also be prospective.

Moreover, one of the potential investment projects may lie in the intersection of both capitals: human capital engaged in agricultural land and forest resources, at both levels of bureaucrats and technicians and practitioners. Using agriculture and forest at the environmental education scene would also lead to capacity building of future generations.

Investing in conventional human capital straightforwardly involves raising the national average of educational attainment. For example, female representation in higher education is lower than male and thus can be raised. In primary and secondary education, remedial projects can also be meaningful to improve some social issues. For example, addressing bullying and nonattendance of pupils and students could involve not only school educational reform but also enhancing school-home communication. In addition, those non-school elements still not reported in UNU-IHDP and UNEP (2014) such as on-the-job training in workplaces, leadership, and health can come to the fore.

From another aspect, total factor productivity growth is negative in Japan in the studied period (UNU-IHDP and UNEP 2014). The government would therefore be inclined to include investment in R&D activities as a candidate project. One of the most straightforward ways to do so is to inject the raised resources into researchers' payroll in promising areas.

Finally, one could argue that the proposed bond could be a way to raise financial resources to combat climate change, either for the sake of mitigation or adaptation. In so far as this involves mitigating carbon stock or enhancing social resilience, it can be regarded as investment in inclusive wealth. In fact, in practical accounting, carbon stock is not a (negative) capital *per se*, but carbon emission or associate damage is recorded as a negative adjustment to inclusive wealth (World Bank 2012; UNU-IHDP and UNEP 2012).

Nations could invest bond revenue in mitigation or adaptation of climate change either

domestically or worldwide. The recent Paris climate conference (COP21) in 2015 was commended for an agreement on the global target to confine the global temperature rise within 2 degrees compared to pre-industrial levels. However, neither clear roadmap, economic incentives nor legally binding commitments were contained. Thus, "determined and far-reaching government intervention in energy markets" makes or breaks the landmark Paris agreement (Clémençon 2016). In view of this, a progressive government concerned about the situation may pledge a share of the issued bond proceeds to be fed into a climate fund such as Green Climate Fund (GCF). A particular obstacle for this worldwide investment option is that, since carbon stock is a (negative) global public natural capital, the return on this particular investment for a given country may be uncertain. Investment in mitigating emission even domestically has another challenge by nature: it is global carbon stock that matters to damages, which hinges on global cooperation. Countries therefore may have more incentives to invest in adaptation projects where investment-return relationship is clearer and more certain.

6. Conclusion

Traditional environmental policy instruments include taxes, subsidies, tradable permits, funds, and quotas in addition to command-and-control regulations. Some financial vehicles such as SRI or SIBs are slowly becoming realized for the purpose of sustainable development, but these are securities covering individual assets or projects. The *Inclusive Wealth Report* (2012) argued that mainstreaming wealth in debates about economic policy is crucial for sustainable development; however, specific suggestions have thus far not been made to facilitate mainstreaming from the financial assets side. Further, as far as we know, there is no proposal that has been made to link financial bonds to sustainable development at the macro level, meaning that few assets currently exist to be set against human and natural capital.

Our proposal for an inclusive wealth- or gNNP-linked bond would address this

motivation by tapping into investors' resources being shifted into non-conventional capital assets, which will become increasingly important for long-term sustainability. Moreover, we showed that this proposal is founded on the sound welfare economic theory of green national accounts, making it even more plausible than the oft-cited proposal for a GNP-linked bond. It could lead to the virtuous cycle of increased government expenditure toward inclusive wealth, expanding tax revenue, increased coupon payment to investors, and increased social well-being.

Obviously, a detailed modelling exercise is needed to fully capture the effect of our proposal. Challenges also exist in putting the presented idea into practice. Government budget deficits, moral hazard, and measurement issues are three major concerns we have identified. However, as we have demonstrated, some of these issues can be overcome via thoughtful system design and an appropriate regulatory framework. Ensuring transparency in the inclusive wealth accounting methodology and presented figures, as well as minimizing manipulation and increasing citizen involvement in the accounting process, would also be crucial.

