

The economics of Africa's floriculture air-cargo supply chain

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ABSTRACT

This article examines the economics of Africa's emerging air cargo supply chains, taking floriculture as a case study. Floriculture is an important employer, and earner of foreign exchange for several regions of central/southern and eastern Africa including more recently Ethiopia. Air transportation often plays a critical role when the supply-chain involves high-value, non-durable, relatively light-weight, and compact consignments such as flowers, and geographically when regions are difficult to access by other trunk modes. The success of air cargo chains, however, depend as much on the quality of surface modes serving various "last mile" access and egress functions, as well as efficient nodal interchange points and the availability of suitable airport and airline capacity. The last, because of the important role of belly-hold space, includes consideration of passenger as well as cargo specific services. To meet the needs of Africa's floriculture sector, a variety of supply-chain models have emerged that embrace air and surface links, as well as storage at various points in the chain. The paper considers the nature of these chains, the *raison d'être* for their structures, and their limitations.

1. Introduction

The most dynamic trading regions are now those that have become linked into the network of global value chains. Unfortunately, Africa is not a significant player in these networks. Drivers for the development of global value chains are considered to be low transportation costs; information and communication technologies; high quality telecommunication infrastructure; technological innovations; education and skills of the workforce; competitive labor costs; political, social, and cultural environments; stable legislation and ability to enforce contracts; proximity to supply sources; and proximity to market. In general, Africa falls short in most of these.¹

The focus of this paper is on the peculiar economic challenges associated with Africa's floriculture aviation supply chains.² The requirements of this industry differ considerably from the traditional view of supply chains in Africa with their focus of bulk raw materials and cheap consumer goods.³ The modes used differ, the organization of the various links in the supply chain differ, the perishability of the products differ, the informational needs differ, the linking of the long and the

short hauls differ, and so on. And, importantly, the aviation supply-chain dominates the delivery of transportation to the floriculture industry.

Africa has the world's worst road, railroad, and airport infrastructures in terms of both quantity and quality (Gwilliam, 2011; Buys et al., 2010). It also has the least number of commercial aircraft per capita. Having said this, the forecasts for aviation activities are relatively optimistic. Boeing Commercial Airplane (2018) predicts that intra-Africa revenue passenger kilometers flown will grow an average annually by 6.6% between 2019 and 2038, and those between Africa and the Middle East and Europe by 7.3% and 4.1% respectively. Physically, air cargo is projected to grow between Africa and Europe by 3.7% per year, between Africa and East Asia by 6.1%, and between Africa and North America by 5.3% per year. But this is from a small base.

This paper looks at the economic challenges that still confront aviation-based floricultural supply chains in Africa, and how they are being confronted. This is done largely within a managerial-economics framework.⁴ I am much less concerned with the other significant

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¹ The majority of work for this paper was completed before the onset of the Covid-19 pandemic. It is implicitly assumed, therefore, that the impacts of the virus are transitory and will have few long-term effects on the supply chain under consideration. For a brief overview of the immediate impacts of the virus on Africa's floriculture industry before mid-April 2020, see Bhalla and Wuilbercq (2020).

² Although the terms air transportation and aviation supply chains are sometimes separated, with the latter being more inclusive, I use them interchangeably to embrace the software, hardware, and orgware that is deployed when air transportation constitutes the dominate mode in any supply chain (Dobrov, 1979).

³ Leinbach (1995) offers a more traditional view of the transportation needs of developing countries.

⁴ It is assumed that decision-making processes in the chain aim at efficiency in the neoclassical economic sense, rather than the larger perspective of more contemporary behavioral approaches to management economics (Durach and Wiengarten, 2019).

challenges these supply chains encounter, such as culture and ethics issues (Hughes, 2000, 2001), although there is some discussion of the various forms of governance and government set within Williamson's (2000) new institutional economics. Methodologically, the article is an exercise in what used to be called "descriptive economics"; and which should not be taken as a pejorative term.⁵ It involves gathering and compiling data about the economy and entails economists making observations, noticing patterns and recording facts. Descriptive economics is mainly qualitative and inductive in its nature.

Initially, the general characteristics Africa's floriculture sector are outlined, and the aviation services available are described. I then move to the specific challenges of the floriculture supply chain. Finally, attention is paid to the main African chains, with a focus on the alternative structural models in place. These chains involve the linking of short-haul domestic African routes and their interface with inter-continental, trunk-haul airline services as well as the air transportation itself.⁶

2. The economic geography of Africa's floriculture

Africa's modern commercial flower production began in the 1960s. It has always been largely an export orientated industry. Flowers are neither a major part of most African cultures nor used much in decoration. Outside of Africa, prior to the 1960s demands for cut flowers in Europe and North America were met by local production. In Europe, which still has the largest per capita consumption of stems in the world, and about eight times that of the US, production was concentrated in the Netherlands.⁷ With the coming of expedited movements within the EU, it also became possible to economically produce cut flowers in Southern Europe.

The energy crisis in 1973 put producers in northern Europe under further pressure because of the higher costs of greenhousing. Subsequently, the supplying of cut flowers to European markets began to shift to lower cost producing regions with climates that allow continuous production without high-energy consumption. Growing exportable floriculture products in Africa then became concentrated in Kenya and South Africa, with Uganda, Tanzania, and especially Ethiopia rising in importance over recent years. Zimbabwe's output declined dramatically from the early 1980s with the country's land reforms but there has been some recent recovery (English et al., 2006).⁸

At the same time, new markets are being developed for floriculture products in East Asia, the Middle East, and the US. Kenya's current 500 t of daily exports of flowers, for example, end up in 60 national markets. Ethiopia's growers, and exporters, while continuing to encourage trade with traditional European partners, have also begun exporting to Saudi Arabia, Qatar, and Bahrain. Accompanying this have been tighter controls imposed by importing markets and, in particular, on the quality of products and on the environmental implications of their cultivation (Kuiper and Gemählich, 2017). This has increased costs of production, and particularly so for some of the newer regions.

The traditional distribution channels, notably the flower auctions in

⁵ The approach has an established pedigree and is, for example, referred as one of several branches of economics by Jevons (1871), generally seen as the father of mathematical economics, in his seminal work on *The Theory of Political Economy*.

⁶ In doing this there are inevitable caveats regarding the quantity and quality of data. While global bodies, such as the World Bank and the African Development Bank, and national governments, collect some aggregate statistics, much of the information regarding specific African supply chains is piecemeal, often gained from case studies or profession bodies in individual countries, and sometimes from the grey literature. Additionally, up-to-dated information can be found at the website of organizations cited in the text.

