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The impact of disruptive technologies on infrastructure networks

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Technological change has profound implications for infrastructure networks and their regulation. New technologies are changing the approach to infrastructure planning, management and investment. Regulators need to understand those changes and especially the potential effects of innovations both at the asset level (e.g. new maintenance techniques) and at the service level (e.g. platforms) across sectors.

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Executive summary

1. Disruptive technologies are transforming network industries. This is particularly the case with digitalisation, machine learning and automation even if more 'traditional' sources of disruption continue to have an impact on network industries.

2. Disruptive technologies could make some current regulatory frameworks ineffective, obsolete or even harmful. Disruption exacerbates traditional regulatory challenges such as asymmetric information and risk management. At the same time, innovation is directly related to dynamic efficiency, so it is important to assess whether regulatory schemes sufficiently stimulate innovation.

3. Technology increases efficiency in the management of infrastructure. It can reduce the cost of design and construction, as well as of maintenance and operation, particularly so as it empowers infrastructure managers to adapt capacity to demand. Cost reductions can be substantial. However, the right incentives have to be on place to ensure that infrastructure managers do effectively invest in new technology. At the same time, the regulatory framework has to ensure that cost reductions are shared with consumers in the form of lower prices.

4. Technology generates new risks for infrastructure managers: there is uncertainty in the selection of the best technology to be deployed, and uncertainty in the evolution of demand. Furthermore, technology empowers infrastructure users, for instance by providing more transparency, but also by allowing them to become more active in the market, sometimes up to the point of becoming themselves sellers of services (sharing economy).

5. Technology can transform the market structure and the role of infrastructure managers in the market. As digitalisation creates a data layer on top of the infrastructure, new players can use such data to become the coordinators of the underlying infrastructure as intermediaries between users and infrastructure managers. Online platforms can create multisided markets in which infrastructure managers become just "one side", a commoditised provider of services under the coordination of the online platform. It has been observed in other industries, particularly in the content and media industries, and it is starting to happen in infrastructure industries. The platform reduces the value traditionally captured by the infrastructure manager, as new competitive pressure destroys value, and furthermore, the platform has the ability to capture its own share of value. This is particularly relevant in infrastructure network industries, as funding will always be necessary for construction and maintenance.

6. Therefore, infrastructure managers are facing the digitalisation dilemma. Digitalisation increases efficiency in the design, construction and operation of infrastructure. But digitalisation might allow online platforms to transform infrastructures into multisided markets, with online platforms intermediating and coordinating the use of infrastructure by final users. Infrastructure managers could be "platformed" as their services become just a commodity traded by online platforms.

7. However, managers and regulators are not bound to be mere spectators in the process of digitalisation and emergence of new market structures. The challenge for all actors is to ensure a balanced and sustainable competitive environment. New market structures will only be sustainable if the new value created by technology is fairly

distributed, and in particular if infrastructure managers are not deprived of the necessary funding for the maintenance and construction of infrastructure.

8. We provide a case study in the annex to this paper, reminding us that technical progress and oligopolistic behaviour can disrupt an industry – in this case, global maritime infrastructure, private assets, market structure and business model – and those adjacent to it even before digitalisation deploys its transformative power. We find that lack of regulation and decentralised private and/or governmental decisions are taking cargo flows far from least cost door-to-door routes.

1. The theoretical, institutional and historical conditions of regulation in infrastructure networks

1. Disruptive technologies have the potential to open up regulated monopolies in infrastructures, where entry of competitors was deemed to be practically impossible. In turn, this could make some current regulatory frameworks ineffective, obsolete or even harmful. Before considering how disruption may occur, it is therefore important to briefly review how regulation in infrastructure operates.

2. In essence, regulation in infrastructure networks is intended to strike a balance between public and private management of essential facilities. Public intervention in network industries is considered as necessary because of the following arguments:

- Large fixed costs give raise to natural monopolies, implying prices higher than marginal costs.
- Lack of sufficiently developed financial markets and private investors in the face of very large investment costs and risk.
- Strategic sectors, meaning that some sectors are considered to exert positive externalities towards other sectors of the national economy.
- Distributive concerns and regional economic policies, for instance when it is thought that competitive markets would not create sufficient incentives to serve remote areas or rural communities.

3. For all the reasons above, (large) infrastructure networks have been traditionally managed, at least in Europe, through direct public intervention. It is only from the ‘80s of the last century that, progressively, infrastructure networks have been opened to various degrees of private management.

4. This change has been driven by a number of factors. First, evidence of inefficiencies in public owned infrastructure, in terms of overemployment, financial imbalances, “white elephants”, became more compelling. Second, a positive cultural attitude towards the functioning of competitive markets, heralded by economists of the neoclassical economics “Chicago school”, emerged. Third, the accumulation of public debts in some countries forced the selling of financial assets in the hand of the public sector.

5. In parallel, economic theory has been characterised by the blossoming of the so-called “New Economics of Regulation” (Laffont, 1994), which promised to provide operational solutions for the alignment of private and public objectives, thereby making the pursuit of profit compatible with social welfare maximisation, even in the presence of a series of potential market failures, which are typical of infrastructure networks. The framework is a principal-agent set up in which the principal is the State or independent regulatory authorities and the agent is the regulated firm. The principal maximises social welfare under incentive constraints, which result from the informational advantage of the agent and its strategic behaviour. The regulation problem is essentially a control problem under incomplete information.

6. Notwithstanding the progresses in economic theory, however, theorems and results from the New Economics of Regulation have not found their way to become operational schemes in real world markets, mainly because of their complexity but also because of their

unrealistic Bayesian[1] description of asymmetric information. Consequently, regulation in infrastructure networks is still dominated by the two opposing schemes of “cost-plus” and “price-cap” (and their combinations). Pros and cons of those systems are well known and will not be reviewed here (Braeutigam and Panzar, 1993; Liston, 1993; Littlechild, 2003).

7. A relatively recent but very active stream of research investigates issues of income and wealth inequality, also in relation with the emergence of market power in regulated markets (Stiglitz, 2015). In fact, inequality has dramatically risen in developed countries during the very same years when many infrastructure and network markets have been liberalised. It is suggested that network externalities have given real market power to a few firms and the move to a service sector economy may have resulted in greater market power. In addition, changes in technology have given more scope for network externalities, and thus for market power, in a way that it could be hardly detected and fought by traditional antitrust institutions.

[1] Bayesian formulations express knowledge as random variables, whose distributions are updated whenever new, indirect information becomes available.

