The Level Playing Field

Business of Weather, Water, and Climate Services

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Abstract

Efforts to improve weather and climate services involve both public and private actors in the meteorological value chain governed by two determinants—to protect society from the impact of extreme meteorological and hydrological events and to increase economic activity in range of weather sensitive sectors. As well as the public tasks of the National Meteorological and Hydrological Services (NMHSs) such as public safety, some governments increasingly expect their agencies to provide a return on capital employed by competing for commercial services with the private sector. While this has largely been an issue in developed economies, governments in many low- and middle-income countries are considering similar approaches without necessarily understanding the impact on their nascent meteorological services markets. This poses many risks, the biggest of which are the disruption and distortion of the market through anticompetitive practices that can stymie its growth and reduce benefits to the economy, and an overemphasis on commercial activities that can detract from the public tasks of the NMHS mandate. Therefore, creating a level playing field on which both public and private actors can operate and compete is critical. This technical note highlights some of the benefits of competition to both the private and public sectors and provides recommendations on what policy and structural reforms are needed to develop the business of weather, water, and climate services.

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Introduction

Opinions differ on the best way to develop the global weather enterprise (National Research Council 2003; Rogers and Tsirkunov 2013; World Bank 2019). The nature of the relationship between the public and private sectors is changing because of scientific, technological, and organizational innovation (Thorpe and Rogers 2018). Any effort to improve weather and climate services further must explicitly consider the role of both the public and the private sectors throughout the value chain—from the delivery of observations to the provision of services to end-user customers and clients (Thorpe and Rogers 2021). While markets for weather services have existed for some time in advanced economies, governments in low- and middle-income countries (LMICS) are beginning to push their NMHSs in the same direction without necessarily fully understanding the risks and opportunities of this approach. Working with other development partners, the World Bank Group (WBG) is helping LMICs expand their range of options and solutions to sustainably grow their economies, reduce poverty, and expand opportunities. While countries have unique needs, the WBG is helping find the right mix of public and private funding to meet their development objectives,[1] which are to improve their ability to achieve their public safety related tasks and to provide guidance on building effective weather services markets.

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The 17th World Meteorological Congress in 2015 gave a new perspective to public–private engagement by acknowledging the growing involvement of entities belonging to the private sector—private companies, citizens' associations, bloggers—in weather, climate, water, and related environmental matters. Since then, the Members[2] of the World Meteorological Organization (WMO) have highlighted the different, and at times, complementary roles and responsibilities of National Meteorological and Hydrological Services, academic institutions, research and technological agencies, and the private sector. They felt that closer interactions between the public and private sectors would stimulate innovation and facilitate cross-fertilization, benefitting society.[3] This was reinforced by the Geneva Declaration[4] of the 18th World Meteorological Congress in 2019 that aims to strengthen links further between public, private, and academic sectors so that countries can better tackle the risks related to extreme weather, climate, water, and other environmental events.

Previous publications have focused on various aspects of the development of NMHSs (Rogers et al. 2019) and their relationship with the private sector (Rogers et al. 2020, 2021a, b). These emphasized ways to increase the capacity of NMHSs in LMICs to provide higher quality public services and did not consider in any detail the potential role of NMHSs in fostering and participating in economic activities. Since many NMHSs also provide commercial services, it is important to explore how public and private actors can both engage in the market and how to ensure that competition is fair and of social and economic benefit to society. The *Power of Partnership: Public and Private Engagement in Hydromet Services* report (World Bank 2019) recommended minimizing the role of public entities in the provision of nonpublic services when the private sector is able to provide them or, if that is not possible, ensuring a level playing field for all participants. We further examine this issue by analyzing which structures of a national weather market enable both public and private sector actors to contribute most effectively to the production of high value weather information, in particular, by establishing a level playing field.

Many countries have established national meteorological services as public entities that can also provide commercial services either as a state-owned enterprise (SOE) or as an additional activity within a government institution, which primarily carries out a public task.[5] In practice, whether the entity is an SOE or a government-operated institution, problems can arise when both commercial and noncommercial activities are pursued within an integrated platform (Christiansen 2013). Some crucial questions surface because of these issues:

- Do commercial activities need to be owned or be performed by the state?
- Is the government-owned entity competitively neutral or does the state subsidize its competitive activities?
- Is there any mechanism to transfer some commercial activities from the public to the private sector?
- Does an appropriate regulatory body oversee commercial activities of the public and private actors?
- Which body monitors sufficient transparency and accountability to ensure that the interests of the public and other users are properly represented?

A well-defined role distribution between state and commercial companies can drive innovation in certain areas if otherwise public goals are not achievable by market mechanisms only. The space industry in the 1960s was one example, while challenges through climate change in the coming decades could be another one. A proactive approach by the state can shape a market to drive innovation if the state is ready to play a large scale entrepreneurial role in new areas. Integrating more commercial actors once market mechanisms have been developed can then be a second step. The free exchange of public data can be one of the conditions that a regulating authority would have to set for meteorological services (Mazzucato 2013).

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The creation of SOEs or the provision of commercial services by government-operated institutions is often justified on the grounds of efficiency whereby following commercial practices is expected to create better managed government entities.[6] Sometimes, moving financial responsibility for the provision of a public service to a semiautonomous agency rather than retain it within central government department can seem attractive. In this case, the agency is expected to provide services more efficiently and more importantly, at lower cost to the state than would be expected through direct budgeting and make up any shortfall by generating commercial revenue.

A government department or agency should benefit from participating in a commercial market if the process of competition leads to improvements in the products and services they create. In turn, this can have a positive impact on the noncommercial services provided as part of their public task. However, attempting to provide commercial services could risk detracting from the core public task and result in weaker public services. Care must, therefore, be taken in any effort to balance commercial and public activities within an NMHS.

From the perspective of the private sector, the main consideration is likely to be that a conducive market for weather services is created in which competition is fair whichever organization, public or private, takes part in commercial activities. In addition, companies need to be able to benefit from unfettered access to public meteorological data that