⁷ Individual cut flowers are "stems".

⁸ <https://www.floraldaily.com/article/9016096/zimbabwe-making-flower-exports-blossom-again/>

Amsterdam, are responding to this. The auction systems have been computerized and the auction houses have taken on new roles including acting as intermediaries between growers and buyers when flowers go directly to final consumers (Mwangi, 2019). Competing auctions have also emerged, most notably in Dubai (Babalola et al., 2011).

Despite these developments, Africa's floriculture industry is at the micro-level, geographically specific. There are variations in the needs of the varieties of plant grown, with each depending on appropriate amounts of sunlight, a narrow temperature range, and water supply, as well as specific soil compositions. Altitude can be important in some cases. There are also differences in the ideal agroecological conditions for cultivating plants and cuttings for export as opposed to stems. The regions around Lake Victoria are, for example, ideal for long-stemmed cut roses as are 1200 ha on Lake Tana in Ethiopia, the source of the Blue Nile, and another 2000 ha on the Blue Nile itself.

The majority of floriculture in Africa is located within relatively short distances of international airports. Most of Ethiopia's floriculture is, for example, within a 290 kms radius of Addis Ababa airport. Similarly, Kenya's flower farms are mainly situated around Lake Naivasha, about 90 kms northwest of Nairobi airport. From an employment perspective, however, they do not bring more farm jobs to rural areas, but rather work is focused close to major cities, reinforcing urbanization trends. One reason for this is the cost structure of the industry. Although this can vary a lot according to location, climate, and product type and quality, for an 18-ha farm near Lake Naivasha the cost per stem was estimated in 2015 at \$0.03 to \$0.04 for growth and \$0.05 to \$0.07 for transportation.⁹ A stem would sell wholesale for \$0.20 to \$0.30.¹⁰ Given that production costs are largely fixed – wages are often already low and most operating capital is tied up in such as irrigation systems, cold storage, and ventilating systems – transportation is major variable element in the cost function.

Linked to this, another key factor influencing location is the lack of durability of stems. This means production has to be close to the trunk mode and there must be appropriate intermodal transfer facilities. Flowers and cuttings, for example, need to be at the retail market within days of cutting; e.g. roses last for three to five days, carnations seven to ten days, standard chrysanthemums seven to 12 days, and pompon chrysanthemums ten to 14 days. On average, for every extra day spent travelling flowers lose around 15% of their vase lives. Africa's surface transportation infrastructure, despite considerable investment over the past decade, is seriously deficient in both quantity and quality. Physical proximity to a major airport is, therefore, important to the floriculture industry.

Regarding regional economic effects, floriculture's impacts are highly geographically specific. Unlike many other agricultural products, floriculture workers migrated to and live in areas that have become urbanized as the flower business has developed around them. As noted earlier, this has contributed to urbanization rather than slowed it as intended with agricultural retention programs (Hall et al., 2017). The industry is important because it creates employment and development possibilities, and especially because it provides relatively steady work throughout the year unlike other agricultural activities (Mitullah et al., 2017; Kabiru et al., 2018). It is also a major employer of female labor, which constitutes about 75% of workers in Kenya's flower production (Kuiper, 2019). Although increasing over time, along with improved working conditions, farm workers' wages are in general still low. While the majority of those employed in floriculture in Kenya earn wages above the agricultural legislated monthly minimum (Dettmer et al., 2014) they still often fall below local poverty lines (Kazimierczuk et al., 2018).

There are also often problems of displacement. In the Lake Victoria

⁹ <https://gro-intelligence.com/insights/articles/east-african-floriculture-blossoming>

¹⁰ Taking 100 Kenyan shillings are about \$1.

region, for example, workers migrating to the area have led to tension with local society which has traditionally been supported by grazing. Floriculture's dependence on lake waters and the need for farmland not only raises concerns over ecosystem preservation but results in competition for water access and for land with local Masai herders. Cultural, conflicts also exist between the herders and Kikuyu flower growers (Kuiper, 2019).

3. Africa's aviation supply-chain capacity

Economic theory highlights the key market characteristics required for viable aviation networks, but Africa is an awkward “shape” for any of these (Scotti et al., 2017). The US is good for hub-and-spoke systems with its contiguous states forming a virtual square embracing large populations at each corner that act as gateways for international traffic as well as large markets for domestic flights. Major cities in the center act as domestic hubs. Europe is ideal for discrete, short-haul, non-connecting services emanating from bases, such as in Ryanair's business model. The bulk of its population and economic activity is located a dense economic corridor stretching from North Wales to Northern Italy; the “Blue Banana”. China, with its concentration of economic activity in the south and west, in many ways, parallels that of Europe. The linear networks found in such as Norway facilitate “bus-stop routes”, with planes maintaining their load factors by picking-up and dropping passengers as they move along routes. Most of Africa's human geography does not conform to any of these patterns.

Institutional structures have not helped the situation. Until the 1990s, intra-Africa air services were regulated on a piece-meal basis by restrictive, bilateral national agreements with nearly all carriers state-owned and lacking a commercial focus. Airlines were characterized by mismanagement, political interference, high operating costs, and outdated equipment. Their focus was on inter-continental traffic, with the intra-Africa network taking a secondary role. The 1999 Yamoussoukro Decision sought to readdress this. It was a commitment to deregulate air services and to open regional air markets to transnational competition. The expected gains have yet, however, to materialize on any scale, although in those regions where Yamoussoukro has been implemented, frequencies have often increased and privately funded airlines have emerged (Njoya, 2016). But the impact is patchy. The creation of a Single African Air Transport Market (SAATM), which has been planned since 2018, may offer another opportunity for enlargement of air services.

Most analyses of Africa's aviation supply chains have focused on tourism (e.g. Sifolo, 2020; Steyn and Mhlanga, 2016). This is not surprising given the overall economic contribution of the sector to Africa's economy. The World Travel and Tourism Council (2019) estimated that in 2018 tourism accounted for 8.5% of the continent's GDP. But, as we have also seen a number of Africa's regions have the geography to grow quality flowers in volume. Like tourism, floriculture has a high labor content and its localized economic impacts are often where unemployment is high and labor productivity has been rather low. Further, because Africa's floriculture is almost exclusively an export industry, it is a major source of foreign exchange.

Fig. 1 stylizes the stages in air cargo supply chains.¹¹ It is conceptually identical for passengers with some differences in terminology; e.g. warehousing would be hotels and integrators would be inclusive package tour operators. Basically, shippers can make all or some the decisions concerning modes of movement, routing, warehousing, distribution etc., or can engage integrators or forwarders to act as agents and carry out all or some of the stages. Some of these decisions are of a purely technical nature (Yang et al., 2010), but other, partly due to market uncertainties, are more subjective.

