Should measures of the nation's capital stock be expanded to include types of assets that are currently excluded, and if so what measurement changes are needed?

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I. Introduction

Since the development of national capital accounts in the post-WW2 era when manufacturing, agriculture and physical goods dominated the economy, the role of the services economy, intangible goods and the relationship between the economy and the environment has become increasingly important. Reflecting such changes in national accounting systems is crucial for national accounts to remain relevant to economic analysis and policy making, and to maintain an accurate understanding of the productive potential of capital in the economy. Although there have been significant advancements for the integration of intangible assets such as software and databases, progress remains to be made for the valuation of missing capitals such as natural capital. Natural capital is defined by the ONS (2021) as all the ecosystem services that natural assets provide, and include soil, air, water and all living things. Despite being intrinsic to the great majority of consumption and production processes, natural capital is largely unpriced and thereby mostly ignored in decision-making. This essay discusses how incorporating natural capital in national accounts enables policy decisions that better examine the trade-offs between asset use and economic growth. While this should, in theory, lead to investment decisions that prioritise the needs of future generations, the commodification of nature and its valuation carries the risk of assuming natural capital's substitutability with other forms of capital that provide higher returns. It is therefore critical that necessary measurement changes to include natural capital into national accounts adequately reflect the costs of environmental degradation and the investment needed to undo any damage. These particularly concern the depreciation rate of natural capital and the spatial variation of ecosystem services, which are becoming increasingly prevalent in the context of anthropogenically driven environmental change.

II. National Capital Stock, Measurement and Missing Capitals

Capital stock is a measure of the total quantity of produced, durable, non-financial assets in an economy at a point in time, which in turn contribute as productive inputs for further production of goods and services (Boldizzoni, 2008). Nationally, it is the sum of private and government fixed assets (Costa et al., 1987). Capital stock measurements provide insights into the drivers of growth of a national economy, as capital is a key factor of production. It is conventionally modelled in the neoclassical production function $Y = F(K, H, L, A)$, where Y, K, H, L and A respectively represent output, the stock of physical and human capital, the amount of labour employed, and the residual – what is unexplained by the other inputs – respectively (Barros, 2016). Accounting for the different input stocks improves our understanding of economic growth through the measured variables rather than the residual, and serves as a guide for investment – a flow – into the economy (Usher, 1980). Without accurate statistics, we would expect the systematic underinvestment of unmeasured capitals, resulting in inefficient outcomes.

The ONS currently uses a Perpetual Inventory Method (PIM) to model capital stock data. This method entails accumulating investment flows for fixed assets and writing down assets kept in

the aggregated stock for retirement and fixed capital consumption (ONS, 2018). It uses assumptions about the expected lifetime of assets in different industries, including a specified depreciation function to account for the loss of value of assets over time (McLaren et al., 2011). Until recently, the ONS assumed a straight-line depreciation model, by which capital stock would decrease by a constant amount each year until it reaches zero at the end of an asset's life-length (Eurostat, 2014). This proved inconsistent with empirical evidence (Hulten and Wykoff, 1981), resulting in an overvaluation of second-hand capital. As a result, the ONS replaced the model in 2019 with a wider range of nonlinear depreciation patterns that capture more accurately the loss in value of assets as they age (ONS, 2019). The UK National Accounts and PIM align with the European System of Accounts (ESA) and the System of National Accounts (SNA) which enables consistency and comparability of accounts across countries (McLaren et al., 2011).

An important limitation of capital stock is the existence of "missing capitals", which is both highlighted by the Bean Review (2016) and recognised by the ONS (Dutton, 2019). Missing capital refers to forms of capital which are either ignored or only partially recognised by measurement statistics (Hamilton and Hepburn, 2017). This results in a systematic undervaluation of the nation's capital stock, and as a result an inadequate understanding of productivity and growth (Dasgupta, 2015). Leading forms of missing capital that have been proposed over the years include sets of intangible capital such as organisational capital and human capital, with the most pervasive missing one being natural capital (Bright et al., 2019). Whilst progress has been made to include intangible capital such as intellectual property in the form of software and R&D, tangible assets still dominate measures (see Appendix). Integrating these capitals in economic accounts systems is essential to record a more inclusive measure of a nation's wealth, as outlined in the Dasgupta Review (2021). A comprehensive understanding of an economy's productive potential is otherwise not possible, if most of the asset base we rely on is not currently included in National Accounts (Martin, 2021).