2. When something goes wrong: static and dynamic inefficiencies of regulation in the real world

8. In principle, optimal regulation introduces constraints and distortions in a market so that resources are efficiently allocated, in a way akin to perfect competition, even when conditions for perfect competition are not met. Similarly to a sequential game, the principal (State) sets the rules and the agent(s), that is the regulated firm(s), follow.

9. Game theory teaches us that, under full information, the first mover principal can precisely anticipate the moves of the follower(s), which could therefore be seen as a purely passive *longa manus*. Of course, asymmetric information prevents this, so the best the principal can do is set incentive-compatible rules which reveal ex post (part of) the private information, through actual behaviour. It is well known that this implies giving up some "informational rents" to the agent. As Laffont (ibid.) puts it: "This fundamental trade-off between rents and allocative inefficiency is in my view one of the basic insights of economics".

10. The allocative efficiency mentioned here is a static one: not wasting any piece of a pie to be split. But there is also another type of efficiency, the dynamic one: allowing the pie to grow over time at its maximum rate. We believe that theoretical studies as well as regulatory policies have largely neglected some fundamental issues of dynamic efficiency.

11. For instance, the degree of asymmetry in information should not be taken as given and invariant over time. Historically, one can see (especially in network markets) that regulated incumbent firms often have a progressively growing informational advantage, making the entry of competitors virtually impossible. Competition "for the network" (e.g., auctions for frequencies in telecommunications) cannot substitute for competition "in the network" and "between networks".

12. More generally, it should be noticed that a trade-off between static and dynamic efficiency exists, alongside static efficiency and reduction of rents (distributional objectives). Consequently, dynamic gains could compensate static losses. The archetypal textbook example here is (perfect) patenting, whereby a legally enforced monopoly is created, in order to induce socially beneficial innovation.

13. Innovation is directly related to dynamic efficiency, so it is important to assess whether regulatory schemes sufficiently stimulate innovation, in particular in network markets. Actually, a vast literature (applied and theoretical) exists in Industrial Organization, addressing issues of innovation, research and market structure. Unfortunately, this stream of research has hardly been linked to the one on regulation.

14. Some key insights, relevant for network infrastructure, can be summarised as follows:

- <u>Innovation in monopoly is lower than the one in competitive markets, if successful innovation generates market power</u>. This is because a monopolist "replaces herself". However, if innovation allows a competitive firm to differentiate its products, or to get a persistent cost advantage, then market power would be created where it was previously absent. This is a non-marginal, "disruptive" change.

- No innovation takes place in contestable or competitive markets if innovation is a pure public good (replicable at negligible cost). Indeed, if innovation could be readily imitated, there would be (almost) no innovation at all.
- The social marginal return on innovation is normally higher than the private one, meaning that the degree of innovation is sub-optimal. As an example, consider a reduction of marginal production costs in a monopoly. Part of the cost reduction would be transferred to consumers through lower prices, thereby raising the consumer surplus. If innovation is costly, lower than the increment in social welfare (profits + consumer surplus) but higher than the marginal profit, then it would not be introduced. This is one argument to support public subsidisation of research and innovation, alongside the one about positive externalities associated with imitation.
- Innovation can be employed effectively as a barrier to entry, as well as to extend market power in adjacent markets. The first point is an application of general principle: incentives to retain market power are normally higher than those related to expected profits by a new entrant. The second point has been investigated in many antitrust cases on "linking practices": the Explorer browser by Microsoft, complementary apps linked to Google's Android operating system, and others.

15. Some regulatory schemes already allow for compensation after productivity improvements, better quality of services, or introduction of new services. This raises the question of a proper evaluation of innovative activities. On one hand, the regulated incumbent may have better information about the potential usefulness of an innovation, but has also incentives to exaggerate it. On the other hand, to the extent that innovations (and the corresponding compensations) are approved almost automatically by the regulating authority, then the same problems typical of cost-plus regimes may emerge, with an excess of possibly wasteful innovation.

16. Another crucial aspect is the one of risk, as the effects of innovation are inherently uncertain. If regulation schemes provide some safety net, in terms of a partly guaranteed return on investments, then a moral hazard problem, similar to the one of bankruptcy, may emerge, inducing again an excess of risky innovation.

17. A special case, related to digitalisation and complementary services in infrastructure networks, has recently emerged. It is well known that most services provided free on the web are indirectly paid through the collection of valuable information about consumer's habits and user profiling. Many regulated firms in network infrastructures are now introducing digital services (e.g., apps for smartphones), which are claimed to be enhancements in the quality of their services, but at the same time allow them to collect precious "big data". The latter may thus become a strategic resource for the firm, to be used as a barrier to entry, or to extend market power.

18. A serious debate on all the issues above is still lacking. However, assessing some exemplary cases as they have occurred in the real world markets may help shedding some light.

3. The digitalisation dilemma

19. Digitalisation poses a dilemma to traditional players, including infrastructure managers. On the one hand, digitalisation increases efficiency in the management of infrastructure. As described below, digitalisation, algorithms and automation reduce the cost in the design, construction and operation of infrastructure. There are very clear opportunities to increase efficiency in the digitalisation of infrastructure, even if new risks also emerge as users are also empowered by technology.

20. On the other hand, as digitalisation creates a data layer on top of the infrastructure, new players can use the data to transform the structure of the industry. Online platforms can create multisided markets in which infrastructure managers become just one side in a multisided market, a commoditised provider of services under the coordination of the online platform. The platform reduces the value traditionally captured by the infrastructure manager, as new competitive pressure destroys value, and furthermore, the platform has the ability to capture its own share of value. This is particularly relevant in infrastructure network industries, as the availability of funds for the construction and maintenance of infrastructure has to be ensured.

21. This is the digitalisation dilemma: when traditional players digitalise their operations, they are facilitating the transformation of their industry into a multisided market, with a third party, the online platform, eroding the value traditionally captured by the infrastructure manager, and taking the role of the coordinator of the market, and the power that such a position entails.

22. The major technological disruption (Christensen, 1997, Gans 2016) of our days is digitalisation. Digitalisation is creating a virtual mirror image of reality, and a data layer has emerged on top of reality, which virtually recreates it.

23. Infrastructure is also affected by digitalisation. Sensors can be installed in the physical assets that capture and transmit data to the infrastructure manager. Such data can recreate in the data layer the status of the infrastructure (location, attrition, damage, collapse, etc.), as well as the use of the infrastructure for the provision of services. In the transport sector, for example, digitalisation helps measure traffic, identify congestion, and manage dynamic tolls.