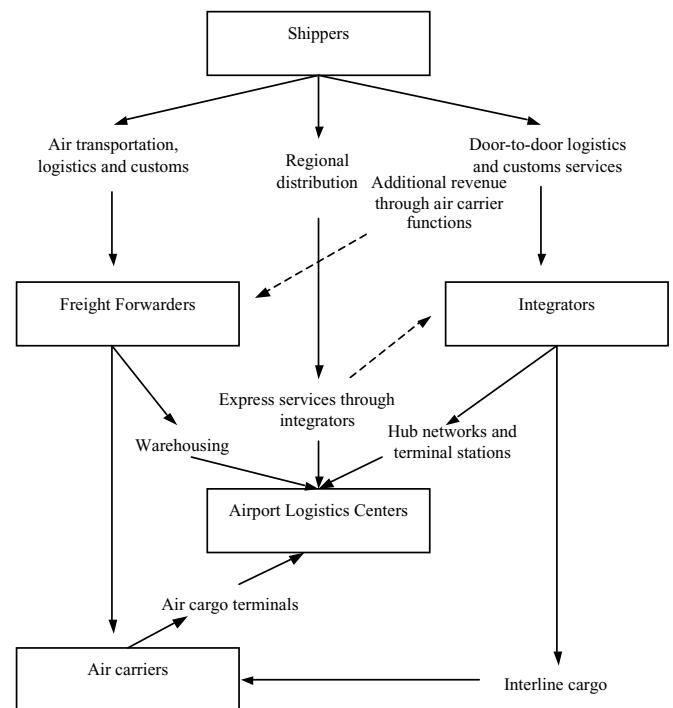


Fig. 1. The air cargo logistics supply chain.

Source: Kasarda et al. (2004).

The generic pattern of air cargo logistics and the branches in the decision tree are similar irrespective of whether the logistics involves developed or developing countries. The range of options, however, tends to be smaller when developing countries are involved, and some of the options may be of lower quality. This is particularly so with cold chains that require actions and equipment designed to maintain a product within a specified low temperature range from harvest to consumption. An increase in temperature beyond four degrees at any point in the cold chain, for example, compromises the quality of cut flowers.

At a more macro level, there are two broad frameworks typifying aviation supply chains, or at least to significant elements of them. One consists of a series of interacting free markets involving suppliers of various services and shippers – a set of standard neoclassical economic models. Looking again at Fig. 1, this does not mean that at each stage there is competition in selling services. In some cases, to minimize Coasian transactions costs, or to reap various forms of economies of scale, there may be vertical integration of suppliers of logistics services. Thus, as seen later, while Kenya has a largely competitive chain, it falls short of the neoclassical ideal. The alternative is a more command-and-control approach with the government, or a quasi-state corporation, controlling the supply chain, or key links in it. This, although not completely, is the model Ethiopia has adopted in its relatively recent move into floriculture. The authorities provide a considerable degree of “direction” in the chain.

A challenge in developing efficient aviation-supply chains lies in the size of the market. Economies of scale can be particularly pronounced, at least up to a point, in the provision of airport logistics centers (Martín and Voltes-Dorta, 2008) and forwarder/integration services. Economies of density, scope and other network features are relevant when providing airline services and regional distribution. In the African context, Barros and Wanke (2015), for example, find economies of scope are the most important variables for explaining levels of airline efficiency, although the impact of fleet mix and public ownership are also important. This generally means that passengers fares (important when cargo is carried as a complementary revenue source in a plane's hold) and

¹¹ See, Adewole and Struthers (2019) for the general features of the African logistics chain.

freight rates are higher for leaner markets combined with more spartan schedules. It also means that many air cargo services are indirect, collecting traffic along “bus-stop routes” rather than being direct between the flower growing regions and destinations.

Thinner markets also tend to be associated with less competitive airline conditions, affording users less opportunity to exercise any monopsony power they may have over fares and freight rates. There is something of a paradox here. While concentration of business in the hands of a few airlines and other actors along the aviation-supply chain can help reap the gains of various scale effects, lack of competition can lead to both allocative and X-inefficiencies, with suppliers having no incentive to minimize their rates. In this sense, the thin aviation markets found in much of Africa are below the threshold required to bring about a reasonable level of competition between airlines.

A recent change in Africa has been the emergence of Gulf and Turkish carriers (Pirie, 2017). Not only have these expanded dedicated freight services, but their extensive use of wide-bodied long-haul passenger jets has added belly-hold freight capacity on many corridors (Heinz and O'Connell, 2013). Inbound into Africa, the Gulf carriers have diverted traffic away from Africa's airlines. This includes flying out of major European cities such as London and Amsterdam, as well as their own hubs (Pirie, 2017). For example, Emirates' cargo-only service flew to five African cities in 2015. In the same year Qatar Airways launched a specialized freighter service into Djibouti when already operating freighters to Accra, Entebbe, Johannesburg, Khartoum, Lagos, Nairobi, and Etihad increased its freighter links to Africa with the launch of a twice-weekly service between Abu Dhabi and Brazzaville, via Lagos.

Airports Council International reports that Africa had none of the World's top 20 cargo airports in 2018. The main African hubs are at Johannesburg, Addis Ababa, Cairo, and Nairobi, with Lagos and Khartoum being somewhat smaller, and with much of their activity involving aid imports.¹² Other countries, such as Uganda and Ghana, have sought to increase their presence in the cargo market but suffer from inadequate landside facilities and poor access.

Most international air cargo operations confront challenges associated with asymmetric patterns of trade caused by natural market imbalances and institutional factors. These pose backhaul problems restricting maximum utilization of aircraft capacity and, given limited fifth-freedom rights, add to the risk of service withdrawal (Behrensa and Picard, 2011).¹³ Emirates' weekly inbound service to Lilongwe transporting mainly merchandise and pharmaceuticals was, for example, near capacity in the mid-2010s, but very lightly loaded outbound, calling at Nairobi to load additional cargo for Europe. Electronic items, often for onward regional distribution, dominate Emirates' cargo into Kenya while outbound traffic comprises mainly flowers and fish. The airline has also long flown pharmaceuticals from India, automotive parts from Germany and general cargo from China into Johannesburg, taking outbound loads of manufactured goods and fresh produce (Campbell, 2015).

