Natural Resource Development and the Digital Divide

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> The quantitative technologies used to investigate social and economic life work best if the world they aim to describe can be remade in their image.
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> –Theodore Porter, *Trust in Numbers*

This essay examines the equitable dissemination and use of data in the extraction of natural resources to help eradicate poverty in resource rich countries. A combination of the Hotelling and Hartwick rules allow for the planned extraction of natural resources. I introduce these concepts and show how they can aid in economic and social decision making regarding natural resource extraction. I then discuss the resource curse to examine the potential economic drawbacks to resource extraction for developing nations. Following that is a discussion on the complicated nature of applying traditionally western ethics in developing nations using complexity theory and evolutionary economics. Finally, I will explain the benefits of using big data to provide accurate social, environmental and economic forecasts. I will conclude with an assessment of big data in practice and will suggest areas for further research into the use of machine learning systems for economic and environmental development.

The Hotelling Rule measures the future value of natural resources against the discount rate. A fundamental aspect of the Hotelling Rule is the finite availability of non-renewable resources (Krautkraemer 1998). Due to the scarcity of natural resources, the Hotelling Rule states that the marginal value of non-renewable resources increases in tandem with the discount rate. Using this calculation for the future value of non-renewable resources, it is possible to determine if and when non-renewable resources should be extracted. If the financial gains from extracting the resource today could be invested in assets whose value will increase faster than the discount rate they should be extracted. If not, they should remain in place.

There are important economic variables that cause inaccuracies in Hotelling Rule calculations. The most significant of these is the unknowable amount of the available resource stock (Krautkraemer 1998). Absent precise knowledge of the total resource, an accurate marginal value cannot be determined. While it is possible to value a barrel of oil, for instance, and to carry that value forward in line with the discount rate, not knowing how many barrels are in the reservoir makes determining the net present value of the resource difficult. Extracting one barrel of oil costs the same as pulling one million barrels in terms of technology and labor, which means a small reservoir could actually generate negative returns. Conversely, as exploration and production move forward the known resource stock becomes more apparent and new knowledge affects the value of the total resource.

The value of a natural resource also depends on the quality of the resource. Absent advance knowledge of resource quality an accurate valuation is challenging. As with quantity, the quality of the resource is determined after production costs have been sunk. The quality of some resources can change as extraction continues, and changes in quality will affect the valuation. Considering these two primary variables, since there are various costs associated with resource extraction, and profit is the difference between price and cost, the smaller the actual reservoir and the lower the quality of the resource the lower its value. The opposite is also true and since each of these variables, quantity and quality, are independent of each other their fluctuation makes any real predetermined marginal value impossible.

Implementation of the Hotelling Rule and marginal value determination is not enough to establish socially responsible resource extraction; the Hardwick Rule supplies us with data for carrying profits forward into future generations allowing for an equitable allocation of funds and resources. Expanding Solow's (1974) intergenerational equity to include nonzero extraction costs, the Hartwick Rule states that nonrenewable resource rents, which are the amount of earned revenue that exceeds current social and economic necessity, are invested into reproducible capital goods (Hartwick 1977; Krautkraemer 1998, p. 2093; Lund 2009). What this means is that all of the earnings from nonrenewable resources above the current cost of maintaining social systems should be saved and invested for future generations. This allows future generations to benefit from interest accrued on current revenue, providing an equitable and dynamic distribution of resource revenue. Through applying the Hotelling Rule to the determine resource extraction dates based on the discount rate and the Hartwick Rule for an equal distribution of revenue into the future it is possible to develop a fiscally responsible system of resource extraction and production.

Nouveau Riche actors tend toward conspicuous consumption (Veblen 2005). An impediment to economic growth can and does occur in resource rich countries, which the international monetary fund (IMF) defines as a country that derives at least 20% of its fiscal revenue or 20% of its exports from "nonrenewable natural resources" (Venables 2016, p. 162), due to pressure for current spending of resource revenue. This "resource curse" (Auty 1993; Sachs & Warner 1995) has been shown to disproportionately affect resource rich developing countries. A common symptom of the resource curse is the "Dutch Disease," which is an inflation of the exchange rate due to the increase in resource exports (Smith 2015; Venables

2016). While evidence suggests there is a relationship between natural resource abundance and poor economic growth, studies of some resource rich countries have shown that the reverse is possible.

