Utilization of big data analytics in socio-economic impact evaluation on climate response measures

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Abstract. For the past decade, the conversation about climate change has been gaining prominence in the social and economic discourse in Malaysia. This is evident when Malaysia responded positively to the Paris Agreement by committing to reduce Greenhouse Gas emissions by 45% by 2030 in relation to the country’s 2005 GDP. The Paris Agreement is a multilateral environmental agreement under the United Nations Framework Convention on Climate Change (UNFCCC) that compel all signatory countries to focus on greenhouse gas emissions mitigation, adaptation and finance starting in year 2020 as part of the global response in addressing climate change threats. Currently, UNFCCC has acknowledged the need to establish a forum to address the impact of response measures implemented by countries that will be undergoing decarbonizing development in terms of economic diversification and just transition (creation of decent and quality job). This paper will explore the challenges and opportunities to utilise big data analytics in socio-economic models when assessing the impact of a country’s response measures policy implementation.

1. Introduction

In 1997, the Kyoto Protocol was adopted by 192 Parties with the aim to reduce 5% Green House Gases (GHG) from the 1990 levels bound to the developed countries. Following that, a multilateral environmental agreement under the United Nations Framework Convention on Climate Change (UNFCCC) known as the Paris Agreement was adopted by the international community in 2015 with the aspiration to maintain the global temperature rise this century well below 2 degrees above pre-industrial levels. The agreement compels all signatory countries (called Parties) to focus on greenhouse gas emissions (GHG) mitigation, adaptation and finance begging in year 2020 as part of the global response in addressing climate change threats.

Malaysia responded positively to the Paris Agreement by committing to reduce Greenhouse Gas (GHG) emissions by 45% by 2030 in relation to the country’s 2005 GDP. This target was set with 35% on unconditional basis and 10% on conditional basis upon receipt of climate finance funding, technology transfer and capacity building from developed countries. The main GHG emission contributors in Malaysia are the energy industries, transport, manufacturing industries and industrial processes, waste and the agriculture sector. In addition, Malaysia also committed to maintaining at least 50% level of forest and tree conservation.
In order to achieve the ambitious goals as outlined under the Paris Agreement, the UNFCCC secretariat was setup to support all stakeholders involved in the climate change negotiation sessions. The Conference of the Parties (COP) is convened annually to allow Parties to participate in various plenary sessions, preparatory meetings and thematic consultations to negotiate on wide ranging issues with the purpose to advance the work programme for the implementation of the Paris Agreement. The on-going negotiations being discussed extensively were generally divided into several key areas which include mitigation, adaptation, finance, technology, capacity building, economic instruments, transparency of action and support. Generally, the developed countries, which are often the biggest carbon emission contributors, are expected to bear the heavier burden (providing fund, technology transfer and capacity building) in addressing climate change.

2. Discussion

2.1. The Scope of Response Measures on Climate Change

The Kyoto Protocol committed member countries to strive to minimize the possible adverse economic, social and environmental impacts on other countries, particularly the developing countries, when addressing climate change. The response measures were further addressed in the subsequent Bali Roadmap process, the Cancun Agreements and the Durban Outcome before finally institutionalized for the discussion in the Paris Agreement, which provide a basis for addressing the impact of the implementation of response measures. To date, the modalities, work programme and functions under the Paris Agreement of the forum on the impact of the implementation of response measures have placed a heavy emphasis on economic diversification/transformation and just transition of workforce and creation of decent and quality jobs.

The International Centre for Trade and Sustainable Development or ICTSD recommended that forum consider exploring the impact of response measures implementation namely ‘green protectionism’ that could create trade distortion due to emissions trading schemes, cross border carbon tax adjustments (BCA), national subsidies of green technologies and measures, carbon footprint and green labelling schemes and regulation of international transport [1]. Govindasamy shared similar concerns by highlighting that the climate response would affect trade and competition conditions across different sectors that may not be compatible with WTO rules, emphasising the need to develop a tool-box to assess the impact of response measures encompassing green jobs, emissions trade, carbon tax, energy efficiency standards, green labelling and subsidies [2].

To better evaluate and understand the consequence of response measures, this article will explore the data linkages and possible deployment of big data analytics between the following climate response measures with trade and industry developments:

2.1.1. Green Jobs Potential.

The International Labour Organization (ILO) has defined green jobs as occupations that serve to preserve, restore and enhance environmental integrity. The US Bureau of Labour further defined renewable energy, energy efficiency, pollution reduction and removal, GHG reduction, recycling, natural resources conservation and environmental compliance, education and training related goods and services as part of green labour force that are essential to a growing sustainable economy.

