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Toward a Competitive Air Transport Market in Africa

The Role of Bilateral Air Service Agreements Liberalization

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Abstract

This study examines the impact of bilateral air service agreements on air passenger transport in Africa and quantifies the consumer welfare effects associated with air transport liberalization. Using an unbalanced panel of 71 country pairs from Africa observed over 2011–19, the paper estimates the extent to which bilateral air service agreements liberalization affects the following: (1) passenger travel, (2) average airfares, (3) flight frequency, and (4) market competition within a country pair. The empirical analysis employs the difference-in-differences estimation method and pays close attention to the endogeneity concerns coming from the simultaneity and reverse causality surrounding the pricing, demand, and frequency decisions. The results indicate that both partial and full liberalization of bilateral air service agreements lead to a reduction in airfares and an increase in air travel demand and flight frequency, respectively. The analysis finds no evidence that market competition, as measured by the number of operating airlines, increases following liberalization. After quantifying all the channels through which the policy environment can affect air transport markets in Africa, the findings show that aviation liberalization generates consumer benefits that are equivalent to a 40–42 percent drop in airfares, that is, the price equivalent effect of air liberalization.

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Toward a Competitive Air Transport Market in Africa:
The Role of Bilateral Air Service Agreements Liberalization*

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1. Introduction

Air transport services are essential for the economic growth and development of countries.[1] They facilitate the movement of goods and people across long distances, integrating local communities into the global marketplace, and stimulating specialization and trade. Air services are also crucial for stimulating foreign direct investments, which are an important vehicle for technological diffusion and productivity growth.[2] For all these reasons, air transport services represent a direct factor influencing countries' rate of economic growth. This is why policy makers and global institutions around the world are interested in finding efficient ways to support and promote the activity of the aviation sector.

Air transportation in Africa has the potential to transform the economic activity on the continent in important ways. Air connectivity may be faster and easier to achieve in comparison to transnational highways or railway infrastructure networks, which take significantly more time and coordinated effort to build. By contrast, air transport networks could expand at a more rapid pace, especially when the regulatory environment is designed to facilitate the economic decisions of air service providers.

Despite its crucial role for regional development, the aviation sector in Africa is lagging behind. According to a recent study by the African Development Bank Group (2019), Africa's aviation market represents only 2-3 percent of the global air passenger market even though the continent accounts for 17 percent of the world's population and for 7.2 percent of the world's middle class. This insufficient level of market development is even more difficult to justify when factoring in the absence of feasible transportation alternatives such as fast trains or highway networks. So, why the slow growth in air transport services in Africa?

This is a complex question to address that necessitates multiple avenues of investigation. This study aims to examine one possible explanation: the restrictive regulatory regime that constrains international aviation markets in Africa. We analyze the extent to which liberalizing air transport markets within Africa contributes to substantial market transformations and consumer benefits, which would justify the need for such policy changes.

Historically, the airline industry has been subject to many rules and regulations meant to ensure the safety, accessibility and sustainability of the industry (both domestically and globally). The buildup of such regulations has led to a complicated web of bilateral air service agreements governing international market activity. In addition, government interventions through state-owned flag carriers, a wide range of industry

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[1] Brueckner (2003) and Blonigen and Cristea (2012), among others, provide empirical evidence for the role of air passenger transport for regional development in the United States. Baker et. al. (2015) provide similar evidence using data for rural and more remote communities in Australia.

[2] Giroud (2013) shows that direct flights between the headquarters and firm subsidiaries increase plant investments and plant productivity. Fageda (2017) uses data for Spain to provide direct empirical evidence of the role of air passenger transport for increasing FDI flows.

subsidies and large infrastructure investments have further complicated operations and market transactions. Too often, this has resulted in a suboptimal aviation network prone to market inefficiencies, strategic interests, and binding constraints. Many countries around the world have taken action by promoting industry deregulation and international openness. Many African countries are now in the process of negotiating and implementing a more liberal international aviation policy. It is the scope of this study to examine in more detail the implications of air passenger liberalization in Africa and to quantify the consumer welfare effects associated with such a policy change.