There are endogenous and exogenous factors that determine the long-term economic outcome of resource rich developing nations. Rosser (2007) shows that Indonesia's political victory over counter-revolutionary social forces and its geographic location were key variables that enabled Indonesia to experience 6% - 10% real economic growth through the 1970s and 1980s (p. 39). This suggests that endogenous policies and exogenous forces can combine to combat the typically downward long-term economic trajectory of resource rich nations. In his findings, Rosser explains that the promotion and development of capitalist economic relations were key to Indonesia's successful economic trajectory (Rosser 2007, p. 53). A second factor was Indonesia's access to foreign investments and technology, which were aided by its geographical location in the global economy (Rosser 2007). These findings show that, with the right political, economic and social conditions the resource curse can be overcome (Rosser 2007, p. 54). Given the ability for countries to operate in the global market through modern computer technology, developing nations with abundant natural resources whose political leadership is "defined in ethnic, religious, family or tribal terms" must grapple with socio-political issues if they are to overcome the resource curse (Rosser 2007, p. 54).

The trouble with suggesting a cultural shift to a western style democratic system is that it is made from nations who generally display an ethics of autonomy, a moral world made up of individuals who promote individual choice and the pursuit of personal preferences. Many developing nations preserve an ethics of community, seeing the world as a collection of institutions whose purpose is to preserve the moral integrity of community, and an ethics of divinity, which posits a moral world of souls housed in bodies – gifts from God that must be protected against degradation (Haidt & Graham 2007, pp. 102, 103). Accordingly, western social justice is built on a foundation of "care" and "fairness" while developing nations tend to include "loyalty", "respect" and "purity" alongside the other two. That is to say, care and fairness make up 100% of the western social justice foundation while they only make up 40% of social justice ethics in developing nations (Haidt & Graham 2007). The correct way to speak of this can only be poetic, "We measure time according to the movement of countless suns; and they measure time by little machines in their little pockets. Now tell me, how could we ever meet at the same place and the same time?" (Gibran, *Sand and Foam*).

Social theory has made several worthwhile attempts to understand this phenomenon. Durkheim wrote about anomie and the transition from mechanical to organic solidarity (Durkheim 2012), In his *Protestant Ethic,* Weber analyzed differences in economic development in Catholic and Protestant communities (Weber 2011), Eisenstadt looked at multiple modernities and more recently Henrich & Norenzayan (2010) highlighted these differences with their research on the "WEIRDest" people in the world - Western, Educated, Industrialized, Rich, and Democratic. These analyses all address transitions to modernity that occurred during and after the industrial revolution. Western liberalism is often confused by morals based on ethics of community and divinity, because there is an "invisible wall" preventing loyalty, respect and purity to be understood as a foundation of morals (Haidt & Graham 2007, pp. 103, 111). As a result, there are fundamental differences in they way various cultures define terms like value and nature – and we, in the west, are the WEIRD ones.

In addition to allowing developing nations to define value and nature on their terms, localized knowledge of environmental conditions must be considered when applying endogenous national policies for resource exploitation and climate change. Atran, Medin & Ross (2004) show that populations with an impoverished experience with nature are ill-equipped at tackling environmental issues. Their research suggests that western educated scientific thinking pales in comparison to uneducated rural members of society in their understanding of nature. As in the case of China (discussed below), micro level data from rural communities regarding changes to the environment enable policy makers to push legislation that is ultimately beneficial at the macro level, even if their reasons are based on selfish political gain.