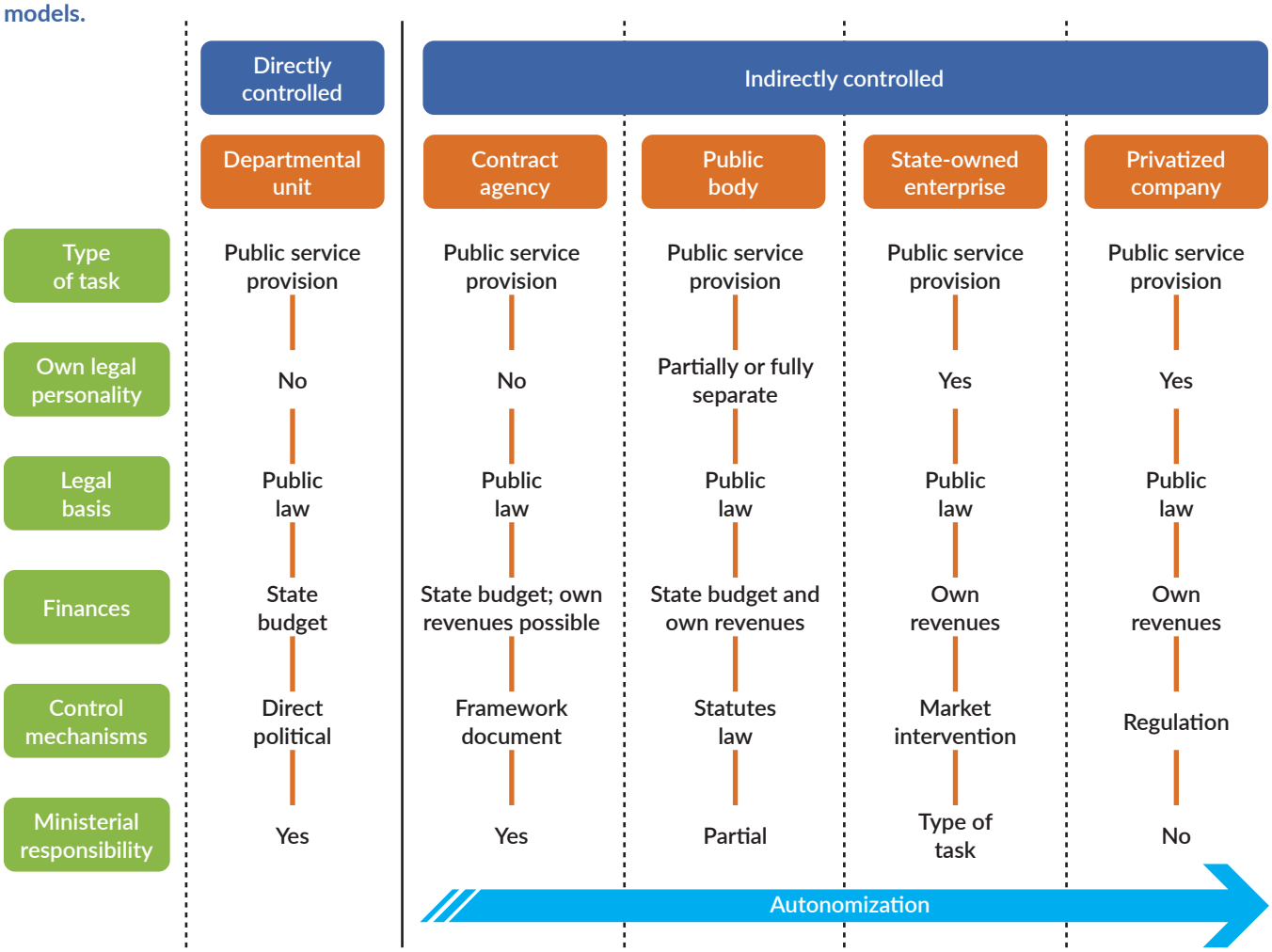
enables them to add further value. Clarity in and stability of any regulations that apply to national weather markets are also fundamental in providing the right incentives for companies to enter into and contribute to that market. The benefits of a vibrant private sector in weather services include aspects such as job creation, corporate tax revenues, and stimulation of innovation through competition or cooperation or both.

With a goal of understanding the factors that need to be in place to establish a fair, effective, efficient, and competitive weather market, this technical note focuses on the role of the government in creating a level playing field and how the market is affected by the operating structure and commercial activities of the NMHSs. It considers aspects of competition law and how the law is applied in different jurisdictions; it assesses good and problematic practices and provides some recommendations on the provision of public sector undertakings and how these could positively impact the development of both the public and private sectors within the weather, climate, and water services market.

Operating Models for NMHSs

Rogers and Tsirkunov (2013) defined five NMHS operating models: departmental unit; contract agency; public body; state-owned enterprise; and private company (Figure 1).

Figure 1. Five NMHSs' operating models.



Source: Rogers and Tsirkunov 2013. Adapted from Gill 2002; Greve, Flinders, and Van Thiel 1999.

Note: The first four models can work with privatized companies as public-private partnerships.

Each of these five models has trade-offs.

- **The departmental unit** is the simplest model to implement. Financed by the state budget to deliver noncommercial services to the public or support other government bodies, it does not have an independent legal personality, meaning that it does not have the capacity in its own name to enter into contracts, to hold property, to open a bank account, or take or defend legal proceedings. Salaries of a departmental unit will generally be restricted to civil services pay scales, meaning that remuneration may not be used to reward risk-taking initiatives or to compete with the private sector. And under this model, any revenue generated from commercial activities is typically payable directly to the central treasury bank account and cannot be used for strengthening or funding meteorological activities or rewarding good performance. Consequently, a feature of this model is the total dependence on a single source of income to maintain services. In cases where the government funding is insufficient or reduced, deterioration or reduction of services are inevitable. At the same time, adequate public funding can guarantee strong public weather services. Approximately forty countries use this model (Rogers and Tsirkunov 2013).
- **Contract agencies** have more autonomy, but they still have a strong hierarchical and financial relationship with their parent department. The Federal Office of Meteorology and Climatology (MeteoSwiss), which is part of the Swiss Federal Department of Home Affairs, is an example of this model. Depending on their organizational structure, contract agencies may generate their own revenues. However, they operate under public law and do not have their own legal personality (Gill 2002).
- **A public body** operates at arm's length from the central government. They have less political and hierarchical influence and have more operational and managerial freedom. Public bodies are also established on the basis of public law but in comparison with contract agencies and, depending on their level of autonomy, have a partially separate or fully separate legal personality (Greve et al. 1999). They may, however, be entitled to conclude contracts for the provision of services in accordance with private law. Governments usually refer to the additional discretionary funding mechanisms as commercial, although exclusivity normally associated with commercial activities is lacking (Rogers and Tsirkunov 2013). Even if the government is still responsible for public services, the goal is to shift the complexity of service provision to the public body. Some form of commercialization is often practiced in public bodies and as a result they are organized at arm's length from the government (Van Thiel 2012).

  In Europe, the enthusiasm for developing public sector commercial services has been strongest in France, the Netherlands, Scandinavia, and the UK with varying degrees of success (Rogers and Tsirkunov 2013). This has prompted many other governments, particularly in Africa, to transform their meteorological departments into public bodies to increase their capacity to make strategic and tactical decisions, particularly budgetary decisions.

  Another feature of the public body model related to their ownership by the particular government department on which they depend, is the relationship with other government departments. Services provided by the public body may be sold to other government departments. The owning department may require the public body to return an annual dividend to them. When the public body is contracted by other government de-

The public sector cannot, on its own, provide the range of commercial weather and climate services required in most countries.

partments, the financial return is, in effect, an overcharge if it contributes any dividend to the owning department. The emphasis on receiving income from multiple contracts to maintain services also has potential problems. Unless there is sufficient long-term financing from one source, it may become difficult to maintain infrastructure, such as observational networks. Another risk is the potential to distort the commercial market limiting its potential as an engine for economic growth. Good business management, accounting, and auditing practices are essential.