24. Algorithms are making possible the full exploitation of Big Data (Domingos, 2015). Sophisticated algorithms are necessary to put order in the massive amounts of data created by sensors, to make it relevant. Furthermore, algorithms are now incorporating machine learning tools, or "artificial intelligence" (OECD, 2018). They are not anymore a set of fixed rigid commands rigidly linking a fact to a consequence. On the contrary, algorithms peruse through the available data in order learn from previous experience and dynamically link facts to consequences. Algorithms improve themselves with each interaction, and they are growing to become predictive (Agrawal, Gans and Goldfarb, 2018).

25. Algorithms are indeed increasingly used for the management of infrastructure. They are used to create the virtual mirror image of the infrastructure, which is useful to reduce construction and maintenance costs. Furthermore, intelligent algorithms can be used to predict traffic flows (be it cars in roads, electricity in energy networks, etc.) in order to manage them more efficiently.

26. Automation is the ultimate goal of many digitalisation projects, and automation of processes is already in place. Intelligent algorithms are used by online platforms such as Uber and Lyft for the automated matching of passengers and drivers. Intelligent algorithms are used by platforms such as Waze to automatically suggest efficient routes to travel from A to B.

27. More ambitious automation projects are currently being developed, also in the transport sector. Automation is pervasive in air transport. It is also common in the maritime industry and increasingly present in the railways sector. The automation of road vehicles promises to be the most disruptive project in land transportation.

28. Digitalisation, algorithms and automation can significantly improve the efficiency of the infrastructure manager, reducing the investment necessary for the construction and maintenance of infrastructure, and improving the efficiency in the provision of infrastructure-based services.

29. However, technology can also disrupt existing business models and erode the position of the infrastructure managers and the funding available for the construction and maintenance of infrastructure. New players, active in the data layer, can displace or "commoditise" the services of the infrastructure managers, and they can capture value which is necessary for the deployment and maintenance of the infrastructure.

4. Technology can reduce the cost of infrastructure

30. This section describes how technology can reduce the cost of infrastructures. Reductions can affect design and construction costs, as well as maintenance costs. Smart meters are of particular interest. However, the right incentives have to be defined for investment on technology to take place, and for the benefits to be evenly shared with consumers.

31. Technology can reduce the cost of design and construction of infrastructure. Automated computer design can reduce design costs. Technology can further enhance design and construction methods by better coordinating all the participants in a network. Building Information Modelling (BIM) is described as “a set of interacting policies, processes and technologies generating a methodology to manage the essential building design and project data in digital format throughout the building's life-cycle” (Succar, 2009), can reduce construction costs. In the case of roads, cost reduction by using this technology for the design and construction of the infrastructure has been estimated to be between 15% and 20% against the traditional design system (Blanco and Chen, 2014). This has been considered potentially disruptive (Oliveira Cruz and Miranda Sarmento, 2018).

32. Technology can also reduce the cost of maintenance of infrastructure. Traditionally, managers would plan the necessary interventions in the infrastructure based on the average life expectancy of each element (“preventive maintenance”). As a complement, managers would intervene if a fault were detected (“corrective maintenance”), which might be too late if the fault led to the collapse of the infrastructure.

33. Technology is transforming maintenance. The Internet of Things (IoT) allows to install sensors in all the elements of any infrastructure. In this way, the infrastructure manager can monitor the status of such elements, and maintenance can be tailored to the real condition of the infrastructure, making possible “conditions-based maintenance” for infrastructure (Jardine and Banjevic, 2006). Even more, intelligent algorithms can make use of existing data to predict the need of maintenance, enabling the so-called “predictive maintenance” (Daneshkhah, Stocks and Jeffrey, 2017).

34. Maintenance costs can be reduced, as interventions take place when they are really necessary, and not based on a conservative theoretical analysis or even worse, when costly and unfortunate faults take place. As an example, for railways rolling stock, it has been estimated that “condition-based maintenance” can reduce costs from 10 to 15%, while predictive maintenance can reduce cost a further 10% (McKinsey, 2016).

35. Technology can also reduce the cost of charging for the use of infrastructure. The charges for the use of infrastructure are usually related to the volume of use of the infrastructure (the number and duration of telephone calls, the kilometres of highway use, the kilowatts of electricity used, etc.). Metering the usage of an infrastructure generates a cost. The cost is higher when measuring takes place in the periphery of the network, as it is the case of electricity, gas and water networks. Meters have to be installed in each point of consumption and the information has to be transferred to the infrastructure manager for the production of the invoices. Furthermore, measuring and charging can disturb the traffic flow, as it is often the case of road tolls, which have traditionally obstructed traffic and created congestion at peak times.

36. Technology is reducing costs by digitalising meters. The so-called “smart meters” are reducing the cost of charging users in the electricity industry (European Commission, 2015). Meters in themselves, and the associate communications technology, may have a substantial cost. However, they can significantly reduce the meter reading costs, as well as general maintenance costs and costs generated by electricity theft. The experience with water meters is somehow different, as the low price of water does not always justify the investment, other than in areas with water scarcity (Espinosa and Lavrijssen, 2018). Smart meters can also reduce external costs. It has been identified in Taiwan that electronic tolling in road transportation can reduce congestion (- 60.1%) and CO2 emissions (- 12.4%) (Tseng, Lin and Chien, 2014).

37. Technology can significantly reduce costs for the infrastructure manager. Even if implementing new technical solutions is a cost in itself, an investment has demonstrated to pay off in many different contexts. Technology can reduce the cost of design, construction, maintenance and charging for traffic. As an example, it has been estimated that as an average, a 30% reduction in CAPEX can be expected from the implementation of the leading technologies in the road industry (Oliveira Cruz and Miranda Sarmento, 2018).

38. In any case, it is always important to identify the existing incentives. Infrastructure managers might not have the right incentives to reduce costs. It has already been pointed in Section 2 how monopoly disincentives innovation and no innovation takes place in competitive markets if innovation is a pure public good (replicable at negligible cost).

39. On the contrary, incentives might be excessive if infrastructure managers can monopolise substantial cost reductions and not pass them to customers in the form of lower prices, as it has been identified in France for smart electricity meters (Court des Comptes, 2018).

40. Finally, as the social marginal return on innovation is normally higher than the private one, regulatory support for innovation in infrastructure might prove to increase consumer welfare.