III. Benefits of integrating Natural Capital to the National Accounting Framework

It is widely established that natural capital stock and flow accounts are predominantly missing, or partial in the UK's balance sheet. The UK Natural Capital Committee (2015) defines natural capital as the elements of nature that directly or indirectly provide a value to society, including ecosystems, freshwater, species, land, minerals, the air and oceans, as well as natural processes and functions. Despite providing real welfare benefits, the public goods nature of environmental goods, owed to their open-access and lack of ownership, results in these goods not being independently traded in markets (Day, 2013). Their intangible nature is associated with a lack of monetary valuation, whereby its degradation becomes easily unreported and private and public decision-making is carried out without regard for its value (Arrow et al., 2012). As Coyle (2014) suggests, including the valuation of natural capital in GDP measurement metrics allows for measurement of economic growth that is inclusive of environmental impact. This is essential in light of the need for national accounts to remain aligned with and recognise defining challenges of the 21st century, such as climate change and loss of biodiversity (Royal Geographical Society, 2017). The Bean Review (2016) proposes that integrating the depletion of natural resources and environmental degradation into an adjusted measure of GDP is one important way to link economic output together with natural capital. Incorporating natural capital into these accounts enables the comparison of different types of capital, hence also the comparison of the current depreciation and accumulation of different types of stocks. For such to be achieved, it is important that models of depreciation are reflective of real degradation of natural capital, and that the accounting method is part of a global, consistent, and replicable framework as will be further discussed in Section IV.

The availability of data on natural capital accounts facilitates the evaluation of the current state of natural capital, which in turn provides evidence on the impact of investments and how they can be improved to achieve better results. As in the perfect competition model, symmetry and transparency of the goods and services traded on the market improves the allocation of resources, boosting efficiency (McGrath & Hynes, 2020). This enables public actors such as governments and institutions to carry-out better informed decision-making for the management of natural resources (Bright et al., 2019). At the same time, private actors are able to integrate key data on natural capital and better evaluate the costs and benefits of an investment plan, thus their business risk. Further, the increased transparency that natural capital accounting provides regarding the environmental impacts of both public and private actors incentivises them to minimise actions that have negative environmental externalities. Hence, adopting a holistic, value-based approach allows for a better understanding of the trade-offs between asset use and economic growth, which is crucial to improve the efficiency of the economy (White et al., 2020). The long-term viability and strength of national businesses and thus stability of the private sector depend on it. Agarwala et al. (2014) analyses the case of ExxonMobil, where the company has committed to greener investments in response to stakeholders' discontent. They have also been incentivised to enhance their sustainability communication (Pritchard and Van der Horst, 2018). A positive or negative natural capital stock impact could also determine a firms' levels of taxes and subsidies imposed or provided by public institutions. Therefore, the transparency of actions supported by natural capital stock data brings trust and stability to a company and benefits in the short and long-term.

Whilst integrating natural assets into capital stock accounts enables a better understanding of the trade-offs between asset use and economic growth - thereby conveying the durability of an economy's productivity - criticisms concerning the adoption of a valuation-based approach towards nature must be addressed. Firstly, assigning a monetary value to nature, or commodifying it, implies that nature and other forms of capital are somewhat substitutable. However, valuation does not represent the degree to which natural and physical capital serve as substitutes - substitution rates are indeed found to be low (Cohen et al., 2018) - but rather the degree to which they function as complements (Rouhi Rad et al., 2021). Next, marketisation typically implies the designation of something as property, creating expectations that natural capital could be traded or held in exclusive possession (Gray and Gray, 1998). This clashes with the public good nature of many forms of natural capital. Well-defined regulation could mitigate these threats, preventing the replacement of natural capital with investment into physical capital offering seemingly higher returns. Finally, there is the belief that assigning monetary value to natural capital provides legitimacy to the market mechanisms that have systematically neglected the environment (Monbiot, 2014). This belief mistakes poor valuation design for failure of valuation as a whole. Monbiot (2014) cites limitations of the European Emissions Trading Scheme as an example of valuation failure. However, it is the inflexibility in designating carbon caps that is attributed with being the scheme's core limitation (Laing et al., 2013). Furthermore, the scheme was still found to be successful in reducing carbon emissions (Bayer and Aklin, 2020).