Africa's air passenger capacity, jointly supplied with belly-hold capacity, has grown. The Centre for Aviation (CAPA) estimates intra-Africa business grew from about 95 million return seats in 2015, to 105 million in 2017, to 112 million in 2019. Added to this has been the growth in activities of foreign carriers. Much of the expansion in inter-continental capacity between 2006 and 2012 was associated with Middle East airlines that roughly doubling their share to about 20% with European carriers maintaining about a third. (Pirie, 2014, 2017). In particular, there was growth in inter-continental connections, much

of which involved traditional hubs in Europe. But the Middle East also enjoyed increased connectivity.¹⁴ This has led to Africa's airports becoming more dependent on a limited number of airlines which enjoy quasi-monopoly power (Scotti et al., 2017).

The floriculture industry is highly sensitive to geography, and in particular to climate, water supply and altitude. Unlike some more footloose industries, where transportation can have significant effects on their locations, transportation is largely a facilitator that releases the natural flower-growing potential of an area. But having an airport nearby is not sufficient, it has to be accessible and offer appropriate transit facilities. Surface access to Africa's airports, however, varies considerably. Unlike seaports that require heavily engineered access routes, those serving flower farmers, both because of relatively infrequent truck movements and light loads, can be less-substantial and are generally built to a lower design standard. Congestion and poorly maintained roads can, however, reduce the reliability of the local just-in-time supply chain that floriculture relies on to connect to relatively infrequent flights.

4. Floriculture supply chains

The temporal and temperature fragility of perishables normally means that a cold-supply chain is adopted. This involves rapid harvesting of the product when at the ideal stage in its life cycle, the movement of relatively small units, often in chilled containers, and storage at suitable consolidation facilities prior to long-distant movements to final customers. The perishable supply-chain, excepting capital outlays on the storage facilities, almost exclusively involves forward integration. From the perspective of economic development, this has major advantages in conservation of foreign exchange and in generating domestic jobs. The quality of the supply chain, and its associated labor, has also evolved as the floriculture sector has moved to higher value-added products. Kenya, for example, has shifted away from exporting lower value to higher-value stems and onto bouquets (Kuiper and Gemählich, 2017).

The quality of any supply chain is dependent on its weakest link, and thus while aviation may be an important element in chains involving flowers, even good aviation infrastructure and services may not lead to successful flower production. In the case of the cold chains, the roles of large forwarders and agents are important (Babalola et al., 2011). Delays often mean the loss of produce, and excessive storage time is costly in terms of ultimate shelf lives. In many cases, the trunk-haul aviation link is tied directly to local forwarders that own reefer trucks and warehouses.¹⁵ Such forwarders are often, in turn, tied to larger, international companies active in the global supply chain that generate cost economies of scope and density, as well as ensuring quality control.

Dettmer et al. (2014), using South Africa's international trade data, shows air transportation generally has a comparative advantage when the trunk-haul movement is over relatively long distances, the perishables involved are light weight, low volume and high value items, and especially if the shelf-life of the product is short. In many cases, the aviation supply chains can be combined with those of other goods, or passenger supply chains. In the case of landlocked countries, or those with no easy access to major markets, the air transportation supply chain has considerable advantages for the export of perishables (World Bank, 2009a, 2009b). The chain is, however, expensive, with estimates by Africa's flower exporters, and particularly those in Kenya, that logistics represent 40% to 60% of the cost of production of stems.¹⁶

¹² Johannesburg's 380,000 tons in 2018 is dwarfed by Hong Kong, the world's largest cargo airport, and with 5,120,811 tons.

¹³ Fifth-freedom rights allow an airline to carry traffic between two countries outside of its own country of registry, as long as the flight originates or terminates in its own country of registry.

¹⁴ African carriers lost market share partly because of blacklistings by the EU for inadequate security and safety reasons; https://ec.europa.eu/transport/modes/air/safety/air-ban/search_en

¹⁵ Although most large farms in Kenya do purchase a fleet (usually 2 to 5 vehicles depending on volumes exported) of reefer trucks (Mwangi, 2019).

The development of wide-bodied aircraft has produced significant economies of scope as larger planes can combine passengers and belly-hold cargo. This offers an alternative aviation product to specialized air freighters. The movement, albeit slow and incomplete towards more liberal markets, both within Africa and inter-continently, has led to passenger flights being more frequent, less expensive, and more widely available. But in the adherence to tight timetables, belly-hold cargo may get bumped at the pilot's discretion if it misses its loading time. Freighters usually offer better temperature control, fewer inspections, and additional capacity, which is particularly valuable for large quantities of short-season goods. But dedicated freighters can be costlier, may fly less often and to fewer locations, and may sit until they reach capacity, endangering perishables. Services with several stops are also common to increase the load factor. The aviation infrastructure in Africa also often limits when and where large planes, both passenger and cargo, can operate, restricting the hubs and routes that may be served (World Bank, 2009a, 2009b).

Being a network industry, cost minimization in cargo aviation involves consideration of economies of density as well as those of scope. This raises challenges of balancing two-way traffic flows. The majority of passengers make return journeys, whereas freight consignments are usually unidirectional. In the case of Africa's trade, much of the cargo suitable for air transportation involves imports of such things as components and spare parts. These are generally higher value commodities than perishables such as flowers, less dependent on just-in-time services, and are more easily handled. In many cases, therefore, inbound freight is treated as the primary cargo, and capacity decisions based upon it, with exports of flowers seen as the marginal cargo – the return load.

The development of hub-and-spoke networks has allowed consignments from diverse origins and destinations to be consolidated and transhipped to a wide range of destinations. Again, however, there are trade-offs (Chung and Han, 2013). Trans-Shipping consignments through hubs can, through help in traffic consolidation thus increasing load factors on planes and as a result, reduce costs. But consolidation and transshipment add to the time costs of a movement, increase the possibility of a consignment being damaged or mis-routed, as well as adding direct handling costs of transference.¹⁷ Finally, there are technical reasons for having both light and heavy products on a plane to ensure balance. Thus, there appears to be a strong incentive for the flower and vegetable industries of a country to collaborate in developing air cargo routes and negotiate prices with the airlines.

Producers of floriculture products sell their stems in two main ways. Many still go through a competitive, spot-auction markets and especially the Amsterdam flower market (the *Bloemenmarkt* located in Aalsmeer). There are, for example, 42 floral cargo flights from Kenya to Amsterdam in a regular week.¹⁸ The alternative is to sell directly to retailers and wholesalers where the price is known in advance (Hughes, 2000). The latter has the advantage of facilitating a more certain supply chain for growers, with buyers largely taking the market risk, and offers opportunities for providing value-added services, such as labelling.¹⁹ It also avoids the costs of middlemen and usually gets the stems to the retailers more rapidly than through an auction, thus maintaining the quality of the product. In addition, if the business is regular, forwarders can arrange block space agreements with airlines that reserves capacity for the producer; This can reduce air cargo rates and guarantee capacity will be available, as well as ensuring revenue for the carriers. But direct

selling may not realize the highest current price. Prices are agreed before cutting.