- **State owned enterprises** are a critical element of public service provision in a number of countries (Gill 2002). SOEs generally have the same legal status as private firms, the only difference being that some or all of the shares are owned by the state. They operate under private law and have their own independent legal personalities. SOEs are often found in the fields of postal service, railways, or power supply or other strategically important sectors. Sometimes SOEs are a halfway house on the path toward the eventual privatization of public bodies. Similar to public bodies, SOEs have to fulfil tasks assigned to them by government and are controlled through market interventions. Ministerial responsibility is limited to regulatory, strategic, and financial decisions, largely by reason of the fact that the state is the main or sole shareholder and, therefore, has the right to appoint the members of the management board or to control the annual general meeting. SOEs are usually financed by their own revenues (Gill 2002), but some are subsidized by government, especially investment intensive public services. The responsibility of an SOE is to operate as a successful business—to be profitable and efficient, to be a good employer, and to exhibit a sense of social responsibility. A significant downside to this model is the transfer of control of observational networks from the government to the SOE.

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MetService, New Zealand, was the first and only example to date of an SOE providing public meteorological services. When the government of New Zealand created MetService, it transferred the weather observations network to the SOE effectively commercializing the observing system. A recent report by PricewaterhouseCoopers (PwC),[7] commissioned by the Ministry of Business, Innovation and Employment and the Treasury in New Zealand found that weather data was more restricted than in other countries owing to the requirement to earn commercial revenue to support data collection networks and their operating costs.[8] The report highlighted that the New Zealand model is at the most commercial and restrictive end of cost limitations on data use,[9] which has a negative impact on the development of the market. At the same time, it also indicated that New Zealand has low public expenditure in funding weather services. The report did not consider the potential economic value of a more open market but highlighted the number of sectors that would benefit from access to open meteorological data, which, in turn, would increase competition for services. The same issues face many governments and if it is concluded that open data fuels economic development (Rogers and Tsirkunov 2021), as most do, then government will have to make a greater financial contribution to national meteorological and hydrological observing networks.

- The final model, **a private company**, is one step beyond the SOE in that they are fully responsible for their performance. They operate freely in the market and generate their own revenues although economic activities are controlled to a certain extent by regulations (Hughes 2003). It is widely accepted that governments should not own

companies in the private sector, such as financial services or industry. However, the situation is different for public services where opinions regarding privatization diverge (Bourguignon and Sepúlveda 2009). An example of privatization in the field of NMHSs occurred in the Netherlands where the Royal Netherlands Meteorological Institute (KNMI) privatized its commercial interests into the Holland Weather Services with KNMI reverting to fulfil the role of a government entity closer to the departmental model (Rogers and Tsirkunov 2013). Although our original analysis focused on privatization (Rogers and Tsirkunov 2013), the category applies also to any private firm contracting weather services to the government as client.[10]

The variety of operating models for NMHSs is matched by an equally varied ownership within government including ministries of environment, transport, business, science, agriculture, defense, communication, and education. Still others report directly to a state council or equivalent body. The push toward more autonomy appears to be driven primarily by a desire on the part of government to increase efficiency in the delivery of public tasks and increasingly to create a return on investment to offset expenses. Difficulties arise if this strategy distorts or limits the development of the market. Managing these risks requires an appropriate legal and regulatory framework.

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Seen from a global perspective the provision of data from all parts of the world and the necessary international exchange of data is the most important basis for successful numerical weather prediction models. Mechanisms to achieve this go beyond individual national data policies and have to be organized on a global scale. Funding of such mechanisms through a larger community of countries would have to find the right balance between the limited capacities of certain developing countries and the economic benefit for the global economy.

Data Management

In practice, regardless of the governing model, many NMHSs engage in some form of undertaking[11] including from the sale of observational data, model output data, and value-added services. The European Union (EU) identifies meteorological data—historical, real-time, and model output—as high value, which should be made available free of charge, in machine-readable format and via application programming interfaces (APIs), and where applicable, as a bulk download (Rogers and Tsirkunov 2021, Thorpe and Rogers 2021). Similar policies are gaining traction in many countries, reflecting the realization that open data have a significant economic and social value when used as widely as possible (World Bank 2017b). As exemplified in New Zealand, this may put the NMHS's existing business model at odds with the state's aspiration to support open data. Recent changes in the meteorological law in Germany allowed Deutscher Wetterdienst—the German weather service (DWD)—to revert to focus exclusively on its public task[12] and to make all of its data associated with that task freely available in line with the EU directive on open data.[13]

The sale of meteorological data by the NMHSs is often a result of underfunding of their public task and in some cases, it is a governmentwide policy to recover the marginal costs or more of making data available among agencies. Since the cost of making data available in machine-readable formats is negligible, this latter practice is decreasing. However, underfunding remains a stubborn issue.

Public data, which the NMHSs make freely available, are generally equivalent to the commitments made to the WMO to share data for the global public good (Rogers and Tsirkunov 2021, Rogers et al. 2021a). However, modern techniques provide forecasts at much higher resolution than was foreseen when the original data sharing agreements were made, and efforts are underway to oblige countries to share more higher temporal and spatial resolution data in support of the global public good. But access to the bulk of the data collected by the NMHSs at these high resolutions remains limited or restricted.

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In most countries, the high capital costs of national weather, climate, and hydrological observational networks create a natural monopoly that is operated by an NMHS under any one of the models previously discussed. Contract agencies, public bodies, SOEs, and private companies require regulation to prevent them from exploiting the benefit of the monopoly by restricting access to data or inflating prices. In a few countries, the government monopoly is coercive, granting permission to the NMHS to be the sole provider of data, excluding potential competitors by law, regulation, or other mechanisms of government enforcement. However, the collective consumption of weather, climate, and hydrological data by society suggests that they could be treated as public goods and economic products since they underpin a state's security and economic development. It may be in the economic interest of governments to provide these goods especially observations, but model products also, through taxation rather than the market and to allow the market to provide value-added services that build on these basic public goods (Martin and Anderson 2005). This latter approach is exemplified by the national weather enterprises in the USA, Japan, and Germany where the private sector provides a broad range of specialized services. However, many governments hope for even greater economic returns by pursuing a more liberal market structure in which actors from the public and private sector can, in principle, contribute to all aspects of the value chain.

Data from observations and models are essential inputs to the production of value-added services for a wide variety of industries, and increasingly for artificial intelligence (AI) created innovation. Creating a competitive market for services is key to innovation and fair pricing whether the services purchased are supplied by a public entity or private firm. Commercial weather services generally fall in two categories: tailored services and business data integration (World Bank 2019). The latter is an increasingly important aspect of productivity where weather intelligence is blended with business information. Several examples come to mind, including: (i) the integration of weather data and navigation data to develop an AI ship-routing service that optimizes real-time decision making, improving efficiency and safety in the maritime industry (Rogers et al. 2021b); (ii) the integration of real-time and historical weather data within a fire-risk algorithm that blends information on available fuel, fire movement, and spread rate; and (iii) the integration of weather intelligence for predictive demand control and inventory optimization control in the energy sector. Each of these applications and many others depend on real-time, machine-readable weather data that can be blended seamlessly with other information to create new insights and tools. The opportunities are significant and varied but still fundamentally depend on access to observational weather data and results of numerical weather prediction shared in real-time.