To date, the Input-Output (IO) analysis and Social Accounting Matrices (SAMs) are the most widely used empirical tools in assessing green jobs creation. These models would employ a matrix/table to list relevant sub-sectors by linking outputs from one sector as an input to another. By evaluating the labour intensity of an identified sector in a particular value chain, the model would be able to determine the impact of the increase in green service/product on employment. Furthermore, the empirical data obtained from I-O analysis or SAMs could be carefully designed by combining with
a series of economic equations to fully explore the effect of climate change response measures on future green employment scenario [3].

The data sets involved in a typical I-O analysis for job measurement would entail sales and purchase made by a specific sector (total purchase value per unit production), GHG emissions, fluctuating demand of green services/products, number of employees per sector and average wage rate [4]. However, Bowen and Kuralbayeva had cautioned that green policies may affect labour markets indirectly through supply chains and market demand changes such as elimination of non-green jobs from polluting industries and rising cost of employment for green compliance purpose [5].

2.1.2. Green Labelling

Green labelling or energy-efficiency labelling summarised a manufactured product’s energy performance, thus allowing consumers to make an informed purchase while indirectly encouraging competition among manufacturers and retailers to innovate and market the most energy-efficient products. As an effort to encourage economic sustainability, some governments have considered imposing energy-efficiency standards by prohibiting the sale of products that are unable to fulfil the minimum standards threshold [6].

Cohen and Vandenbergh listed the following five main principles for an efficient green labelling screening methodology [7]:

a) Able to identify goods where changes in consumption (either substitution or reduced usage) would reduce carbon emissions significantly;
b) Able to account for the costs involved for information gathering;
c) Able to capture the carbon footprint of each step in the product’s life cycle including production, transport, storage, sales, consumption and disposal.
d) Able to accommodate the behavioral plasticity of consumers purchasing a carbon label product with a new implicated cost; and
e) Able to account for those goods (e.g. polluting vehicles) that would greatly incentivise firms to pursue green labelling.

The illustration below highlighted the full extent of the measurement scope for green labelling specifically environmental analysis (GHG emissions), utility analysis (energy consumption) and manufacturing analysis (employment and cash flow).

![Figure 1. Measurement Scope for Green Labelling.](image-url)
2.1.3. Cross Border Impact on Trade

According to IISD, there has been little progress or experience to date concerning the assessment of cross-border impact following the response measures implementation including carbon cap-and-trade schemes and green tariffs [8].

The United States Environmental Protection Agency defined cap-and-trade schemes or ‘emissions trading’ as one of the environmental protection approach by placing a limit (cap) on pollution for individual emissions sources and authorising tradable allowances that are equal to the emission limit of pollutant. The approach is market based in nature thus allowing the emission sources to freely buy and sell the allowance depending on their own compliance priority [9]. The assessment parameter for the scheme is mainly categorized into three areas namely:

a) Environmental Assessment – Evaluation of emission, ambient air concentrations, atmospheric pollutants related data.
b) Economic Assessment – Evaluation of environmental preservation, human health benefits and costs of compliance.
c) Market Assessment – Evaluation of allowance activity (e.g. number of transactions that occur) to ascertain economic benefits and costs of emission reduction target.

Green tariffs encourage customers to procure renewable energy in a collaborative arrangement between designated users and utility company, either through a subscription mechanism or direct purchase agreement for lower cost of electricity. Belcher and Sunkara elaborated that an effective green tariff framework would entail the following contracting and rate mechanism [10]:

a) Framework for efficient cooperation – Users will be involved more in the negotiations on pricing terms via sleeved power purchase agreements, providing financial certainty for the utility company to pursue renewable facilities financing project.
b) Phasing and renewable intermittency – Utility company will align the actual cost, with real time or seasonal variability, to reflect the intermittent nature of renewable energy sources.
c) Cost recovery – Users would be required to pay their fair share of the renewable resource cost with basic energy rate (based on consumed energy) and separate ‘surge demand charge’ to cover additional costs as well as increased rate adjusting to new technology adoption/deployment.

2.2. The Role of Big Data Analytics on Response Measures Implementation

Big data refers to large data volume, often unstructured, that inundates an organisation on daily basis. The big data concept first gained prominence in 2001 when Laney articulated and defined big data with three Vs [11]:

a) Volume – Large data sets (in terabytes) are collected from various sources including social media, financial transactions and sensor/machine registered information.
b) Velocity – Real time data collected with unprecedented speed including smart sensors and RFID tags that often require time-sensitive analysis.
c) Variety – Heterogeneous data collected in different forms or formats including email, video, audio and text documents.