Direct selling can have important cascade effects on floriculture supply chains (Nolan et al., 2008; Kuiper and Gemählich, 2017). In the flower industry, inter-firm coordination occurs when a supermarket chain acts as lead firm in partnering with a brand-name global consolidator-exporter.²⁰ The aim is to ensure a consistent, high volume supply of quality, certified flowers by simplifying the supply chain seen in Fig. 1 by taking produce directly from farmers to supermarkets (Riisgaard and Gibbon, 2014). More direct selling has, though, led to a wave of consolidation among farmers to counter the power of supermarkets.

For the consolidator, as the main point of contact for the large supermarkets, consignment size matters. The large consolidators have developed deeply integrated, networks of growers to source from, and invested in innovative technical and logistical capabilities enabling them to meet demands consistently and on time. Smaller consolidators are better suited to non-traditional markets which demand smaller quantities of niche varieties and can provide the types of relationships often desired by smaller producers and buyers.

Since the 1990s, the traditional African floriculture producing areas have encountered challengers from new supplying areas. Some of these, however, have been handicapped by major transportation problems. Rwanda, for example, has been trying to develop its flower exporting industry, but it remains small (Chantal et al., 2018). It has the natural advantage of high altitude, ranging from 1400 to over 2400 m, fertile soils, plenty of rainfall throughout the year, cheap labor, and a relatively good road network.²¹ It has seen a joint venture between the Rwandan government and Kenya's Shalimar Flowers to bring Kenyan expertise to Rwandan undeveloped flower sector. But, along with lack of adequate quality controls and suitable labor, long-haul transportation remains a serious impediment to development. Belly-hold capacity to Amsterdam, Brussels and Dubai is available, but involves connecting flights, while the dedicated cargo capacity to Amsterdam provided by Martin Air is via Nairobi.²²

Some of the smaller suppliers are seeking to circumvent air transportation limitations by increasing the self-life of their products and reducing the associated high costs of transportation. They have begun growing varieties of flowers and plant materials suitable for drying. South Africa has an established record in this market, and Rwanda has recently been developing such products. Durability means they can be exported using standard road and air services to a global market without the need for a cold chain.

In summary, the floriculture supply chains in Africa are technically challenging and, in many instances, lack adequate investment in hard, soft, and orgware. There is evidence that floriculture supply chains can be inflexible and susceptible to disruption because of difficulties in adapting to emerging international protocols, certification requirements, and to regulations (McKinnon et al., 2010).²³ The result has been, even for the more well-established growing regions, periodic squeezes on profits. The Euro crises from 2009 was an example of the problem. More recently, the hoped-for pick-up in demand after the Great Recession did not materialize to the extent many had hoped, and the onset of Covid-19 has resulted in collapses of many markets.

²⁰ Kuehne and Nagel and Panalpina Airflo, part of the Dutch Flower Group, are, for example, the largest international freight companies in Kenya carrying flowers.

²¹ According to the World Economic Forum, in 2019 Rwanda had the third best quality road system in Africa (roahttps://www.theglobaleconomy.com/rankings/roads_quality/Africa/).

²² https://www.floraldaily.com/article/9122700/rwanda-s-only-rose-farm-spreading-its-wings/

²³ These regulations are designed to minimize the transactions costs of buyers in the sense they do not individually have to check on sourcing or quality (Spiller, 2013)

¹⁶ https://www.flowerweb.com/

¹⁷ Transportation damages attract "quality remarks" presented to bidders at Dutch auctions that adversely affect sale prices by up to 20%.

¹⁸ https://lot.dhl.com/kenyan-flower-exports-in-full-bloom/

¹⁹ Steen and Gjolberg (1999) analyze the challenges of forecasting prices at the Amsterdam market. Jaffee (1994) considers the costs and benefits for Kenyan horticulturalists of being contracted to supply final customers.

5. Regional approaches to developing floriculture

While there are standard requirements to sustain a successful floriculture supply chain, there are several ways these requirements can be met. The role of government has been important in the choices that have been made. In particular in the role of the authorities in controlling elements of the chain and in providing public finance has proved significant. The two main growing areas have developed under somewhat different economic structures and with differing degrees and forms of government intervention in their supply chains.

5.1. Market oriented: Lake Naivasha region

Flower production in Kenya goes back to British colonial times, and with this the application of the Anglo-Saxon approach to government intervention. The country's floricultural industry is largely market driven with state involvement only when this is seen to enhance outcomes. The support of the Kenyan government in promoting the floriculture industry has been mixed and has not been the decisive factor in its development (Kazimierczuk et al., 2018). Kenya's main comparative advantage derives from its climate and low labor costs, but it has benefited from less stringent environmental regulation, government controls over land rights, and lower trade barriers (Jaffee, 1992; Rikken, 2011). In addition, farmers utilize modern technologies including drip irrigation, fertigation systems, net shading, pre-cooling, cold storage facilities, bouqueting, recycling systems to prevent wastage, wetlands for waste-water treatment, artificial lighting, grading/packaging sheds, and reefer trucks. The use of hydroponics reduces the water used in production and makes it independent of the soil quality (Bolo, 2006).

As early as 1988, Kenya's industry exported 10,946 tons of floricultural produce, climbing to 86,480 tons in 2006, 120,220 in 2010, 136,601 in 2014, but falling slightly to 133,658 in 2016. It then rose to 159,961 tons in 2017 (Mwangi, 2019). The country's flower industry employs about 100,000 people directly and up to two million indirectly, mostly women. Physical quantities are not, however, the whole story. The export-oriented nature of Kenya's industry makes it vulnerable to global macroeconomic cycles and shocks. The global economic crisis of 2008, for example, led to significantly lower flower prices, and even when exports in 2008/2009 grew by 25%, the value of stems dropped by 8%. Slow economic growth caused foreign consumers, and by extension their grocery stores, to encourage price wars between suppliers that depressed the prices obtained by farmers. The problem was made worse in the short term by the higher air freight rates associated with the "Icelandic ash cloud" (Kazimierczuk et al., 2018).