5. Technology can transform the use of infrastructure

41. Technology is not only transforming infrastructure itself, but it is also transforming the use of infrastructure. Some transformations driven by the infrastructure managers have the ability to reduce costs. However, not all infrastructure has the same potential to reduce costs and cost reduction might not happen at the same pace. Furthermore, technology is empowering users to modify their using patterns and find alternatives to reduce their expenditure. Therefore, uncertainty on the distribution of traffic flows might increase.

42. Infrastructure managers have new tools to manage demand and increase efficiency. Adapting capacity to demand is the key strategy in infrastructure management. Infrastructure presents obvious network effects: the larger the number of users, the larger the pool to distribute the high fixed sunk costs of operating the infrastructure. It is not by chance that infrastructures are considered network industries. However, as network industries, they may also face negative network externalities, for instance in the form of congestion. A mechanism to reduce congestion without diminishing the use of the infrastructure is to distribute traffic evenly across time and space.

43. Technology provides instruments to adapt demand to capacity. As infrastructure managers have new tools to predict traffic flows (predictive algorithms), they can incentivise the use of the infrastructure in off-peak periods against the use in peak periods. Infrastructure managers have always tried to manage demand. The novelty is that infrastructure managers can now predict peak/off-peak usage in real time with far more accuracy, depending to several factors (time of the day and year, weather, specific events, etc.). They can build more sophisticated pricing schemes, based on metering and billing. For example, smart meters in electric networks are increasing the sophistication in the pricing of the service, with incentives to reduce consumption when demand is peaking.

44. Infrastructure managers can also respond to fluctuations in demand in real time through dynamic pricing. They can automatically adapt their metering and billing systems, as well as to inform the users in real time so they can take their consumption decisions. Infrastructure managers can also reduce congestion by distributing traffic across the network in ways that are more efficient. Discounts can be offered to users if they take alternative roads, or if they take alternative railway services, possibly with a detour that requires more time. Such network management is possible if the infrastructure manager has better knowledge in real time of the situation of the network (or is in the position to predict it effectively) and has the ability to respond in real time with new alternative capacity and new prices.

45. As a conclusion, a larger control over the load factor empowers infrastructure managers to adapt the existing capacity of the infrastructure to cope with growing demand without congestion. This ability can also be used in case of unpredictable events, such as black-outs and accidents. In this way, costs can be reduced very substantially.

46. However, not all infrastructure has the same potential to reduce costs, or to reduce them at the same pace or amount. Road transportation costs might be substantially reduced as automation (autonomous vehicles) is implemented for freight and passenger transportation. Road transportation might gain a competitive advantage over railways, which do not appear to get similar cost reductions from automation. These secondary effects are out of the control of the infrastructure managers, and they add uncertainty in the planning of investments in infrastructure.

47. Technology does not only empower infrastructure managers. It also empowers users, giving them more information about alternatives, and the ability to switch to such alternatives.

48. Technology is empowering users to better adapt the infrastructure-based services to their specific needs in each moment in time. Infrastructure managers are increasingly required to provide infrastructure-based services. This is commonly named "infrastructure as a service". Telecommunications bandwidth as a service, also named "Software-Defined Networks", is a good example. Business users are increasingly demanding telecommunications services that adapt to the capacity they need at any given time. If they need more bandwidth because their servers are getting more traffic, the telecommunications infrastructure manager can increase in real time the available bandwidth (and the price charged for it). When demand returns to normal, bandwidth and price will be reduced. The "bandwidth on demand" services are already a reality (Kreutz et al., 2015). Dynamically adapting supply to the needs of the user increases the difficulty to manage the load factor of the network and may increase costs, as capacity has to be increased to meet peaks in demand.

49. Even more important is the empowerment of the users to substitute the provision of the infrastructure-based service. Infrastructure managers have traditionally operated with little or no competition, either from direct competitors (monopolies have always abounded in infrastructures) or from other infrastructures, offering some degree of substitution. Technology is now offering new alternatives.

50. First, digitalisation has created new services that directly compete with traditional infrastructure-based services. In some cases, the new digital services are displacing the old physical services. Postal services are the best example, as letter mail is being displaced by electronic mail at a rate of 4% to 7% annually worldwide (Finger, Bukovc and Burhan, 2014). Under these circumstances, it is evident that the revenue needed to finance infrastructure has severely decline.

51. Second, digitalisation has helped new service providers to enter the market, reducing the traffic managed by traditional infrastructure managers. This is the case of long distance car-pooling services in the sharing economy (Montero, 2018). Railways faced limited competition from air and particularly road travel in countries such as France, were the service was provided by SNCF under exclusive rights and parallel coach services were traditionally prohibited until the 2015 "*Loi Macron*". Nowadays, technology has empowered passengers to contact private drivers to get a ride to their destination. Therefore, railways experienced losses between 6 and 10% of passengers in 2015 (Finger at al., 2016). Coach companies in Spain claim 20% revenue reductions for the same reason (Montero, 2018).

52. A similar effect is emerging in the electricity industry. Alternative distributed networks – for example, consumers installing their own power generating technologies, are challenging traditional centralised networks, often with exclusive rights in their territory. New players have entered the market, including equipment manufacturers, digital companies, telecoms, and start-ups (McKinsey, 2018), but it is difficult to quantify the impact at this stage.

53. Third, digitalisation is not only enabling users to select infrastructure-based services, but also to optimally combine them. This is particularly the case in transportation, as different networks provide partial services and often lack a door-to-door service (for both passengers and goods). Digitalisation and algorithms allow users to identify the

existing options and the fastest/cheapest combinations of transport modes. Users can therefore migrate to new transport modes, as they have better information.

54. Actually, digitalisation challenges the strategy of traditional operators to increase scale and integrate into neighbour markets to control all the value chain. This strategy has been particularly clear in maritime transport. A handful of large shipping companies are building ever-larger container ships. Such mega-ships demand the transformation of ports and furthermore they are transforming the logistic chain, as shipping companies vertically integrate to control all the logistics supply chain, from door to door. They are creating large centralised networks (See Annex below). As an opposite strategy, online platforms aim to grow scale by logically connecting a large network of suppliers and the largest pool of demand. Platforms create decentralised networks empowered by technology. In the following years, we will see the confrontation of centralised and decentralised networks not only in transportation infrastructure, but also in electricity, media, etc.

55. Overall, technology is introducing more uncertainty in the management of infrastructures. Even if technology is providing new instruments to predict and manage traffic flows, technology is also empowering users to make a more effective use of the existing infrastructures, and to introduce more competition among infrastructures.