Complexity and evolutionary economics show that microlevel events emerge into the macrolevel environment. In their analysis of a valuation perspective on social change and climate change in China, Engels & Wang (2018) show that agents of social change are indirect sources reacting to different social dynamics (p. 117). Independent localized responses to climate change at the micro level led to emergent political changes in the macro. The Chinese government began to establish policies to combat air pollution in order to maintain political stability. A national political reaction to localized public concern over air pollution was made possible through China's increasing access to micro level data. Although this is only one example of the benefit data can have for developing nations, it serves as an important example of the need to increase global access to big data. There are other examples, but for the purpose of this essay it is more important to define what it means to talk about data and information as a tool for economic growth in developing nations.

Claude Shannon (1948) revealed that one binary unit (bit) of information cuts uncertainty by half. The process is elegant. Listing the letters of the alphabet, Shannon showed that he could transmit information regarding a single letter to another individual in five bits of information. Answering yes or no to the binary question, "is the letter in the top section?" divides the alphabet and reduces uncertainty by half. Repeating the question halves uncertainty again and after five successive binary questions regarding the top or bottom location of the letter information transmission for the specific letter is completed.

The common assumption that organisms evolve and develop along patterns that are only recognizable in retrospect needs revision. Evolution and natural selection are a canalizing process; development is not determined through biological mutations alone. Martin Hilbert (2013) combined the Price equation (George Price 1970, 1972) and Shannon's entropy and mutual information with information metrics, (Fisher 1930, 1958[1]; Kolmogorov 1941; Kullback-Leibler,1951; Massey 1990, 2005) to quantify growth in relation to information density. He shows that optimal economic growth is derived through a combination of informed intervention and blind natural selection. What this means is, an organism evolving into an environment suitable for the next mutation is essential for positive growth.

[1] Hilbert uses the 1930 first edition of *The Genetical Theory of Natural Selection*. I use the 1958 second edition.

Before moving on to a discussion on data and forecasting, it is important to address a common temporal misconception. A confusing aspect of forecasting involves present and future knowledge. Forecasting does not project forward from the present into the future, at least that is not its primary function. Using past data, it is possible to forecast conditions that determine the future value of present action. In other words, the purpose of forecasting is to travel backward from the future to determine the future value of action in the present.

Insight into the future environment gives those with information an evolutionary advantage. If a nation divides its resources among several possibilities, the distribution will be an even split – R/P, where R is total resources divided by P, the number of possibilities. Given one bit of information the set of possibilities is reduced by half, while the number of resources remains unchanged – doubling the number of resources devoted to each of the remaining possibilities. Allowing total resources to be devoted to half of the original set doubles the opportunity to make the correct decision regarding the allocation of resources. The simplified equation for this is:

1 bit = 0.5(uncertainty) = 2(growth)

Therefore, the more bits of information a nation has, the greater its chances for positive economic growth until R = P, where 100% of available resources are devoted to a final remaining possibility.

The distribution of digital technology has resulted in the one-way communication of data. The universalization of digital devices ended stage one of the "digital divide," but there is a second, growing, divide in terms of information capacity (Hilbert, 2014). In 2001, the divide in digital devices, the real number of technological devices capable of transmitting information, between OECD countries and developing nations was 1.2/0.2 = 6; in 2006 the divide was 1.5/0.5 = 3. This shows the divide among digital devices was shrinking. However, in terms of information capacity, in 2001 the divide in kilobits (kbps) per person was 50/5 = 10, and in 2006 the divide was 700/50 = 14 (Hilbert 2014). This means that while the divide with regard to devices is shrinking, the divide in information capacity is growing. From Hilbert (2013), we can see that, in terms of growth based on information, the possibilities for economic growth in developing nations compared to OECD countries are shrinking.

It is important to understand this issue from an economic perspective. Looking at the data revolution through an economic lens we can say that aggregate output is equal to the sum of capital and labor. Today, we can add digital capital and digital skills to this formula, plus some residual data output, which is not quantified in traditional economic models. The difficulty is in the means of applying residual data outputs into economic growth models. The danger of including digital capital without including digital data is explained though Hilbert's example of the shrinking digital capital divide and the increasing divide in residual digital data.