Gaghmous and Kumar heralded the arrival of big data research that would bring forth novel data, methods and evaluation challenges to climate science that simultaneously require theory-guided data science methods to provide insightful climate data findings [12]. Accordingly, the sheer amount of data obtained from diverse sources could present significant challenges when one attempts to connect and correlate multiple data linkages. Labrinidis and Jagadish explained that the overall process involved in extracting insights from big data comprise two key processes namely data management (data storage and retrieval) and analytics (analysis and interpretation) [13].
The following table attempts to summarise the different data sets that fulfil the afore-mentioned 3Vs criteria and would require big data analytical tool-box to correlate climate change policy with the identified response measures:

| Response Measures                  | Data type/characteristics | Volume | Velocity | Variety | Source of data                                      |
|-----------------------------------|---------------------------|--------|----------|---------|---------------------------------------------------|
| **Green Jobs**                    |                           |        |          |         |                                                   |
| Energy Consumption Cost           | √                         | √      | √        |         | Energy bill encompassing the product life cycle from different energy sources. |
| Service/ Product Demand          | √                         | √      | √        |         | Production Report                                  |
| GHG emission                     | √                         | √      | √        |         | GHG Inventory, NRE                                 |
| Wage Rate                        | √                         |        |          |         | Labour Dept. Statistics                           |
| Employment Numbers               |                          | √      |          |         | Labour Dept. Statistics                           |
| **Green Labelling**              |                           |        |          |         |                                                   |
| Energy Consumption Cost           | √                         | √      | √        |         | Energy bill encompassing the product life cycle from different renewable energy sources |
| Service/ Product Demand          | √                         | √      | √        |         | Production Report                                  |
| GHG emission                     | √                         | √      | √        |         | GHG Inventory, NRE                                 |
| Employment Numbers               |                          | √      |          |         | Labour Dept. Statistics                           |
| Cash Flow for Manufacturers       |                          | √      |          |         | Sample financial statements from manufacturers    |
| **Cap-and-Trade Scheme**         |                           |        |          |         |                                                   |
| GHG emission                     | √                         | √      | √        |         | GHG Inventory, NRE                                 |
| Environmental preservation       | √                         |        |          |         | Environmental Impact Assessment Report            |
| Human Health Benefits            | √                         | √      | √        |         | Health Statistics, MOH                            |
| Cost of compliance               | √                         |        |          |         | Manufacturer’s compliance record                  |
| Allowance Activity               |                          | √      |          |         |                                                   |

Figure 2. Big Data Processes.
Green Tariffs

| Parameter         | Energy Consumption | GHG Emission | Energy bill encompassing the product life cycle from different energy sources | GHG inventory, NRE |
|-------------------|--------------------|--------------|--------------------------------------------------------------------------------|-------------------|
| Cost              | √                  | √            | √                                                                              |                   |

As illustrated above, many of the response measures share similar parameters and data sets particularly energy consumption cost, GHG emissions and service/product demand that fulfil the big data 3Vs criteria namely volume, variety, velocity. In this regard, big data analytics would allow stakeholders to track the vast troves of vital information such as production capacity and cost (‘volume’), examine the energy consumption and GHG emission granularly (‘variety’) in real time (‘velocity’).

The establishment of a centralised data analytics structure to deposit the above shared data set would allow relevant stakeholders evaluate the overall impact of climate response implementation simultaneously on green jobs, green labelling and green tariffs. Moreover, a carefully constructed data analytic methodology including storage, scrubbing (transform information into readable dataset), profiling (end-to-end inventory of metadata), mapping (information flow), analysis (measuring of impact), visualisation and compliance of data would provide an outline of the sector’s overall green performance in an aggregated manner [14]. By carefully studying the analytical results with in-depth understanding of the data linkages and interoperability, stakeholders will be able to evaluate the impact of response measures and adjust policy strategies in a fast changing climate environment.

3. Summary

The transformative impact of big data analytics is poised to alter the conventional data analysis by obtaining valuable insights concerning the correlation between climate risk and impact of the response measures implementation. By integrating a big data infrastructure with cross-border trade, industry performance, energy utilization and green job related database analytic modelling, the relevant stakeholders will be able to implement evidence-based climate policy decisions while limiting the adverse consequences arising from such measures. Aside from maintaining the momentum of sustainable development, countries will stand to benefit by developing better insights and positions while pursuing future climate change negotiations.

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