Another innovation, which is altering the relationship between government and the private sector, is CubeSat.[14] This satellite technology has created opportunities for the private sector to develop, for example, tracking services for a variety of marine and aviation

applications and obtain satellite navigation radio occultation measurements of pressure and temperature for weather forecasting. The latter is made available to the meteorological community as a fee-based service. As this is an example of a prevailing and emerging technology, it is inevitable that only a few providers operate, and hence, encouragement is needed for companies to enter the market and not be discouraged because of perceptions of monopoly pricing. Both companies and public customers of such data services could therefore benefit from a robust regulatory framework.

Intellectual Property

Data-driven digital technology is the dominant force in economic production and distribution in the digital economy (Rogers and Tsirkunov 2021). Advanced digital technologies, including AI, are capable of developing new and beneficial products and services through access to and the manipulation of large quantities of data.[15] While there is broad agreement that making public data available is a good thing for the development of useful and beneficial products and services,[16] many NMHSs continue to limit open access to some public weather, climate, and water data reserving it for their own commercial use.

Their right to do so derives from the intellectual property rights (IPR) they hold with regard to observational and other data. In practice, access to data is either completely denied or that commercial users must buy a license to use it. Licenses restrict what licensees can use the data for—in the most restrictive cases requiring separate licenses for the use of the same data for another product, a practice that undermines the large-scale use of data for development of machine learning algorithms, for example. At the other end of spectrum, open data licenses, open government licenses, creative commons attribution licenses, and similar licenses (Mockus and Palmirani 2015) are intended to facilitate the use of data by any third party, providing the original creator is credited or the source is acknowledged. In all cases, some form of general data protection is applied to protect personal data.[17] IPR, therefore, can be used positively to nurture the digital economy or act as barrier to innovation and competition. An important consideration is whether the intellectual property derived from data belong to the creator of the products resulting from the data or to the creators of the data. If it is the latter, then inventors of new products may be required to disclose the purpose of the license, thereby losing a competitive advantage if the creator of the data makes similar products.

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In the public sector, as sources of data increase with greater dependence on third-party data, such as crowd-sourced data or data provided by commercial firms—even with pay per use licenses—closer attention to the management of IPR will be needed to prevent potential disruption to the flow of public information. Similarly, IPR associated with source codes, such as climate data management systems (CDMS), are often restrictive for public use, preventing their optimal use in the provision of public sector services. Given the importance of climate data and services to society, public–private engagement may provide the best approach to the development of CDMS with emphasis on open source and open government licensing, which does not restrict either the public or private sector from providing competitive value-added products and services derived from a CDMS.

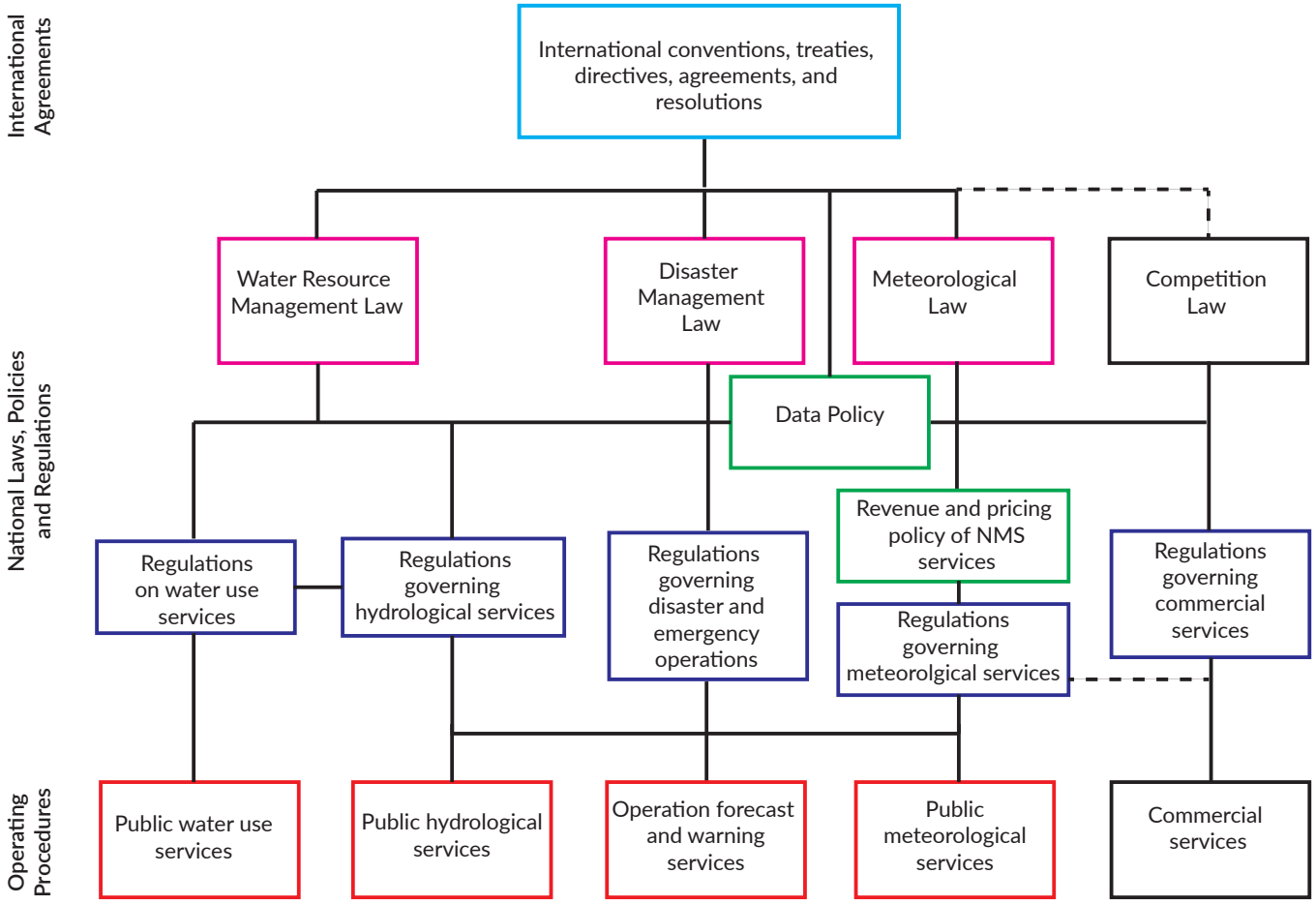
A key point to note is that the issue of access to and use of the meteorological data held by an NMHS will depend entirely on the data policy of the NMHS concerned, and compounded by arrangements between the NMHS and commercial data providers, if

the latter provide a higher share of the overall data provision. This may be a formal policy document developed internally by the NMHS itself, it may be based on a broader policy and legal framework relating to access to public data in general or it may be set out in a specific meteorological law. Alternatively, the NMHS may have no formal data policy with requests for data being dealt with on an ad hoc basis. A fundamental prerequisite is a clear data policy that confers clear rights of access to meteorological data on the private sector to create a genuinely level playing field and incentives for new market participants and investments for innovation. In order to provide legal certainty, this would be set out in law.

Legal and Regulatory Frameworks

The next issue that arises is the question of minimum standards for the provision of meteorological services and the role of legal and regulatory frameworks regarding: (i) international law, primarily by reference to various international agreements; and (ii) national laws in the form of laws, policies, and regulations (Figure 2).