Global climate policies are historically ineffective; each nation prefers to apply its own policy based on its own economic and political self-interests. Therefore, a policy among OECD nations that seeks to shrink the digital divide is essential for establishing effective climate policies at the national level in non-OECD countries. Put simply, although independent nations prefer to generate policies based on their own self-interest, local policies made using shared global data regarding global climate change and local environmental issues will lead to a more standardized overall aggregate climate policy.

James Beniger (1986) published *The Control Revolution and* coined the term, which is defined as the "complex and interrelated sequences of rapid change in the technological and economic arrangements by which information is collected, stored, processed and communicated" (Beniger 1992, p. 12). His research focused on long standing policies regarding the assimilation of information as a method of control. There is a gap in academic research combining early ideas pertaining to communication in bits of information, the relationship between information and economic growth and the increasing divide between OECD countries and developing nations in their access to information and informational capacity. Research into this field is necessary for the development of OECD climate policies if we are going to bring developing nations into the mix.

Limited access to climate information has had lasting effects on developing nations throughout all sectors of their economies, and there has been an increasing call from researchers and informed policymakers to investigate the potential causes of environmental migration, future risks posed by climate change, and the role of migration within broader processes of adaptation. Researchers (Piguet 2010; Bates 2002; Gemenne 2011; Warner 2010) suggest a larger focus on empirical research in a field that has often been normative in scope. In order to develop empirical research into the effects of climate change, global policies must insist on an equitable and global dissemination of information.

This essay proposed the equitable distribution and use of data as a tool for reducing poverty in resource rich developing nations. Using the Hotelling and Hartwick rules, I showed how nations can determine if and when to engage in resource production and how to distribute economic gains across generations in a socially responsible way. Developing nations can avoid the resource curse from endogenous and exogenous forces, and I provided support for the application of data to mitigate these difficulties. I introduced methods for the use of technology and big data to determine the micro level concerns of large populations to inform macro policy decisions and to customize each nation's response to global concerns over climate change.

The way knowledge is accumulated produces asymmetries and inequalities that determine what can be known and who is allowed to know it. Additionally, western economic modeling is performed in and on a cultivated environment. Many parts of the developing world remain uncultivated by western standards. It is easier to plan for events in an ordered environment. We cannot order the world, but we can provide it with data. With access to data, each nation will be empowered to generate their idea of wealth, measured either in dollars, the maintenance of the environment, or both.

Discussing the future of developing nations in terms of natural resources necessarily includes thinking on future outcomes, and future predictions. Considering the environment, a living thing with natural resources, it is essential to understand that nature evolves. We are living beings, humans, extant in a living thing, nature, and as humans we have determined that a number of aspects of the natural world are economically useful for production. Understanding how these resources can be used in a way that promotes the equal distribution of economic gains across the current population while preserving gains for future generations and maintaining the environment is essential for long-term economic growth in resource rich developing nations, and it this all begins with data.

References

Atran, S., Medin, D., & Ross, N. (2004). Evolution and devolution of knowledge: A tale of two biologies. *Journal of the Royal Anthropological Institute*, *10*(2), 395-420.

Auty, R. (1993). Sustaining development in mineral economies: the resource curse thesis. *London: Rout-ledge*.

Bates, D. C. (2002). Environmental refugees? Classifying human migrations caused by environmental change. *Population and environment*, *23*(5), 465-477.

Beniger, J. (1986). *The control revolution: Technological and economic origins of the information society*. Harvard university press.

Beniger, J. (1992). Communication and the Control Revolution. *OAH Magazine of History*, *6*(4), 10-13.

Durkheim, E. (2012). *The division of labor in society*. Mansfield, CT: Martino.

Engels, A., & Wang, C. (2018). The Value of a Valuation Perspective for Theorizing about Social Change and Climate Change. *Valuation Studies*, *5*(2), 93-130.

Fisher, R. A. (1958). The genetical theory of natural selection. *The genetical theory of natural selection.*, (2nd Ed).