Subsequently, with eventual economic recovery, the Kenya Flower Council estimated the country's flowers exports in 2018 contributed \$1.06 billion in exports, compared with \$0.77 billion in 2017. Although there are some 500 commercial flower growers of all sizes, about 75% of such exports are produced by a few dozen large and medium producers. These larger farms are better equipped than rivals in other African countries to control their entire production process, allowing integration into complex, expansive product chains. As with many sectors of Africa's trade, there has been a widespread adoption of third-party logistics service providers as part of the chains (Sohail et al., 2004).

Kenya is the largest external supplier to the European flower market with a 38% market share. Its major competitors, Colombia, Ecuador, and Israel each have only half this.²⁴ About 70% of the exports by weight are shipped to the wholesale markets in the Netherlands to be sold retail in other EU countries and the UK. As noted earlier, while the

²⁴ There are few detailed comparative studies of South American floricultural supply chains. Vega (2008) is an exception but it is dated.

Dutch auctions have historically been the most important channel, changes in consumption patterns and supermarket supply chain rationalizations have led to more direct contracts. Currently, about 25% of the exports to Europe are sold directly to UK and Germany providing an opportunity for value added at source through sleeving, labelling, and bouquet production.²⁵ Table 1 provides an indication of the geographical spread of sales by value.

Lake Naivasha's location permits year-round production and facilitates the growth of the medium-sized roses that are often found in the floral sections of EU supermarkets, as well as of larger blooms favored in Russia.²⁶ These natural advantages have been supplemented by governmental support for the sector through reduced duties and taxes on crucial imported inputs and facilitating cooperation with the industry. The availability of air freight, with Nairobi airport being a regional cargo hub, and good surface transportation provides high levels of accessibility to markets. This is combined with a ready supply of workers; Kenya had an unemployment rate in 2018 of about 9.3% according to the International Labor Organization.

Cut flower exports began in the late 1960s when wide-bodied jets were introduced and offered additional cargo capacity to the fresh produce industry. Foreign investors and partners played a critical role in launching and expanding the floriculture industry in Kenya.²⁷ Dutch and Israeli advisors, for example, were important sources of technical support.²⁸ Although Kenyans of foreign descent or members of the Kenyan elite, were initially involved in developing the industry, smallholders were also present and remain so. In 2016, approximately 190 large flower farms and numerous smallholder farmers were involved in the flower production, although the former dominated output (Zylberberg, 2013; Kazimierczuk et al., 2018). The latter generally cooperate with the larger producers who in turn coordinate the logistics of getting flower to market. The success of the industry is, to an extent, the result of the capacity of the private sector to develop independently from the state and its capacity to quickly adapt to changing circumstances (Jaffee, 1992; Tyce, 2020).

While the initial shipments were exclusively carried as belly-hold cargo, as demand grew, economies of scale made dedicated freighter services viable. The industry is well organized. In 1996, the Kenya Flower Council was established to coordinate the efforts of independent growers and exporters and ensure implementation of acceptable international standards. Its members produce over 70% of the country's flower exports. About 75% of these are rose stems which make a fast supply chain particularly important. The larger forwarders block space on flights from Kenyatta Airport both on passenger airlines and freighters that offer day services to Europe and the Middle East.

A range of aviation services are available at Nairobi Airport, provided both by domestic and foreign airlines. As much as 90% of the shipments to the UK are carried as belly cargo on Kenyan Airways with Lufthansa Cargo and Cargolux, providing dedicated cargo space to Frankfurt and Maastricht. About 70% of the flowers are grown around Lake Naivasha, some 80 to 100 km northwest of Nairobi. Good road links allow, for example, flowers picked in the morning to reach Amsterdam by evening. The airport handles the vast majority the

²⁵ <https://www.voanews.com/africa/kenyas-flower-producers-eye-us-market>

²⁶ Kenya grows a number of flower types. Roses have the advantage of taking only 8 weeks between flower to bloom whereas, carnations take 16, astromeria, 52, and lilies, 12.

²⁷ Dansk Chrysanthemum Kultur (DCK) drove Kenya's flower exports during this period (English et al., 2006). Established in 1969, DCK's owner reputedly gave shares in its East African subsidiary to the Agriculture Minister and Attorney General, which helped to secure a comprehensive support package that included a low-cost long-term lease on 6000 ha of land, unlimited expatriate work permits and a 25-year guarantee against changes to taxation and profit repatriation laws.

²⁸ For example, Amiran brought consultants from Israel to advise the future flower growers of Kenya on the adoption of large-scale greenhouses.

Table 1

Destinations of Kenyan cut flower export by value (\$1000).

Source: Based on Trademap (<http://trademap.org>).

	2015	Share	2016	Share	2017	Share
Netherlands	250,121	52%	247,080	53%	281,333	52%
UK	92,726	19%	91,341	17%	85,149	16%
Russian Fed.	21,187	4%	14,589	3%	20,729	4%
Norway	14,076	3%	16,037	4%	20,178	4%
Germany	22,140	5%	18,296	4%	19,872	4%
UAE	7411	2%	12,337	3%	14,886	3%
Saudi Arabia	3209	1%	9202	3%	14,816	3%
Australia	20,356	4%	13,187	2%	13,503	2%
Japan	10,250	2%	7498	1%	7537	1%
Switzerland	6282	1%	6181	1%	6503	1%
France	3870	1%	6217	1%	6428	1%
Sweden	6435	1%	5549	1%	6274	1%
Latvia	515	0%	427	0%	4314	1%
Italy	2481	1%	2712	1%	3945	1%
US	3170	1%	4041	1%	3839	1%
Others	15,769	3%	24,447	5%	31,589	6%
Total	479,998	100%	479,141	100%	540,895	100%

flowers exported.

Nairobi enjoys significant advantages over Entebbe in terms of the scale and scope of the air services offered, its terminal facilities, and its land access. In the latter context, the main growing areas are served by the major road networks in Kenya.²⁹ The Lake Naivasha region is served by Nairobi - Nakuru highway, the Thika region by the Thika Road while the Athi River and Kitengela areas are served by Mombasa Road (Ong'uti, 2015). These major routes, although not always well maintained, provide easy access into the city center and into the airport. The feeder roads into the interiors of growing regions that move the flowers to the integrators and forwarders as seen in Fig. 1, are of lesser quality but went through some upgrading and improved maintenance in the 2010s.

There are both charter and scheduled carriers based at the airport. As an example of global access, Kenya Airways' passenger services directly link Nairobi with 26 African and intercontinental destinations including London and Amsterdam, and together with its strategic partners provides a cargo network involving over 100 destinations (Amankwah-Amoah and Debrah, 2011).³⁰ The airport also has significant cold-chain capacity both within its perimeter and immediately outside, although rapid transfers from road to aircraft keeps down its use.