Figure 2. Legal and regulatory instruments governing the provision of meteorological and hydrological services.



International Law

International law is the body of law that regulates the legal relationship between States and international organizations recognized under international law such as the WMO and the International Civil Aviation Organization (ICAO). As for international law related to meteorology, the principal legal agreement is the Convention of the WMO, which provides the legal basis for the establishment and functioning of the organization. The Convention does not, however, seek to set out minimum standards for the provision of meteorological services. Instead, such standards for the production of services by National Meteorological Services (NMSs) are set out in the Technical Regulations of the WMO.[18]

However, the standard practices and procedures described by these technical regulations in many cases do not impose binding obligations on WMO Members. They are duties of best endeavor rather than of outcome, qualified by the "shall be the practices and procedures that WMO Members are required to follow or implement" and "Members shall do their utmost to implement the standard practices and procedures." Moreover, they are addressed to Member States, but in reality, reach only the NMHSs as the countries' permanent representatives with WMO are NMHS directors and the private sector is less represented.

One specific category of meteorological services in international law is governed by a legally binding regulation namely, the "meteorological service for international aviation", adopted under the auspices of the Convention on International Civil Aviation, often referred to as the "Chicago Convention", which is implemented by ICAO. The experience of providing aeronautical meteorological services yields some insight into the potential benefit and downside of a regulated meteorological service market. Aeronautical meteorological services are unique in that their provision is controlled by international convention on a cost recovery basis.

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Governance issues surrounding the provision of aeronautical meteorological services are a major challenge. One of the problems is the difficulty of arbitrating over costs of service for example, in the UK, between the UK's Civil Aviation Authority on the one hand and the meteorological authority, which is responsible for arranging for the services, on the other. This is further compounded if, as is often the case, the meteorological authority is located within the government agency responsible for civil aviation. While the meteorological authority is responsible for cost recovery measures, it does not necessarily have control over the financing system. The level of charges should be directly related to the quality of service (QoS) delivered and should be justified in a transparent manner, especially if the funds are allocated from air charges; however, these funds do not necessarily return directly to the meteorological authority and may not be factored back to the aeronautical meteorological provider. Furthermore, the aeronautical meteorological provider for regulated aviation services in most countries is the NMHS or a state-owned enterprise so there are limited opportunities for the private sector to compete.[19] Inevitably, issues arise related to the monopoly of the government in providing services paid for by commercial airlines.

As a regulated service, the relationship between the aeronautical service provider, the meteorological authority, and private sector services is clearly defined. Those activities mandated by International Civil Aviation Organization, overseen by the authority, and provided by the designated service provider do not prevent the private meteorological

service providers from competing for provision of direct support to airlines, with the latter focused on efficiency and passenger comfort—like avoiding meal services in areas of turbulence, or providing tailored guidance for aircraft type, and pilot experience. However, efforts to increase competition in the provision of regulated aeronautical meteorological services have proven difficult. In Europe, the Single European Skies initiative was expected to retain a monopoly for air traffic control services, while competition in support services, such as meteorology and communication would be open. However, fair competition has been elusive in part because of potential liability issues and in part owing to the states' reluctance to embrace fair competition in the sector.[20]

National Law

Despite an all-encompassing need, meteorological and hydrological laws or acts are not common and where they do exist are not necessarily fit for purpose. In particular, they often focus on the specific activities of the NMHS concerned and not on the wider aspects of the sector. Moreover, they often muddle law and regulations.

Laws governing the provision of hydromet services may be specific[21,22] or the public body may be bound by more general legislation relating to a class of public institutions.[23] Some laws focus on defining the public task,[24] others restrict the provision and use of meteorological data and information by third parties,[25] and some define explicitly public sector economic activities.[26]

While companies may articulate a preference for minimum regulation, there is widespread agreement that where regulation exists clarity, transparency, and stability are essential.

However, few countries have formal policies governing the delivery and quality of services and, as noted above, even fewer have a regulatory framework governing the entire enterprise, comprising the public, private, and academic sectors.

The *Power of Partnership* report (World Bank 2019) describes the desirability and even necessity of there being a national independent regulator. While companies may articulate a preference for minimum regulation, there is widespread agreement that where regulation exists clarity, transparency, and stability are essential.

Such an approach could specify, usually in regulations, minimum technical requirements, including staff qualifications for private sector service providers. It could also set out a licensing system under which specified weather services can only be provided by a licensed entity. This kind of command-and-control approach is certainly one way to seek to ensure that service providers deliver an appropriate level of service. But it is probably not the only way and may, indeed, not be the optimal approach.

Command-and-control regulation has its own implementation costs and can, if not designed and implemented in an appropriate manner, impose an unreasonable regulatory burden on potential service providers. After all, the state regulatory body may not actually know best, particularly of new and innovative approaches and technology where the private sector may actually be ahead of the game. For this reason, it is important to examine other methods including industry codes of conduct or self-regulation through national or international industry bodies as well as technical standardization rules.

Above all, if no clear legal framework or formal government policy statement exists that encourages private sector service provision, one issue that may arise is potential liability issues for incorrect forecasts; then in practice the lack of a legal framework may be just as discouraging as one that is excessively onerous.

A further issue that arises in sector regulation is that in practice the only body that is likely to have the necessary technical skills to act as a regulator is the NMHS itself. Here a potentially significant conflict of interest may arise if the NMHS is also providing commercial services placing it in the position of regulating its competitors. Building norms are one illustration where, for example, in Austria representatives from the public and private sectors work together to define building norms "fit for climate change conditions." While not without friction, it is at least not one sided.

The experience in Japan where the Japan Meteorological Agency (JMA) does not actively engage in commercial activities, suggests that those NMHSs performing only the public task could take on the role as the national regulator thereby regulating the market. However, separation of technical and business regulations may be more appropriate with technical regulations governing the QoS aspects conducted within the public task of the NMHS in alignment with WMO policies while commercial activities are overseen by an independent economic regulator.

In summary, applicable legal and regulatory instruments are vital to ensure effective and efficient market conditions that stimulate both innovation and fair practices. In particular, competition laws are crucial to ensure a level playing field, particularly where an NMHS is competing for commercial contracts. The private sector inevitably questions the existence of a level playing field if the NMHS carries out undertakings and it falls on appropriate regulation at national level to ensure that fair competition is actually taking place.

Encouraging Competition

Considerable debate continues within the global weather enterprise about the efficacy of the public sector providing commercial services (World Bank 2019; Rogers and Tsirkunov 2013; National Research Council 2003). However, since an increasing number of NMHSs are providing paid-for services, it is essential to understand how these services can be provided without distorting or preventing the development of the domestic market. This requires an understanding of the potential applicability of competition law or antitrust law to public NMHSs if they operate as undertakings,[27] and how well are they enforced in different jurisdictions.[28]

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Competition Law as an Enabler

The basic purpose of competition law is to promote or maintain fair competition in markets by preventing anticompetitive behavior. Examples of such behavior include cases in which: (i) companies collude by for example, fixing prices or production levels or market share to reduce or distort competition; and (ii) a company abuses its dominant position in a given market through predatory pricing and the imposition of unfair or discriminatory conditions or with both.