Gemenne, F. (2011). How they became the human face of climate change. Research and policy interactions in the birth of the 'environmental migration' concept. *Migration and climate change*.

Gibran, K. (n.d.). Sand and Foam. Retrieved March 21, 2021, from http://wwwpersonal.umich.edu/~jrcole/gibran/sandfoam/sandfoam.htm

Haidt, J., & Graham, J. (2007). When morality opposes justice: Conservatives have moral intuitions that liberals may not recognize. *Social Justice Research*, *20*(1), 98-116.

Hartwick, J. M. (1977). Intergenerational equity and the investing of rents from exhaustible resources. *The American economic review*, *67*(5), 972-974.

Henrich, J., Heine, S. J., & Norenzayan, A. (2010). The weirdest people in the world?. *Behavioral and brain sciences*, *33*(2-3), 61-83.

Hilbert, M. (2013). Linking Information, Knowledge and Evolutionary Growth: A multilevel interplay between natural selection and informed intervention. *Knowledge and Evolutionary Growth: A Multilevel Interplay between Natural Selection and Informed Intervention (April 15, 2013)*.

Hilbert, M. (2014). Technological information inequality as an incessantly moving target: The redistribution of information and communication capacities between 1986 and 2010. *Journal of the Association for Information Science and Technology*, *65*(4), 821-835.

Kolmogorov, A. (1941). Interpolation and Extrapolation of Stationary Random Sequences (Selected Works of AN Kolmogorov), V. Tikhomirov, Ed.

Krautkraemer, J. A. (1998). Nonrenewable resource scarcity. *Journal of Economic literature*, *36*(4), 2065-2107.

Kullback, S., & Leibler, R. A. (1951). On information and sufficiency. *The annals of mathematical statistics*, *22*(1), 79-86.

Massey, J. L., & Massey, P. C. (2005, September). Conservation of mutual and directed information. In *Proceedings. International Symposium on Information Theory, 2005. ISIT 2005.* (pp. 157-158). IEEE.

Massey, J. (1990, November). Causality, feedback and directed information. In *Proc. Int. Symp. Inf. Theory Applic.(ISITA-90)* (pp. 303-305).

Lund, D. (2009). Rent Taxation for Nonrenewable Resources. *Annual Review of Resource Economics*, *1*(1), 287–308. https://doi.org/10.1146/annurev.resource.050708.144216

Piguet, E. (2010). Linking climate change, environmental degradation, and migration: a methodological overview. *Wiley Interdisciplinary Reviews: Climate Change*, *1*(4), 517 524.

Porter, T. M. (2020). *Trust in numbers: The pursuit of objectivity in science and public life*. Princeton University Press.

Price, G. R. (1970). Selection and covariance. *Nature*, *227*, 520-521.

Price, G. R. (1972). Fisher's 'fundamental theorem' made clear. *Annals of human genetics*, *36*(2), 129-140.

Rosser, A. (2007). Escaping the resource curse: The case of Indonesia. *Journal of Contemporary Asia*, *37*(1), 38-58.

Sachs, J. D., & Warner, A. M. (1995). *Natural resource abundance and economic growth* (No. w5398). National Bureau of Economic Research.

Solow, R. M. (1974). Intergenerational equity and exhaustible resources. *The review of economic studies*, *41*, 29-45.

Smith, B. (2015). The resource curse exorcised: Evidence from a panel of countries. *Journal of Development Economics*, *116*, 57-73.

Veblen, T. (1898). Why is economics not an evolutionary science?. *The quarterly journal of economics*, *12*(4), 373-397.

Veblen, T. (2005). *The theory of the leisure class: An economic study of institutions*. Aakar Books.

Venables, A. J. (2016). Using natural resources for development: why has it proven so difficult?. *Journal of Economic Perspectives*, *30*(1), 161-84.

Warner, K. (2010). Global environmental change and migration: Governance challenges. *Global environmental change*, *20*(3), 402-413.

Weber, M. (2011). *The Protestant ethic and the spirit of capitalism*. New York: Oxford University Press.