IV. Measurement changes for Natural Capital Accounting and Policy Implications

Despite the theoretical support for the integration of natural capital into national accounts, the measurement of the value of natural capital is lagging for many critical stocks (Barbier, 2011). The ONS uses two main approaches to create estimates of UK natural capital stock and its service flows, stemming from a wide range of data sources (ONS, 2021). The first is to determine a price that

corresponds to the contributions of the ecosystem to the economy, as the ONS has previously attempted to do, for example, by evaluating the share of natural capital in tourism revenues and real estate prices (ONS, 2021). The second approach is used when no market for the ecosystem service exists, such as for air pollution removal, whereby a price needs to be estimated for the value of an ecosystem service in a theoretical market (Jones et al., 2017). A logic chain of how natural capital accounts are developed for air pollution removal by vegetation is shown in Figure 1. The methodologies and data sources used differ according to the service and do not cover all services. Estimates have remained experimental since the project to compile natural capital accounts for the UK began in 2011 (ONS, 2018).

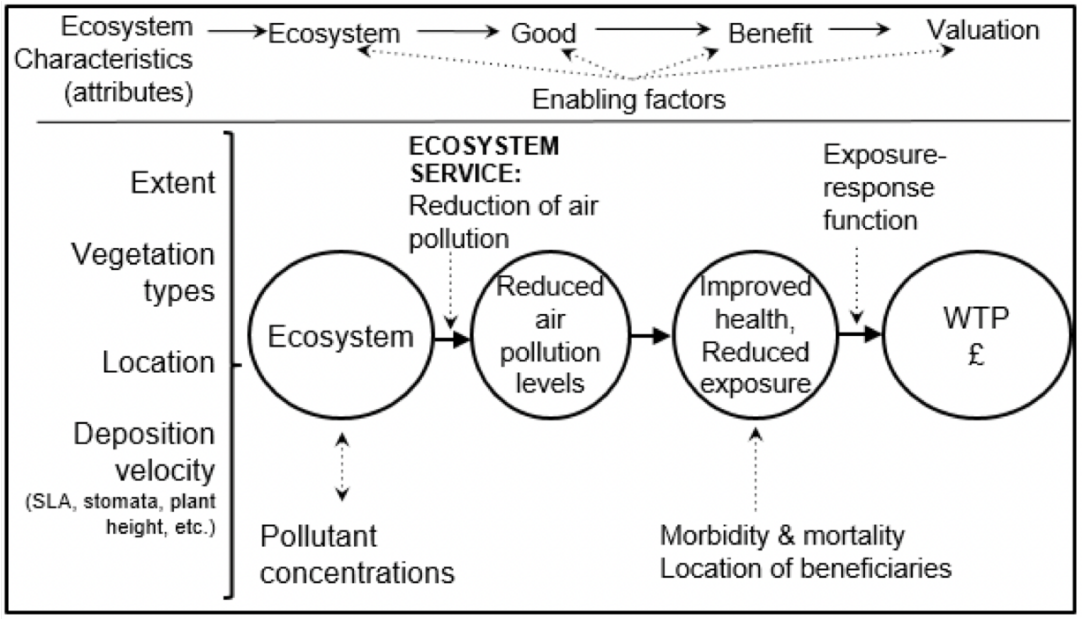

Figure 1: Logic chain for the valuation of air pollution removal. WTP = Willingness To Pay. (Jones et al., 2017)