6. Disruption by new players in the data layer: online platforms

56. Online platforms are transforming the traditional industrial organisation paradigm of large vertically integrated corporations selling goods and services to consumers, into a new model in which online platforms create a multisided market facilitating the interactions between goods and service providers and users (Rochet and Tirole, 2003, Evans and Schmalensee, 2016, OECD, 2009). This is affecting energy, telecoms and transportation industries. Infrastructure managers might become mere commoditised providers working for a platform. Funding for infrastructures might be at risk.

57. A fundamental source of disruption in infrastructure management is the increasing relevance of new players in the data layer. As infrastructure is digitalised, and a mirror is created at the data layer, new players have the ability to take a leadership role in the management of such data, and extend such leadership role to the management of the underlying systems, transforming the use of the infrastructure and substituting traditional infrastructure managers as coordinators of the systems.

58. Online platforms are the leaders in the new data layer. Once an industry is digitalised and a data layer is created on top of it, transaction costs can be drastically reduced. The internet reduces communications costs to nil. Algorithms reduce search costs, information costs and bargaining costs. Platforms can introduce mechanisms to increase trust and reputation (OECD, 2017).

59. The larger the pool of actors interacting through the platform, the larger the network effects: direct effects, indirect network effects and even data network effects. The value created by online platforms should not be underestimated. Network effects grow as the number of users grow. Interesting studies are being developed on the valuation of network effects (for a critical analysis Briscoe, Odlyzko, and Tilly, 2006). Platforms are internalising massive network effects as they pool together incredible large volumes of users. The most successful platforms measure users by billions (Facebook, WhatsApp, YouTube).

60. A more concrete example of the value created by platforms can be described for ride-hailing platforms such as Uber, Lyft and Didi. Platforms make isolated cars work as a network. They identify the location of drivers and riders, and they efficiently match drivers and riders, reducing empty runs. The higher the number of drivers and riders, the shorter the drive to pick up the rider, so the shorter the waiting time for the rider, but also costs are reduced for the driver. Cost reductions have been aggressively passed to riders. Lower prices generate new demand, igniting a virtuous cycle. This is not related to license costs, labour conditions or regulated tariffs. This is the power of network effects. Network effects are even more relevant if riders are ready to share a vehicle for all or part of a ride. The platform coordinates different requests for transport in the same area or direction. Large pools of riders make it possible to match different travel requests to be served by a single driver. Rides take a little longer, but the cost reduction is evident, as the cost is distributed among more than one rider. In terms of prices for the rider, it can add a further reduction of up to 50%, and again, lower prices generate new demand. A further twist was introduced in late 2017, when Uber launched ExpressPOOL. If the rider is ready to compromise with the pick-up and drop-off points, by walking to more efficient locations in order to streamline routes, the price can be 75% lower than the regular Uber service (Washington Post, 2018). This is the power of indirect network effects.

61. Online platforms are disrupting an increasing number of industries. Search platforms, such as Google, and social network platforms, such as how Facebook has disrupted media and content industries, as they have facilitated new and innovative interactions between content providers, advertisers and audiences. These platforms have generated indirect network effects at a previously unknown scale, displacing traditional players in the media industry. Platforms such as Amazon and eBay are creating new marketplaces connecting sellers and buyers again at a previously unknown scale, creating massive indirect network effects. Traditional retailers are being displaced.

62. Online platforms are transforming traditional network industries into multisided markets. The traditional direct link between service providers and users is being substituted by an intermediated relationship, in which an online platform intermediates in the relationship and matches service providers and users. Service providers become a mere side in a multisided market, the service is "commoditised", and the online platform takes the lead in the coordination of the system. There are multiple examples of such a trend in the infrastructure network industries.

63. The most wide-ranging disruptions are taking place in the energy sector, as new technologies (wind, solar, etc.) are making possible the generation of electricity at the periphery of the network. New distributed networks have the ability to substitute the traditional vertically integrated centralised system of electricity generation, transmission and distribution. Distributed networks pose a new challenge for the coordinator of the system, as users become at the same time producers ("prosumers") so the number of producers is increased and traffic flows are less predictable. For the first time, the possibility to create small efficient distributed networks as an alternative to large centralised networks is becoming a reality. Online platforms, and their algorithms for the dynamic matching of distributed production and demand, are key in the transformation of the industry. New platforms for the exchange of electricity to charge electric cars are a good example.

64. In transportation, platforms such as Uber, Lyft and BlaBlaCar are disrupting passenger transportation. No significant innovation has taken place at the physical layer. The same kind of vehicles are being used. The innovation is actually taking place at the data layer. Online platforms have transformed previously isolated vehicles into a virtual network, and they have made this network available for passengers at the tip of their fingers. Online platforms have created a new market, a multisided market, automatically matching drivers and passengers. Online platforms coordinate the market, as they define the conditions for matching drivers and passengers, and they manage the transaction (including prices). Drivers provide the infrastructure (vehicles) which is a mere commodity coordinated by the platform, whose algorithms determine when and how will provide a service to a passenger.

65. Online platforms are becoming intermediaries in the provision of different transport services, to satisfy whatever transport need of a passenger (Finger and Audouin, 2018). Uber is facilitating not only car rides, but also bicycles and scooters, and they have entered into agreements with some transit service providers. A more ambitious example is Whim by MaaS (Mobility as a Service). Originally in Helsinki, but also in Amsterdam, Antwerp and West Midlands (UK), Whim provides under one app, and for a fixed price, unlimited access to taxis, bicycles, car rental and all the public transportation in the city (Holmberg, 2016). There are multiple start-ups with the ambition to extend this model to freight transportation.

66. In telecommunications, platforms such as Skype and WhatsApp have disrupted the traditional carriers. Individuals with an internet connection can communicate with other users without using the specific services of the carriers (telephony, SMS, etc.) and mostly free, as no fee is required by the platform. Peer-to-peer software provided by the platform empowers users with an internet connection to direct connect with each other, creating a distributed network on top of the traditional telecommunications infrastructure. It is not by chance that these platforms are called "Over The Top" (OTT) providers in the industry lingo. As traditional carriers used to charge by the minute for voice conversations and each message for SMS, they had to change their pricing structure to charge fixed fees for access to the internet and a bundle of services, and not rely exclusively on revenue for the use of traditional services. According to OVUM (a London-based research firm), the overall value erosion for the telecom industry by OTTs can be estimated to be $386 billion between 2012-2018, or 81% of the average revenue per mobile user in some emerging markets such as Nigeria.[2]

67. In any case, online platforms are not a perfect substitute to existing infrastructure. They might switch traffic from one infrastructure to another (as from railways to roads in the case of BlaBlaCar), but they are not developing alternative physical infrastructure, so they will always rely on the traditional infrastructures.