While competition law was originally developed to address market abuses by private companies, a key point to note is that in many jurisdictions it may apply to NMHSs as well. The European Union competition law, for example, uses the term "undertaking" rather than company. While the term is not defined, it has been construed by the European Court of Justice to include any entity engaged in an economic activity, meaning an activity consisting in offering goods or services on a

given market, regardless of the legal status of the entity including whether or not it has independent legal personality and the way in which it is financed.

It follows that competition law is an important element of the legal framework governing the provision of commercial weather, water, and climate services by all sectors, irrespective of legal status (Box 1). Whether or not a given NMHS is subject to the rules of competition law will depend on the precise wording of the legislation concerned. It should also be noted that advances in competition and antitrust, for example in Africa,[29] far outstrip the development of adequate meteorological legal and regulatory frameworks.

Box 1. Competitive Markets

Competitive markets are key drivers of economic growth and productivity. An effective competition policy enables contestability and firm entry and rivalry, while ensuring the enforcement of antitrust laws and state aid control (World Bank 2017a). These principles apply equally to the weather enterprise to enable entry of new firms, expand efficiency of existing firms and undertakings, and to change the behavior of firms with market power. This should translate to increases in aggregate output, employment, and consumer welfare. Since weather, climate, and water services are ubiquitous to many economic sectors, reforms targeting those sectors, such as agriculture, should also be matched by appropriate changes in the service inputs. Incumbent operators in agriculture for example, including the government, should not be able to prevent new entrants in agricultural meteorological services from entering the market. This market is particularly important since food products make up the largest category of consumption by the poorest households and agricultural inputs are highly dependent on meteorological and hydrological factors and, therefore, competition policy interventions would have a progressive impact (World Bank 2017a).

Protecting the interests of consumers, promoting economic efficiency, and ensuring that entrepreneurs including small and medium enterprises (SMEs) have the opportunity to exist, compete, and grow in the market economy are important objectives. Most countries have some form of antitrust laws; however, significant variance prevails in their scope, sanctions, and extent to which they are enforced. Competition in domestic markets in developing economies improves and reinforces the investment environment and makes it more attractive for investment by domestic and foreign entrepreneurs. Competition also helps integrate the developing economy into global markets and sustains broad-based economic growth and poverty reduction (Khemani 2007). In the narrow context of weather, climate, and water services, the development of a competitive market increases the availability of solutions to weather and climate sensitive industries, provides opportunities for skilled technology workers, and encourages innovation and the transfer of skills across the weather enterprise. This does not happen automatically.

The competitive process needs to be protected and promoted to develop a sound domestic market economy for weather, climate, and water services in a country. The potential relevance of competition law to services provided by an NMHS is not entirely an academic question.

In 2020, the German Federal Court of Justice ruled on appeal against Deutscher Wetterdienst (DWD, the German weather service) for providing general weather forecasts free of charge on its weather warning app, “WarnWetter-App.” During earlier stages in the case, it was argued that this business act was anticompetitive in competition law by reason that the DWD and by extension the app was state financed.[30] The case was ultimately determined by a narrow interpretation of the precise scope of the rights of the DWD to provide free-of-charge services rather than on the basis of competition law.

Nevertheless, the case highlights the fine line between carrying out a public task and an undertaking, particularly where the activities of the private sector may also impinge on the public task.

Competition and Economic Welfare

Competition fosters economic welfare and makes markets work for development.[31] The aim is to generate the right incentives for firms to improve their economic performance relative to their actual and potential rivals and in so doing deliver the best outcomes for consumers and the economy as a whole (World Bank 2017a). Fostering competition in markets has two key facets: (i) procompetition regulation and government interventions to opening markets and removing anticompetitive sectoral regulations; and (ii) competitive enforcement through competition law.

The concept of the level playing field in commerce is about fairness, ensuring that each participant is following the same set of rules.

In many LMICs, the NMHSs are driven to selling services or data without heed to competition law and without explicit permission of antimonopoly authorities. Meteorological laws are passed that reinforce the natural monopoly, in some instances by prohibiting the provision of any kind of meteorological services other than by the NMHS. Relatively few legal challenges regulate these practices, particularly in LMICs where the nascent market is very small. Nevertheless, competition law is an important tool in economic development and should be applied equally to all undertakings. Competition and regulatory impact analyses should be conducted, involving audits of the nature and extent of exemptions, exceptions, and different treatment of various economic activities (Khemani 2007), and these should include meteorological services provided as an undertaking by a public body. This would widen the understanding of the economic benefits of weather, climate and water services and help ensure a level playing field for all actors. In practice, this is a partnership between the public and private sectors to design a properly functioning market facilitated by competition law policy.

The concept of the level playing field in commerce is about fairness, ensuring that each participant is following the same set of rules. This means that competitive bids submitted by public and private undertakings have constructed those offers in a comparable way and neither is handicapped in a way that favors one of the competitors. In the provision of a commercial service, this would mean that both undertakings, for example, would have to pay the same price for raw meteorological data—the public undertaking should not receive that for free from the NMHS unless the same data were provided for free to the competitor. Otherwise, this would be a prohibited antitrust activity. NMHSs that provide commercial services, but do not conduct their commercial activities in a distinct and separate undertaking are more likely to cross-subsidize, inadvertently or otherwise. Blurring the distinction between noncommercial and commercial tasks is one typical error. Senior management and other personnel with multiple functions, including both the undertaking and public task, must charge their time to the appropriate activity. The expense of the use of government assets in any aspect of the undertaking should be accounted for properly. This is an essential element of regular audits.

Accordingly, it may well be preferable for an NMHS with both public tasks and undertakings to create separate delivery units. These might be distinguished as nonprofit, cost recovery and for-profit centers or public weather service, aeronautical meteorological service and commercial service centers. The names are not important, but each should be able to readily account for revenues, costs and expenses and this can be used to

evaluate each segment's performance. In turn, these centers are supported by internal production and service cost centers, which provide common services including observations, numerical predictions, and forecasts.

Competition and Transparency

Transparency and disclosure are essential to holding NMHS undertakings accountable for their performance to the public and the private sector. Reliable financial information is essential for establishing accountability mechanisms, allowing well informed decision-making on the part of management with each cost center structured so that its revenue, costs, and expenses are accountable and permit well-informed decisions on the part of management and depending on the particular operating model of the NMHS, its board of directors, shareholders, civil society, and citizens.