Defining features for the value of natural capital, such as their depreciation rate and spatial disaggregation, make it difficult to assign an accurate monetary value in a clear and replicable cross-border national accounting framework. The value of natural capital, such as forests, differ widely according to their location, in terms of the services they offer, such as air pollution removal, and the degree to which they contribute to local biodiversity; accounting frameworks need to reflect these variations (Maddison and Day, 2015). For example, data has historically neglected the biodiversity (or lack thereof) of carbon offsets projects, which is crucial for their long-term sustainability (Economist, 2019), resulting in over-exaggerations of their carbon offset. Increased data collection and focus on spatial coverage is essential to enable the accuracy of valuation of natural capital in a wider range of spatial contexts. Assumptions of constant service values throughout asset lives of natural capital also need to be reconsidered according to different spatial contexts, as climate-driven changes to the services provided by natural capital become more prevalent - such assumptions are already being reassessed for carbon sequestration and air pollutant removal (ONS, 2021). Moreover, new models of depreciation rates for natural capital need to be developed that reflect depreciation of stocks driven by anthropogenic forces. The ONS has attempted to update their traditional linear models through nonlinear ones in 2019, which provides a useful gateway into developing more dynamic models. It is critical that these models are regularly updated to incorporate potential climate change impacts and environmental thresholds of degradation. Whereas physical

capital stocks can easily be repurchased should they fall below a certain size, many forms of natural capital stocks may reach disequilibrium if they are sufficiently neglected, making it notably harder to replenish them.

V. Conclusion

In conclusion, although capital stock accounts are beginning to incorporate forms of missing capitals, a stark divide between tangibles and intangibles still remains. Most notable is the overarching absence of natural capital. Rectifying these measurement gaps is necessary to promote efficient policymaking that incorporates environmental consequences. Efforts to value natural capital must be transparent with and accompanied by measurement changes that reflect its features, specifically regarding nonlinear depreciation patterns and varying spatial effectiveness in service provisioning. Such measurement changes will become increasingly important as the impact of anthropogenic forces on the degradation of natural capital becomes more pervasive with time, and potentially irreversible changes occur to the environment.

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Appendix: Classification of Non-Financial Assets (OECD, 2009)

Produced assets	Fixed assets	Dwellings		
		Other buildings and structures	Non-residential buildings	
			Other structures	
			Land improvements	
		Machinery and equipment	Transport equipment	
			ICT equipment	
			Other machinery and equipment	
		Weapons systems		
		Cultivated assets	Animal resources yielding repeat products	
			Tree, crop and plant resources yielding repeat products	
		Costs of ownership transfer on non-produced assets		
		Intellectual property products	Research and development	
			Mineral exploration and evaluation	
			Computer software and databases	Computer software
				Databases
			Entertainment, literary or artistic originals	
			Other intellectual property products	
	Inventories	Materials and supplies		
		Work in progress	Work in progress on cultivated assets	
			Other work in progress	
		Finished goods		
		Military inventories		
		Goods for resale		
	Valuables	Precious metals and stones		
		Antiques and other art objects		
		Other valuables		
Non-produced assets	Natural resources	Natural land	Natural land under buildings and structures and associated surface water	
			Natural land under cultivation and associated surface water	
			Natural recreational land and associated surface water	
			Other natural land and associated surface water	
		Subsoil assets	Coal, oil and mineral gas reserves	
			Metallic mineral reserves	
			Non-metallic mineral reserves	
		Non-cultivated biological resources	Natural forests	
			Other crop and plant resources	
			Wild stocks of fish and aquatic mammals	In national waters including Exclusive Economic Zone
				Outside Exclusive Economic Zone
		Water resources	Aquifers	
			Other	
		Other natural resources	Radio spectra	
			Other	
	Contracts, leases and licences	Third party property rights	Marketable operating leases	
			Permissions to use natural resources	
		Entitlement to future goods and services on an exclusive basis	Of nominated legal persons	
			Of future production	
	Goodwill and marketing assets			