68. However, online platforms might pose risks for the funding of infrastructure. First, they can reduce revenue generated by traffic. Second, they can reduce revenue as they allow users to hack the existing pricing structures, as in the case of OTTs in the telecommunications industries. Thirdly, platforms are businesses that require their own revenues to operate. Platforms in the content industries have successfully financed their operations with advertisement. In the infrastructure network industries, however, platforms usually take a commission in the intermediated services. Such a commission can detract some value captured by the infrastructure manager. Finally, platforms tend to aggressively reduce the price of the underlying service to increase demand and ignite virtuous cycles, but with infrastructures such a strategy might create congestion in the short term, and degrade the infrastructure in the long term, as funds for maintenance might be reduced.

69. A more structural effect of platforms on the funding of infrastructure can be identified. As infrastructure managers become mere sides in a multisided market, the platform gains influence in the provision of the service. The platform has the ability to nudge users from an infrastructure to another, from a transport mode to another, from a telecommunications infrastructure to another, from an electricity producer to another. The services mediated by the platforms become commodities, subject to new competitive pressures.

70. To sum up, there is clear evidence that platforms can diminish the value traditionally captured by infrastructure managers, either because such value is captured by the platforms themselves (commissions), of because it is eroded by the new competitive pressure created by the platforms. Even if platforms bring efficiency to the infrastructure industries, they might increase the difficulties for funding the creation and maintenance of infrastructure. Furthermore, platforms are gaining a leadership position as coordinators of the infrastructure networks, substituting infrastructure managers and regulators.

[2] See reference in https://www.forbes.com/sites/parmyolson/2015/04/07/facebooks-whatsapp-voice-calling/#6fb4dc311388 and https://guardian.ng/business-services/whatsapp-other-otts-slash-81-of-operators-revenue-in-13-years/

7. Strategies for the digitalisation dilemma

71. Infrastructure managers, as well as regulators, are not bound to be mere spectators in the process of digitalisation and emergence of new market structures. Lessons can been learnt from other industries that have been put under a platform, or "platformed" (Montero and Finger, 2018). The transformation of the existing market structures seem unstoppable. Platforms can bring substantial efficiency to network industries, as they create new powerful network effects. Infrastructures will always be necessary, as they will only rarely be substituted by digital services (as seen in letter postal services). Infrastructure managers have to adapt to the evolution of the market structure and find the right place in the new ecosystems. Traditional infrastructure managers have been adopting different strategies.

72. Infrastructure managers might be tempted to reduce the speed of digitalisation, or even not to digitalise their infrastructures at all, as to delay the rise of platforms in their industries. This might not be a wise strategy and does not appear to be in the general interest. Efficiencies derived from digitalisation are too significant to be ignored, as described in the previous Section. Even more importantly, this strategy might not work in the long run. As in a traditional prisoner's dilemma, competitors (where they exist) might embrace change and monopolise the benefits of a good relationship with the platform operator, making the position of the traditional player even weaker.

73. Even infrastructure networks run by a monopoly might not succeed in avoiding the rise of a platform by delaying digitalisation. Data about an infrastructure can be extracted by the infrastructure manager installing sensors, but it can also be extracted by third parties in the most creative ways: data on traffic can be extracted from passengers' smartphones, from sensors installed in vehicles using an infrastructure, by sensors installed in the cargo being transported, by meters used by the users of electricity networks, etc. Platforms can be built over data generated by third parties, not only data generated by the infrastructure managers.

74. Infrastructure managers can vertically integrate into the data layer and build platforms for their industries. This is a common strategy and there are many examples of infrastructure managers creating platforms, such as railway undertakings, shipping companies, telecom operators, electricity utilities, etc. They have the ambition to intermediate not only in the provision of their services, but in the provision of services by third parties, sometimes close competitors. Obviously, other service providers are suspicious and tend not to participate in platforms managed by competitors, as they are afraid they would be discriminated against - in favour of the operations of the competitor managing the platform. There are successful platforms led by vertically integrated companies, such as Amazon Marketplace. However, it seems clear that not all members of an industry can become platform operators. This is not the way forward for all infrastructure managers.

75. The challenge for all actors (infrastructure managers, candidates to become platforms, users, public authorities funding infrastructures, but also regulatory authorities) is to ensure the emergence of a balanced and sustainable competitive environment. However, the system will only be sustainable if the new value created is fairly distributed, and in particular if infrastructure managers are not deprived of the necessary funding for the maintenance and construction (see the previous Section). This is a difficult balance to achieve.

8. The new regulation of networks industries

76. The current regulation of infrastructure networks has to evolve to take into consideration the accelerated technological disruption introduced by digitalisation. Five specific changes can be identified

77. First, more objective grounds have to be defined for the intervention of regulatory authorities regarding technological transformation itself. Regulation often determines the pace of introduction of technology in infrastructure networks. Regulation can accelerate and even make the adoption of technology compulsory. This was the case with digital electricity meters in the European Union (Directive 2012/27/EU). But regulation can also be an obstacle for the deployment of technology. A good example is the U.S. Federal Aviation Administration (FAA) Rule on small unmanned aircrafts (drones) adopted in June 2016. It restricts the operation of drones for delivery networks as drones can only be operated with visual line-of-sight.

78. The right balance has to be identified. Regulatory authorities have to ensure safety in the operation of infrastructure. At the same time, regulatory authorities have to abrogate unnecessary or outdated obstacles to the use of new technology. This is certainly a challenge, as good knowledge of technology is necessary.

79. The principle of technological neutrality, applied in particular in the telecommunications industry, seems to be a good policy option. The main features of technological neutrality are that regulatory authorities should set targets, but no specific technological options to achieve such targets. The same regulation should apply to a service independently of the technological solution applied to provide the service. And regulation should not favour one technology alternative over another (Maxwell and Bourreau, 2014).

80. Second, regulatory authorities will have to work across traditional "silos" to regulate infrastructure. On the one hand, collaboration between regulatory authorities with different areas of competence and expertise will be necessary. As network industries converge, regulatory action will have to converge, through different forms of co-ordination and collaboration. Existing collaboration will have to expand to other authorities, such as telecommunications regulatory authorities in charge of the spectrum, to ensure all infrastructures are connected, and data protection authorities, to control the use of data generated by infrastructures. A successful example was the combined intervention of civil aviation authorities and telecommunications regulators to make possible the use of smartphones in aircrafts.