Where there have been issues these have been in cold-chain warehousing prior to movements to the airports. A report by Tilisi Developments Ltd. based on 52 warehouse owners and tenants questioned in 2017 found that almost two-thirds were facing capacity shortages.³¹ There were also issues of poorly ventilated spaces, leakages, power shortages, and poor structural planning. In addition, there was increased stock contamination, causing flower product deterioration during storage. Added to this, a case study of Equator Flowers located in Eldoret (150 km from Nairobi) found the most significant causes of disruptions to the supply chain were natural disasters, logistics process design, labor union actions such as slow-downs and strikes, and production function mechanics (Kangogo et al., 2013). In terms of the transportation supply chain, road movements seem to pose the biggest problems, with breakdowns and congestion leading to reductions in the vase life of flowers. There can also be periodic shortages of

²⁹ The areas involved are better served than the bulk of the country. Overall, Kenya's paved road density is only about a third of the average of middle-income nations (Ong'uti, 2015).

³⁰ Kenya Airways is the main operator out of Nairobi. It is a public-private partnership with the Kenyan government holding 48.9% of the shares.

³¹ <http://www.kdrtv.com/why-warehouse-crisis-could-slow-down-economic-growth/>

capacity, but to facilitate market access and minimize post-harvest losses, the Horticultural Crops Directorate has provided stand-by capacity with reefer trucks for hire by farmers, built marketing centers, and collection depots This is coupled with damage done at the packaging stage of the chain, and when there is inadequate cold-storage capacity at times of peak demand.

Turning to Uganda, like Kenya and Tanzania, it has perfect conditions for commercially growing flowers. The country's cut flower business dates to 1986, with the cut rose business beginning in 1992 and shooting chrysanthemum production in 1997. It steadily built up a floricultural industry during the 1990s to become Africa's fourth largest producer.³² Various forms of assistance were given to the industry including a withholding tax exemption on interest, tax exemptions on raw material, plant and machinery and on time tax refunds. In 2014, it exported nearly \$100 million of cut flowers and over \$56million of live plants. Despite early setbacks, including growing flowers that were not suited for the climate and not meeting the quality standards of recipient countries in the EU, the industry has become a significant contributor to the national economy.

In 2019 the Uganda Flower Exporters Association recognized 22 firms as involved in the flower industry. The majority of these are in the growing and exporting stages of the value chain, with two also being transporters with the rest outsourcing their transportation. One company is a broker and wholesaler while another is a grower and broker. There are no local breeders and only one freight forwarder that provide cold chain logistics for the industry.

While Uganda's ten largest flower farms export about 75% of their production, worth \$35 million annually as well as directly employing some 6000 workers with another 30,000 indirectly dependent through industries like transportation and storage, they are small compared to Kenya.³³ The flower-growing area is about 200 ha, compared to 2000 in Kenya, and there are many fewer producers. This limits the economies of scale that can be reaped in the supply chain. Given the small overall size of the industry, even using forwarders to get economies from consolidation still makes it difficult to negotiate block-spaced agreements with the airlines, and there are additional risks of suitable capacity not being available when needed.

The largest market for Uganda's chrysanthemum shoot cuttings is the Netherlands, About 90% of roses are handled by European middlemen (Msogoya and Maerere, 2006), with retailers in Norway, the UK, Sweden and Germany taking most of the remainder. Most flower farms are located near Entebbe International Airport. But landing taxes and the lack of dedicated air freight for flowers mean that flying costs are around \$1 per kilo of flowers higher than in neighboring Kenya and Tanzania where dedicated air cargo is available, as well as space on passenger airlines.³⁴ As a consequence, about 10% of the flowers are moved through Kilimanjaro International Airport which can only offer belly-hold space, with the remainder being exported through Nairobi which also has easier, if longer, surface transportation access as well as significantly more air cargo capacity,

South Africa is the most mature producer of floriculture products in Africa, with an industry dating back to the 1920s and 1930s. Partly because of its historic links with the Netherlands, the country has a well-established bulb exporting industry that is not reliant on a cold-supply chain and can be shipped as general cargo. The cut flower industry has just under 1000 large and medium producers of roses, chrysanthemum cuttings, carnations, gypsophila, asiatics, and irises that are mostly located within 300 km of O.R. Tambo Johannesburg

³² <https://asokoinsight.com/content/market-insights/uganda-floriculture-industry>

³³ <http://www.new-ag.info/en/developments/devItem.php?a=1936>

³⁴ By way of comparison, in 2013 Nairobi Airport handled about 159,000 t of perishable exports, of which 55% were flowers. This was five-times that of Entebbe, where only 27% were flowers.

international airport (Reinten et al., 2011). The airport is easily accessed using a high-quality road network and offers a global span of passenger and cargo airline options as well as cold storage and handling facilities.

The flower export industry, however, has been in something of a plateau since 2005, at about \$40 million per annum, after rapid growth following the demise of Apartheid. In part this is because, despite a very good aviation-supply chain, with large capacity, good surface access, and a well-developed forwarder system, it is further from some of its markets than other producers, but mainly it is because of higher labor costs. There are also imports into South Africa by both road and air from Zimbabwe, Kenya, and Zambia of cut flowers varieties that cannot be produced locally. These amounted to about \$1million in 2009. The South African industry, besides its up-to-date logistics that enables produce to arrive in good condition, maintains itself largely through the sale of its indigenous flowers. To some extent counteracting the stagnation in the cut flower business, which by value is now about 60% of floriculture exports, there has been growth in the export of higher value seedling, foliage and decorative plants. These are, however, particularly sensitive to local conditions necessitating care in the transportation supply chain.

5.2. "Planned" approach: Blue Nile Region

Ethiopia is a relatively newcomer to the floriculture industry and, as such, has benefitted from not being a first mover. It has profited from being able to learn from the experiences of established growing regions, and in particular recognizing the importance of meeting international standards (Gebreeyesus, 2015). The development of the necessary infrastructure for a successful export industry should also be set within the broader context of national priorities to improve the country's domestic logistic systems more generally (Tefera et al., 2020).

Ethiopian floriculture involves more state participation and direction than similar industries of the former British colonies. The economy is not as strictly controlled as it was under the former Derg Regime, but there is still a very large public sector, most notably involving banking, telecommunications, and land and air transportation. Floriculture was begun by the Derg in 1991 with the growth of hypericum, erigrinium, gypsophila, and carnation on state farms for export. Growth accompanied assistance from the World Bank and from the Dutch in the case of several local flower growing companies, but wilted towards the end of the 1960s seemingly due to a lack of government interest (Melese and Helmsing, 2010). The Dutch program for emerging markets (PSOM) not only promoted the expansion of production through joint ventures but facilitated the establishment of supporting logistics; e.g. by financing the Ethiopian Perishables Logistics Company.