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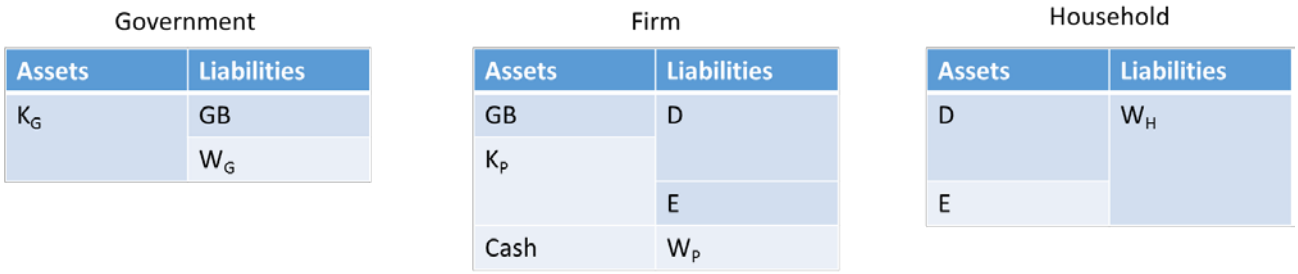
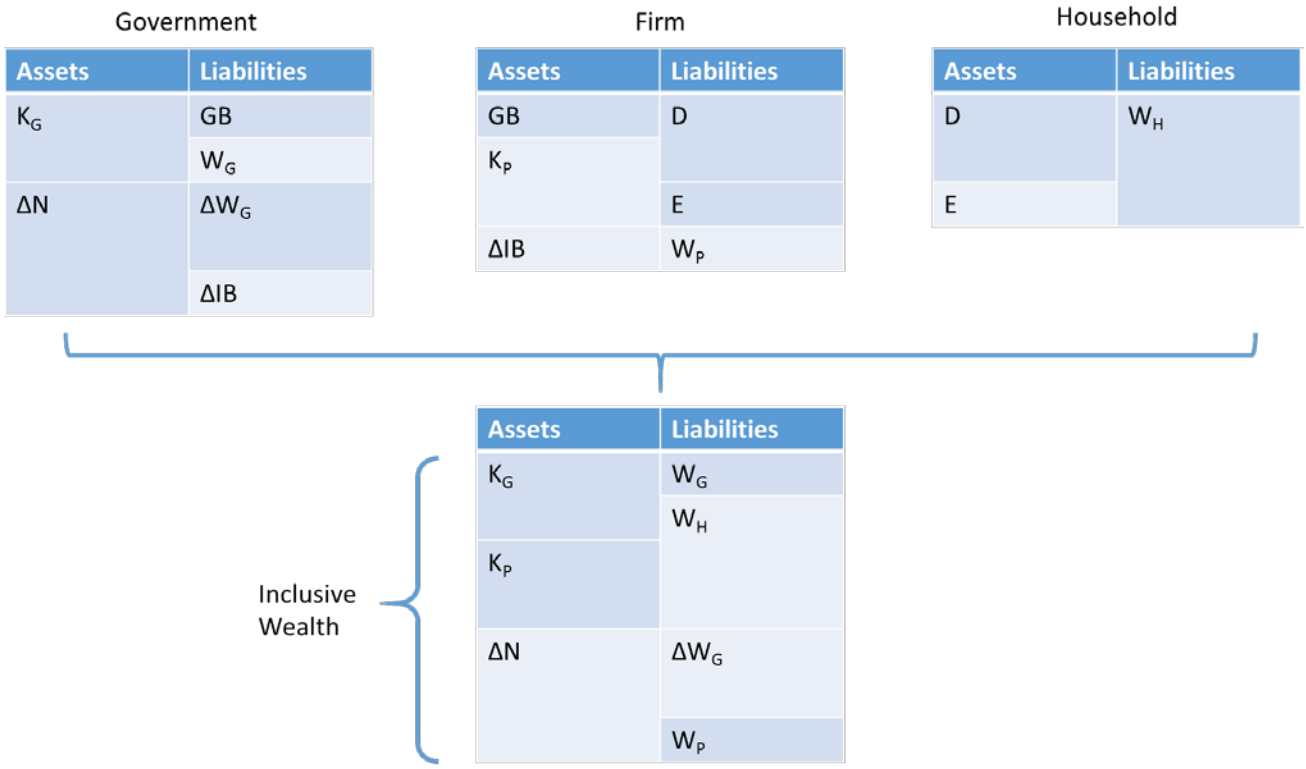
Figure 1. A balance sheet of a nation with three sectors.