81. On the other hand, regulatory authorities will have to collaborate increasingly across geographical and administrative borders. Infrastructure regulation was traditionally local, as infrastructure was unavoidably connected to the territory. However, infrastructures are linked increasingly into global networks, as the case of maritime transport demonstrates. Although originally built to serve local areas, assets have been weaved together to meet greater demand, In the presence of shocks or failures, these cascade much more rapidly and have more profound consequences in globally-connected infrastructure networks. Furthermore, the data layer knows no geographic borders. Platforms operate across states.

82. Regulation should cope with the new multi-service nature of infrastructure managers, where informational services based on digitalisation are provided alongside the

more traditional offer of simple access to the infrastructure. These complementary services could enhance the welfare of consumers, but they could also be used to keep a dominant position in the market, or to leverage on it to acquire power in adjacent markets. Furthermore, it is necessary to redesign the system of incentives in regulated markets, to avoid either a lack or an excess of innovation in this respect.

83. Third, regulation has to be adapted to more liquid markets, with shorter business cycles and higher risks. Infrastructure traditionally had very long business cycles, often measured in decades. Once an infrastructure was deployed, opportunities to adapt it to new circumstances were very limited. At the same time, use patterns tended to be stable and traffic flows predictable within reasonable limits. The incorporation of digital technology into traditional infrastructure leads to shorter business cycles – obsolescence occurs after a few years, not decades. And technology is increasing risk. Infrastructure managers face new risks derived from the investment in technology. While technology offers opportunities to reduce costs, the selection of the specific technology, and the fast evolution of technology generates risks. Infrastructure managers face more risks as demand patterns are becoming more uncertain. In transport, increasing competition between alternatives that were poor substitutes in the past is making traffic flows more difficult to predict and control. As automation impacts on the cost base of the different infrastructures at different paces, further migrations of traffic from an infrastructure to another will take place.

84. Uncertainty recommends considering a reduction in the duration of long-term infrastructure contracts. As technologic change accelerates, risk increases for the operators of infrastructure. Long-term contracts might collapse, to the detriment of the infrastructure manager but also of consumer welfare. In the short term, bidders might react by increasing prices to protect themselves against uncertainty in long-term contracts.

85. Fourth, regulatory authorities have a role to play in the emergence of the new market structures due to digitalisation. Regulatory authorities have to understand that their policies have an impact in the balance of power between infrastructure managers and online platforms. On the one hand, there is a clear risk of regulatory capture as traditional players make use of their close relationship with regulators to obstruct innovation. On the other hand, regulatory authorities might unbalance the power relation in favour of platforms by imposing regulatory obligations on infrastructure managers that do not take into consideration the evolution of the market. Some of the obligations imposed on infrastructure managers such as "net neutrality" obligations in telecommunications (Wu, 2003), which might be extended to the transportation (Montero and Finger, 2018) or electricity industries, may reinforce the position of platforms against infrastructure managers. The regulatory obligations to serve platforms, either as distributors or as wholesale customers, or to provide them with data, under regulated terms (no discrimination, regulated conditions, etc.) could unbalance the necessary commercial negotiations that have to determine the conditions for the cooperation between infrastructure managers and platform operators.

86. The European Union is leading on online platform regulation. On the one hand, the European Union is proposing to level the playing field by increasing the regulatory obligations on platforms. Sector specific legislation is under preparation in the telecommunications and media industries to extend some regulatory obligations from traditional players to platforms such as YouTube, WhatsApp and Skype. On the other hand, the European Union is already working on the regulation of the relationship between traditional businesses and online platforms, including matchmakers, search engines etc. (regulation on promoting fairness and transparency for business users of online

intermediation services). The European Union is also considering imposing obligations on transparency in the algorithms and redressing mechanisms such as internal complaint-handling systems and mediation by third parties.

87. Fifth, regulatory action has to take into consideration the new role of platforms as coordinators of complex systems. Regulatory authorities could traditionally focus their attention on infrastructure managers, as they concentrated the coordination role in the management of the complex systems associated with infrastructures. They build and operate the physical infrastructure. Very often, they vertically integrate and they provide services using the existing infrastructure (this was the case in telecommunications, railways, electricity, etc.). But they also play a more important role as the organisers of the system, determining capacity, prices, managing congestion, etc., often under the supervision and control of regulatory authorities.

88. Regulation has typically overseen infrastructure managers both in their role as pure managers of the infrastructure and in their role in the coordination of the complex infrastructural systems. As deregulation led to market fragmentation, regulatory authorities partially substituted the coordination role of the infrastructure managers. Competition fragmented the market as new players compete with the traditional monopolies (telecommunications, electricity, railway and air transport, postal services, etc.). Compulsory vertical unbundling has further fragmented some of the infrastructure markets (in particular electricity and railways). New regulation was developed to coordinate the different players in each industry, in particular though access and interconnection regulation.

89. Regulatory intervention now has to include platforms as they take a central role as coordinators of the systems in multisided markets. They have an increasing role in managing capacity, setting prices, arbitrating among substitutes, etc. These are the roles traditionally played by the infrastructure managers under the control of the regulators. Regulatory authorities cannot ignore such a new leading role.

90. Regulation is often fostering this trend. On the one hand, deregulation has fragmented the infrastructure industries with new competitors and the unbundling of the vertically integrated monopolies (Montero and Finger, 2018). On the other hand, and perhaps surprisingly, regulation is sometimes ignoring the market power of new actors in the data layer (as advanced in Sections 1 on information asymmetries and Section 2 on growing market power). Examples are regulatory obligations such as “net neutrality” in telecommunications, obligations to share data under consideration for transport service providers, and even obligations on ticketing, which could advantage platforms over traditional infrastructure networks.

91. It should be noted that the new coordination role played by the online platforms is often managed through “black box” algorithms (Pasquale, 2015). In the analogue world, the decisions of the infrastructure managers (capacity, prices, management of congestion, etc.) were public and subject to public discussion and the scrutiny of the regulators. In the digital world, platforms coordinate industries through algorithms that are not public, that are constantly evolving, that can be different in each jurisdiction and even for every user, and that are driven by the interest of the platform.

Annex 8.A. Case Study: The non-regulated disruption of the worldwide maritime freight transport network and its infrastructure

92. One major disruption reshaping the whole of world freight transport, both services and the links and nodes of their infrastructure networks, is that one regarding global supply chains that comprise at least one ocean seaborne leg: the vast majority of global international trade flows (UNCTAD, 2017).