Both local and international transportation in particular has been coordinated with the development of floriculture as part of national economic planning - the state-owned national airline, for example, provides discounts to horticultural exporters - and there have been major investments in perishable handling facilities at Addis Ababa's international airport. The latter have been specifically designed for flower handling and largely funded by direct foreign investment.

Ethiopia is the second-largest flower exporter in Africa, with about 120 flower growers on the 1700 ha of land in production. The industry earned \$660 million from floriculture export in 2015, some 20% of its foreign trade earnings. The region's climate is ideal for several forms of floriculture, with land south of Addis Ababa at 2000 m above sea level providing near perfect environment for growers. The country also has the advantage of a fairly flexible labor market (Mano et al., 2011). The relatively large size of the producers, partly due to the difficulties smaller producers have in raising finance, facilitates economies of scale throughout much of their supply-chains. This has also led to consolidation with significant numbers of take-overs (Mano and Suzuki, 2015). Most of the growers are large enough to have their own cooled processing and packing warehouses and reefer trucks (Melese and

Helmsing, 2010). Problems have arisen in recent years, however, with attacks on producing units and the burning of crops by groups opposed to the government. Unfavorable movements in currency exchange rates have also had adverse impacts (Belwal and Chala, 2008).

With few exceptions, first movers and early imitators were supported by the national government and foreign aid, and involved domestically owned firms. Foreign growers, either by engaging in joint ventures or through full ownership, started to enter after 2003. A significant number of these came from other African countries, including Kenya, Uganda and Zimbabwe, although more recently investment has come from a wider range of countries including the Netherlands, the UK and India, and regional states such as Nigeria, Sudan and Oman. To attract foreign direct investment, the government gave implicit guarantees of stability through its control of Ethiopian Airlines and Bole Airport, and initiated financial incentives including a five-year tax holiday, duty free imports, access to bank loans and farmlands, as well as a 100% exemption from payment of export customs duties (Mushir and Hailemariam, 2015; Bekele, 2007).

The biggest market for Ethiopian roses is the Netherlands which takes about 90% of the country's exports, with state-owned Ethiopian Airlines offering in 2017 two cargo flights of flowers a day each carrying 85 tons. The airline also moves horticultural products to other destinations in Europe, the Middle East and other areas on more than 10 flights a week. Addis's state-owned Bole International Airport has been through major enlargement and modernization, partly funded by Chinese finance. It now has Africa's largest perishable produce terminal including a 17,000 square meters cold storage unit complex that was completed in 2017.³⁵ The new airfreight facility can process about 600,000 tons of cargo a year mainly for transportation to Europe. Given the synergies in storage, the combination of floriculture and horticulture products, reduces the unit cost of pre-flight cold storage.

The effects on the Blue Nile region's economy and population has been somewhat mixed. This was already an area with small scale farms. The arrival of the floriculture has involved taking land from established smallholders and putting it in the hands of large, often foreign owned producers. Set against a typical smallholding of one hectare supporting a household consisting of five members, a hectare production of flowers can employ as many as fifty people. There are clear macro-economic benefits from the conversion, but it has the tendency to cause enclave formation and moves away from the country's objective of food self-sufficiency, or "endogenization". Added to this, those displaced in recent years are among those engaged in civil unrest. One consequence of these actions has been burnings of rose crops.³⁶

6. Conclusions

This paper has considered the important role that air transportation plays in Africa's floriculture supply chains, and the technical, geographical, institutional, but primarily, economic complexities confronting those engaged in it. There is a particular focus on the important interface between short-distance, surface transportation at Africa's end of the chain and the intercontinental air-transportation haul to markets in Europe and, increasingly, Asia. Much of the account is qualitative. Not only is there a dearth of data for conducting any comprehensive econometric analysis, but in practice qualitative factors tend to dominate many decisions along the supply chain.

Africa's nations are among the poorest on the planet. There are signs, however, that some of their economies are growing more robustly in recent years. Much of this growth is through international trade, and the gradual evolution of aviation supply chains has played a part in this.

³⁵ <https://www.cargoforwarder.eu/2019/04/22/addis-ababa-airport-on-way-to-challenge-dubai/>

³⁶ <https://globalriskinsights.com/2016/10/radar-foreign-investors-attack-ethiopia/>

The latter has been important in the growth of high export earning sectors such as tourism and “exotics”, as well, as other industries that can make use of Africa's abundant labor supply. The emerging problem is that other regions of the globe are also rapidly developing their tourism and flower production capacities; tourism often being a compliment to floriculture because of the belly-hold air cargo capacity it provides.

Generally, Africa lacks competitive advantage in high export earning industries because its air transportation logistics are thin, fragile, and incomplete even for the sectors in which it has a comparative advantage in production. These weaknesses extend across hardware, software and orgware. Changes are coming as foreign investment takes place, deregulation of the African aviation industries are occurring, and as the presence of non-African airlines is increasing. The emerging long-term challenge is to get sufficient investment, including human capital, into the air cargo supply chain; and to do this when unified-mega economies such as China and India, as well as some South America countries, are enjoying greater access to pertinent funding.

It is also unclear at this point whether the longer-standing, free market approach to air transportation logistics pursued by traditional African supplying regions can compete with the more planned approach of emergent floriculture suppliers, notably Ethiopia. While the former offers more flexibility, as well as incentives for innovation, the discrete nature of many elements in the floriculture aviation supply chain requires “chunky investments” that, even according to Adam Smith, are sometimes best provided with state financing. The developments around Lake Victoria and in Ethiopia highlight some of the differences in development paths to date, but it is premature to offer conclusions as to eventual outcomes. What is also important, and still under researched, is the more general question of whether floriculture is an efficient way to expend scarce resources even if a nation has a comparative over other African countries. The market for flower production is becoming increasingly global, and perhaps Africa as region has limited comparative advantages.

Looking forward, while the free market in African air services hoped for in 1999 has not materialized and air transportation across the continent is still far from seamless, some new impetus is promised. This comes from the signing in January 2018 of an agreement between 23 state to cooperate in a SAATM and in March by 44 members of the Africa Union of a provisional agreement establishing the African Continental Free Trade Area. Ratification, and subsequent operationalization of the agreements, would significantly improve the continents' aviation supply chains.

Author statement

This is a personal research paper. Credits to referees etc. are contained in the paper.

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