Some countries such as Japan, USA and Germany have achieved clarity, fairness, and transparency regarding competition by limiting the NMHS to its public, noncommercial task only. In Japan a further step has been taken to establish its NMHS, the JMA, also as the national regulator. Furthermore, in Japan, it has been convincingly demonstrated that those sectors most exposed to competition were the most successful competitors, while the protected sectors failed (Sakakibara and Porter 2001). The Japan Meteorological Business Support Center (JMBSC), which is a separate nonprofit organization from JMA, was set up to nurture the development of meteorological services in the private sector.[32,33] However, in recent years, the weather market in Japan has stagnated with few new entrants or new businesses developed. JMA and the commercial sector took a proactive approach to reinvigorate the competitive market by creating the Weather Business Consortium (WXBC).[34] As of January 2020, WXBC had 803 members. The JMA supports the members' commercial activities both as the secretariat and via provision of meteorological data. The main purposes are: (i) to drive commerce involving intensive use of meteorological data in technologies such as Internet of Things (IoT) and AI via extensive joint efforts in the public, private, and academic sectors, thereby enhancing socioeconomic productivity in Japan; and (ii) to reboot weather-for-business activities in Japan for advanced use of weather data in business involving new users. This collaborative approach underpins and strengthens the competitive domestic market increasing opportunities for new entrants. Access to JMA's weather data is critical to fulfilling the aims of the WXBC, and by providing this as open data both SMEs and large companies can exploit it, build on it through their own data services, utilize meteorological data for business, provide data analytics and information systems, and create new businesses. This is transparent because the Meteorological Services Act of Japan[35] stipulates the roles and responsibilities of all actors in the enterprise differentiating between the public obligations of the JMA and private commercial actors, whether national or international service providers. In this case, the JMA does not provide commercial services and so is also *de jure* the industry regulator.

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The Market

The public and private sectors are sometimes perceived as inimical forces rather than complementary actors that would benefit from working together to strengthen and grow the market. Supporting or opposing the participation of public sector undertakings in this market is based on social, economic and political considerations and should follow

a thorough analysis. The directive to generate revenue through the sale of services in many LMICs is not structured with an appropriate business model, so it is not clear that the undertaking is financially sound. The nascent market in some countries may only have the NMHS as a supplier of services, but it is also an opportunity to foster entrepreneurship, innovation, and new business opportunities.

In line with the UN's sustainable development goals (SDGs), UN Framework on Climate Change, Sendai Framework on Disaster Risk Reduction and Addis Ababa Agenda for Sustainable Financing,[36] the aim of the country is to create prosperity through a sustainable economy and to minimize harm to the population due to environmental and other hazards. In achieving these goals, the NMHS may be seen as both a provider of vital forecasts and warnings to protect life and property and as the catalyst to create an economy that can capitalize on weather intelligence (Rogers et al. 2021a, Thorpe and Rogers 2021).

In low maturity value chains, The *Power of Partnership* report (World Bank 2019) recommended that the private sector be used to jump start the market while laying the foundation for a sustainable NMHS. It went further by suggesting that in an intermediate "strengthen" scenario, the public sector should focus exclusively on the public task and that the private sector provide nonpublic services. We posit a different option in which public and private sectors and the *government* work together to develop the nascent competitive market without any a *priori* or presupposed constraint on the undertakings of the public sector, other than creation and adherence of a level playing field and the retention of the authority to provide warnings within the government. The joint commitment of the NMHS and private sector would be the development of new competed services and the growth of the sector through free enterprise.

Recommendations and Conclusions

In this technical note, we have laid out some of the ground rules that govern an economic market and how these rules should apply to public sector undertakings, including the commercial activities of NMHSs. While some actors in the weather enterprise may feel that public sector undertakings are not ideal, they do exist and appear to be growing. Indeed, it should be recognized that such public undertakings create value within the weather value chain (Thorpe and Rogers 2021). Therefore, they should be able to develop with appropriate rules and metrics for success. In practice, in LMICS, many NMHSs appear to operate without a clear understanding of competition rules and in jurisdictions with weak enforcement and relatively few legal case precedents. We argue that the growth of the weather enterprise, and by extension climate and water services, requires a clear regulatory framework and in particular adherence to competition law. Ultimately it is in the interests of the country to develop its economy and avoid distortions, which are limits to growth.

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Our recommendations focus on an approach for NMHSs, particularly in LMICs, which would allow them to pursue undertakings on a level playing field. We make the following assumptions:

- Governments want to develop their economies through open markets and, therefore, value activities that develop new business opportunities, which, in turn, increase employment and its gross domestic product (GDP).

- Prevalent is a general understanding, albeit nascent and in need of further strengthening, that weather, climate, and water intelligence is critical to business development, particularly in the context of climate change and the greater sensitivity of modern economy to environmental factors.
- Governments support open data policies that require public funded data to be made freely available to anyone to use and reuse without restriction and these policies apply to national meteorological and hydrological data. Consequently, the NMHSs cannot sell data as an undertaking.
- The NMHSs must focus on services rather than data to generate revenue.

We consider the business structure rather than a particular undertaking. First, it is important to have a full understanding of the true cost and value of services (Thorpe and Rogers 2021). This includes quantifying the actual costs of services, implementing process improvements, evaluating outsourcing, and aligning activities with strategy (Rogers et al. 2019), rather than simply focusing on input expenses —staffing levels, equipment, and supplies. This requires a shift from budget management to macroeconomic effects and performance-based results measurement using tools based on the application of International Public Sector Accounting Standards (IPSAS).[37] Applying these standards bridges the compatibility gap between public and private sectors' accounting methods and increases the transparency of public sector financial information regarding economic profitability (Ilie and Miose 2012). This is essential if the NMHS is to create viable, competitive undertakings.

Separating the commercial activities of the NMHS from the public task makes it much easier to ensure that there are no cross-subsidies and that the undertakings are fully competitive with the private sector.

Separating the commercial activities of the NMHS from the public task makes it much easier to ensure that there are no cross-subsidies and that the undertakings are fully competitive with the private sector. A subsidiary body is preferable but distinct delivery units would suffice with adequate controls. Application of IPSAS accrual accounting methods allows revenues, costs, and expenses to be clearly delineated, which creates a transparent audit trail. Staff and ICT resources would be supplied by the internal product and service cost centers of the NMHS and reimbursed as an expense by the delivery units. Each link in the value chain (Thorpe and Rogers 2021), for example, could be identified as a cost center. Other cost centers include finance and personnel administration, general IT infrastructure services, utilities, building rent, and so on would be supplied as an indirect cost, and the proportion allocated to the commercial activities would be reimbursed as an expense by that unit. Revenues from commercial and cost-recovery services must cover their allocated costs and expenses. Adherence to IPSAS accrual accounting methods would help remove the concerns expressed by the International Air Transportation Association (IATA)—the trade association for the world's airlines about overpricing of services. Greater transparency would help identify the costs to civilian aviation of the facilities and services intended exclusively for aeronautical users and competition could incentivize greater cost effectiveness and fairer allocation of costs to products and services based on user requirements.[38] Similarly, by using the same methods the NMHS can achieve greater accountability and clarity in the cost and expense of the production and delivery of its public task.

The discussion has focused mostly on market structure and governance including competition. Effective business-oriented mindsets in both public and private insti-

tutions should have a primary ambition that competitive relationships on one topic do not exclude cooperation on others. Noncompetitive relationships between actors in the public, private, and academic sectors have considerable advantages and enable added value creation in the weather enterprise. Cooperation, collaboration, and coproduction are ways in which value can be created in a noncompetitive environment (Rogers et al. 2021a).

Where access to basic observational data is restricted, so too are the commercial opportunities to develop new businesses. These restraints favor monopolies and work against most countries' interests in economic development. A level playing field is essential to create confidence in the market and to allow its unhindered development. NMHSs can be strong motivators for this market even when the value chain is weak and the market nascent. Public and private partnerships to strengthen the market have great potential.