93. Ships, ports, rails, roads, warehouses, etc. are under disruption all over the world: either undergoing a process of upgrading or in danger of being abandoned, because of technical or geographical obsolescence, and replaced by state-of-art new pieces of infrastructure or private capital assets.

94. This gigantic process of world "infrastructural change" is currently realised without any assessment of its efficiency, sustainability or fairness - that is any alignment of private and public objectives.

95. The process is driven by "decentralised" decisions taken:

- by private operators, normally acting within frameworks characterised by oligopolistic or monopolistic competition;
- by unilateral governmental decisions (included those taken by regional organisation such as the European Union); and
- by minor local "regulatory" ruling.

96. Nobody knows if we are getting the best value for citizens and businesses out of infrastructure networks, existing or under disruptive adjustment. No "benevolent dictator" is checking the alignment of private and public objectives.

97. What follows, summarised in table 1, is a rough description of recent trends.

98. Market conditions encouraging the seminal disrupting innovation: bigger and bigger container ships

99. The constant sustained growth in global seaborne container trade (UNCTAD, 2018) since the last decade of the 20th century (due to the high rate of growth of global GDP and – higher-- of global merchandise trade, and the continuous containerisation of previous general cargo), has made it increasingly possible and convenient the exploitation of economies of scale obtainable by an increase in the size of ships.

Table 1. Innovation driven disruption of the world maritime freight transport network

Disruptive innovation	Infrastructure disruption	Capital asset disruption	Market structure disruption	Business model disruption
Panamax Suezmax	Route disruption Network disruption			
Magaships	Port disruption and obsolescence	Fleet disruption	Oligopolistic competition	Sharing (alliances)
Megaports Port systems	Rail, road and inland waterways infrastructure disruption and obsolescence			
Megacargos	Consolidation and deconsolidation points	Warehouses and logistics equipment		Ship, port and logistics integration
Supply chain digitalisation				Ship, port and logistics integration Platform services

100. Due to the new Asian centrality in global manufacturing seaborne trade has gone concentrating along two main routes: the transpacific one connecting China to the USA and the Europe-Asia-Europe one. It is mainly along these two routes that repeated rounds of replacement of existing ships with new bigger ones have fuelled struggling oligopolistic strategies aiming at gaining growing market shares to the innovators.

Neopanamax and Suezmax: two "governmental" caps to megaships

101. Bigger and bigger container ships have been adopted until reaching those technical caps exogenously defined by "local" governmental decisions.

102. The first cap was set up ten years ago by Panama authorities with their decision of enlarging and deepening the Panama Canal in order to increase the largest size of a ship traversing their new locks. For few years the "neopanamax" standard (366 m. length, 55 m. beam and 18 m. depth/15 m. draft) was supposed to set the ceiling to container vessel size.

103. But then came Suez. Unconstrained ship length and beam and a 24 m. depth (20,12 m. draft) encouraged the container shipping companies to push their oligopolistic competition one step further.

104. That is why we now have the OOCL series ships, like the last OOCL Hong Kong with a carrying capacity of 21.413 TEU and a scanting draft of 16 m, and why we can easily predict new ships with a capacity of 22.000 TEU and beyond.[3]

105. The first consequence of this interplay between vessel size and canals' depth is that ship economies of scale can be fully exploited only along the Europe-Asia-Europe "golden route": all other routes becoming somehow less profitable and then, if possible, disregarded (route disruption).

106. The second consequence is that all comparatively smaller ships are becoming obsolete and their ocean going services to be scrapped soon. Some of these ships can be

[3]) Current Suezmaz measures are tecnically supposed to allow fo a further increase in (container) ship size up to some 30.000 TEU

downgraded to serve as feeder connecting the few megaports called by megaships to other existing non-mega-ports (fleet disruption)

107. The third consequence is that the ocean maritime transport market is becoming a more and more concentrated one where oligopolistic behaviour prevails (market disruption).

108. This includes –-fourth consequence-- the creation of operational alliances running a business model that involves the ship-sharing between different shipping companies.(business model disruption). The Alliances formation is the only decision subject to the approval of US, EU and China regulating bodies

Megaships call for megaports (or sophisticated port systems)

109. The progressive substitution of existing ships with larger ones is producing much more profound consequences on port facilities.

110. Only few of the existing ports can accommodate large container ships. The eligible ones are those rich in adequate nautical accessibility (deep waters), large spaces on land and efficient and sustainable connections via rail, road (and inland waterways) to large markets. Since all three conditions can be modified by adequate investments the choice of the megaports made suitable for mega ships is a delicate one. (Port disruption)

111. With two opposite potential dangers. Port overcapacity, when too many ports are try to stay on the contestable global markets and/or rail, road, inland waterways infrastructure underutilisation when the lack of port capacity acts as a crucial “missing link” in the networks.(rail, road, etc. disruption)

112. The coordinated use of all transport infrastructure to be used along the routes followed by global supply chains is crucial for “getting the best value for citizens and businesses” from existing or disrupted infrastructure. By definition there is a delicate governmental role at stake.

Mega ships carry mega cargoes

113. Megaships carry megacargoes ultimately consolidated when loading the ship and deconsolidated at sea (transhipment in a ship-to-ship hub and spoke system or in a ship-to-barge direct final call system) or when unloaded in port. The consolidation/deconsolidation of megacargoes pass through successive steps dealing with sub consolidation/deconsolidation phases. The choice of megaports will dictate which selected links and nodes of the multimodal transport infrastructure networks will be made available for dealing with the freight consolidation/deconsolidation along each supply chain route (land leg and port node on the departing country, maritime leg, and port node and land leg on the receiving country). The choice (competition, when possible) among different routes is somehow in the hands of the government, because of its final say about infrastructure provision, but it is also controlled by the supply chain users: the freight forwarder combining the maritime leg, port legs, and land legs. If, as in the current situation no regulator is supposed to take care of this business, the only agent not controlling the cost and the quality of the service is the final receiver that pays the bill.

114. It is worth noticing that the complexity of the megacargo consolidation/ deconsolidation process and the necessity of dealing with sub-consolidated/sub-deconsolidated lots make the value added generated in this logistic phase greater than that

generated by the pure maritime transport services. Then a new business model is emerging: the one that foresees the vertical integration, under the same firm roof, of the maritime and port services and/or of the maritime, port and logistic services (integrated physical business model)

115. But this integration is eligible for being digitally operated by a suitable platform run by one of the operator controlling one leg of the supply chain or by a third specialised party (digital business model).

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