Note: K_G: physical capital (government-owned); GB: government bonds, W_G: net wealth (government-owned); K_P: physical capital (firm-owned); D: corporate debt; E: corporate equity; W_H: net wealth (firm-owned) or retained earnings; W_H: net wealth (household-owned). Some simplifications are made (e.g., no liabilities in the household, etc.)

Figure 2. A balance sheet of nations with new bonds introduced.



Note: IB: the new type of bond issued.

Table 1. Comparison of GNP- and gNNP- or inclusive wealth-linked bonds

	GNP-linked bonds	gNNP- or inclusive wealth-linked bonds
Primary objective	Fiscal sustainability	Long-term sustainability
Benefits to the government and society	• Reducing interest payments at times of sluggish growth • Reducing debt-service ratio to cut down on default risk • International sharing of default risk	• Restructuring nation's wealth toward sustainable development, by directing financial resources to inclusive wealth • Raising future tax revenue, if combined with tax reform • Intergenerational sharing of well-being with current investors
Benefits to investors	• An opportunity to invest in a country's future growth with an equity-like exposure • An opportunity to diversify assets • A lower probability of defaults and financial crises	• An opportunity to invest in a country's productive base for sustainability • An opportunity to diversify assets and to lower risk and volatility
Drawbacks and challenges	• Procyclicality: increasing payments at good times • Moral hazard: weak incentive to grow • Potential misreporting of data • Insufficient liquidity • Difficulty in pricing	• Possible worsening of budget deficit and default risk in the short run • Moral hazard: weak incentive for the government to invest into inclusive wealth • Potential misreporting of data • Insufficient liquidity • Difficulty in pricing

Source: The author, referring to Griffith-Jones and Sharma (2009), and Kamstra and Shiller (2009)

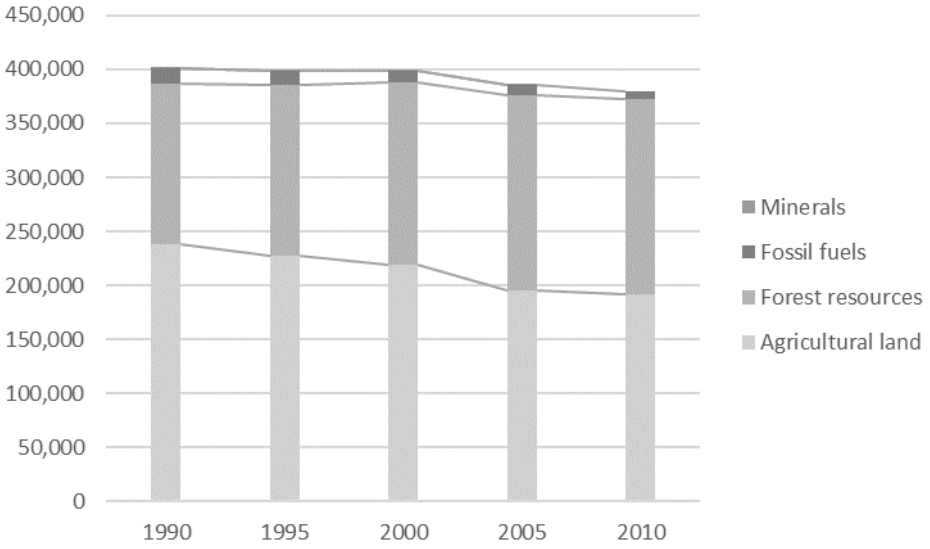
Table 2. Inclusive wealth change in Japan, 1990-2010.

year	1990		2010		annual change rate	
	$billion	share	$billion	share		weighted
produced	13,570	30.7%	20,668	37.8%	2.126%	0.736%
human	30,191	68.4%	33,645	61.5%	0.543%	0.351%
natural	401	0.9%	380	0.7%	-0.269%	-0.002%
total	44,162	100%	54,693	100%		1.08%

Source: Calculated from UNU-IHDP and UNEP (2014).

Figure 3. The change of composition in natural capital in Japan, 1990-2010.

(unit: millions of constant 2005 US$)



Source: UNU-IHDP and UNEP (2014).

Note: Minerals account for too little to appear in the graph.