One approach would be to create a consortium similar to Japan's WXBC. Its purpose would be to bring together the various actors in the weather enterprise with the expressed aim of developing the market for services. It would be a nexus for the public sector and private including both producers and consumers of weather, climate, and water information. Without a formal independent regulator, the consortium could act informally to resolve disputes and foster compliance with competition laws. It would provide a neutral platform for dialogue between the sectors and the opportunity to make joint decisions to promote the uptake of weather and climate information as widely as possible. It should also encourage international participation from advanced NMHSs and the private sector to strengthen a collaborative approach to building the sectors capabilities nationally.

In future World Bank projects, greater emphasis should be placed on helping a country to develop the economic market for weather, climate, and water services with the aim of improving the entire national enterprise including the ability of the public sector NMHS to fulfil its public task. This technical note has touched on a number of policy and structural reforms that are required to create and sustain an effective commercial weather, climate, and water services market (Table 1). Some of these activities are interrelated, but many can be implemented alone. Some can be enacted within the meteorological and hydrological community; others require higher level policy decisions; and most would require a structured stepwise approach with interim goals to attain the necessary reforms.

In future World Bank projects, greater emphasis should be placed on helping a country to develop the economic market for weather, climate, and water services with the aim of improving the entire national enterprise including the ability of the public sector NMHS to fulfil its public task.

Table 1. Policy and structural reforms required to improve weather, climate, and water services market and increase social and economic welfare.

National policy and regulation reform	National competition enforcement	Public–Private Engagement	NMHS Institutional Reform
Introduce effectiveness orientation as a principle for public administration. Open data policy. Reform government interventions that harm competition and distort the level playing field. Remove barriers to encourage entry of new firms and entrepreneurs. Government to finance public task—clearly defined and budgeted. Enact or revise National Meteorological Law. Enact or revise National Water Resources Management Law.	Strengthen antitrust framework to combat anticompetitive conduct and abuse of dominance. Ensure competition regulator is effective. Create a sector regulator for the weather, climate, and water services market.	NMHS and private sector create a platform, similar to the WXBC, to exchange ideas on developing the competitive market. Include all weather sensitive businesses. Provide input to draft data and regulations affecting the meteorological and hydrological sector. Provide a clear rationale for any state-mandated roles and responsibilities of NMHSs.	Introduction of IPSAS accrual accounting systems that link indirect costs to products and services. Adhere strictly to competition law policy to avoid cross-subsidies within NMHS. Prioritize public task. Make meteorological and hydrological data free to use and re-use without restriction in line with open data policy.

Notes

1. https://www.worldbank.org/en/about/partners/maximizing-finance-for-development
2. See WMO Basic Documents No. 1 for a definition of Members https://library.wmo.int/index.php?lvl=notice_display&id=14206#.YDObGS1Q1qs
3. EC 70 Doc 12.2 Public-Private Engagement. https://www.wmo.int/iwe/share/Public-Private%20Engagement/Public-Private%20Engagement%20EC-70%20-%20John%20Hirst.pdf
4. https://library.wmo.int/doc_num.php?explnum_id=10367
5. Noting that some countries have prohibited their NMHS from taking part in commercial activities, e.g., Japan, USA, and Germany.
6. https://www.accenture.com/t20150527T205415__w__/th-en/_acnmedia/Accenture/Conversion-Assets/DotCom/Documents/Global/PDF/Dualpub_8/Accenture-Achieving-Government-Efficiency-Through-Commercial-Consolidation-Practices.pdf
7. PwC is a global network of firms delivering auditing, assurance, tax, and consulting services for businesses. https://www.pwc.com/
8. https://www.mbie.govt.nz/science-and-technology/science-and-innovation/research-and-data/open-access-to-weather-data-review/
9. https://www.mbie.govt.nz/assets/5b3b826f79/weather-permitting-review.pdf
10. https://sdma.kerala.gov.in/augmentation-of-weather-services/
11. Undertaking refers to every entity engaged in economic activity, i.e., offering goods and services on a market.
12. https://www.dwd.de/SharedDocs/downloads/EN/general/dwd_act.pdf?__blob=publicationFile&v=2
13. https://www.europeandataportal.eu/en/highlights/economic-benefits-open-data
14. CubeSat is a class of miniaturized satellites made up of multiple 10cm X 10cm x 10cm cubes based a reference design from California Polytechnic State University and Stanford University.
15. https://www.wipo.int/wipo_magazine/en/2019/05/article_0001.html
16. https://www.europeandataportal.eu/en/highlights/economic-benefits-open-data
17. https://gdpr.eu/eu-gdpr-personal-data/
18. WMO Technical Regulations. Basic Documents No. 2. Volumes 1, II, & III WMO-No. 49.
19. Austro Control is an example of a state-owned limited company, which provides aviation services for Austria, including air traffic control and aeronautical meteorological services. A subsidiary also provides commercial meteorological services outside of the Austro Control's core business. Austro Control is also the regulator.
20. Delphine Defossez, 2015. https://www.researchgate.net/publication/303083493_Will_There_Be_More_Competition_After_the_Single_European_Sky_Is_Implemented
21. https://www.dwd.de/SharedDocs/downloads/EN/general/dwd_act.pdf?__blob=publicationFile&v=2
22. https://www.congress.gov/115/plaws/publ25/PLAW-115publ25.pdf
23. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.183.4530&rep=rep1&type=pdf
24. https://www.govinfo.gov/content/pkg/USCODE-2010-title15/html/USCODE-2010-title15-chap9-sec313.htm

25. http://extwprlegs1.fao.org/docs/pdf/lao184237.pdf
26. https://www.zamg.ac.at/cms/en/topmenu/infopoint/law
27. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/786668/met-office-framework-document-2019.pdf
28. https://unctad.org/system/files/official-document/ditcclp2015d3_en.pdf
29. https://www.bakermckenzie.com//-/media/files/insight/guides/2019/baker-mckenziecompetition-in-africa-reportpdfile.pdf
30. https://www.bundesgerichtshof.de/SharedDocs/Pressemitteilungen/DE/2020/2020028.html
31. Competition policy; https://www.worldbank.org/en/topic/competition-policy
32. http://www.jmbsc.or.jp/en/index-e.html
33. https://www.gfdrr.org/sites/default/files/publication/Met%20report.pdf
34. https://www.wxbc.jp
35. http://www.japaneselawtranslation.go.jp/law/detail/?id=1968&vm=02&re=02
36. https://www.unwater.org/what-we-do/inform-policies/
37. IPSAS. https://www.ipsasb.org/publications/2020-handbook-international-public-sector-accounting-pronouncements
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GFDRR

Global Facility for Disaster Reduction and Recovery

The Global Facility for Disaster Reduction and Recovery (GFDRR) is a global partnership that helps developing countries better understand and reduce their vulnerabilities to natural hazards and adapt to climate change. Working with over 400 local, national, regional, and international partners, GFDRR provides grant financing, technical assistance, training and knowledge sharing activities to mainstream disaster and climate risk management in national and regional policies, strategies, and investment plans. Managed by the World Bank, GFDRR is supported and directed by a Consultative Group that has 17 members and 14 observers.

www.gfdrr.org