In our empirical analysis, we estimate the impact that partial liberalization, respectively full liberalization of bilateral air service agreements (BASAs), have on international air transport markets in Africa. We focus on implications for: 1) total air passenger travel, 2) average airfares, 3) capacity determination via flight frequency decisions, and 4) market competition via free market entry. Our data consists of an unbalanced panel of 71 country pairs observed over the period 2011-2019. For each country pair we collect data on the characteristics of their BASAs and the degree of air liberalization that they provide, as well as data on economic indicators and air transport market outcomes. Our empirical approach consists of a difference-in-differences methodology that pays close attention to econometric challenges such as the endogeneity arising from the simultaneous determination of price, quantity and capacity decisions. Guided by our modeling framework in our choice of exogenous variables, the instrumental variables method that we implement generally performs well, delivering results that improve on standard outcomes.

Our estimation results indicate that both partial and full liberalization of BASAs have a significant negative effect on international airfares in our sample, but they have no effect on the number of operating air carriers (i.e., airline market entry). This may seem counterintuitive since liberalization-induced price changes are often caused by increased competition. One may rationalize these results by considering the economies of scale characterizing the airline industry, which may slow down market entry in the absence of entry barriers. To a lesser extent, the results could be due to the contestability of aviation markets whereby the threat of entry disciplines the price mark-ups of incumbent air carriers.[3]

Our estimation results also indicate that both partial and full liberalization of BASAs impact flight frequency (i.e., the number of departures) indirectly through the increase in passenger volumes caused by the liberalization-induced fall in airfares. However, conditional on demand size, we find no direct impact of BASA liberalization on flight frequency. Although free capacity determination, like free market entry, is an important provision granted by liberal BASAs, it is possible that some of the aviation markets in

[3] The extent to which the airline industry fits the contestable markets hypothesis has been long debated in the economic literature. See, Morrison and Winston (1987), Whinston and Collins (1992), Goolsbee and Syverson (2008), among others.

Africa which are part of our sample are small enough that these constraints may not have been binding under regulation. It is also possible that countries with no national air carriers witness limited benefits from air transport liberalization. Alternatively, some of the sample countries may lag behind in deregulating their own domestic markets despite efforts to liberalize international air transport markets, thus constraining their ability to exploit the opportunities presented by international liberalization.

The finding of a large effect of air transport liberalization on international airfares has important market implications. First, a fall in airfares leads to an increase in air passenger volumes which can be attributed to the change in the policy environment. In turn, the increase in the demand for international air travel leads to an increase in the number of departures offered (i.e., flight frequency). Our intention is to cumulate these direct and indirect effects of a partial, respectively full, BASA liberalization. The goal is to generate a single statistic capable of capturing the total effect of air transport market liberalization. The statistic that we propose consists of the price-equivalent effect of air liberalization. It is inspired by similar work in the international trade literature where researchers try to quantify in percentage terms the impact of the removal of non-tariff barriers to trade. In the same way that tariff liberalization leads to a percentage change in import prices, the liberalization of non-monetary (i.e., non-tariff) barriers can be converted into a tariff equivalent. In this study, we follow the same approach and assume that aviation liberalization is associated with the removal of both tariff barriers (e.g., price mark-ups) and non-tariff barriers (e.g., regulatory constraints) that can be quantified into a cumulative price-equivalent effect.

Based on the size of our estimated regression coefficients, our calculations indicate that the benefits of partial liberalization of BASAs among the African countries in our sample amount to a 42 percent drop in average airfares. The benefits of full liberalization are very similar in magnitude and amount to a 40 percent drop in average airfares. The results point to large consumer gains from air passenger liberalization in Africa. About 40 percent of these benefits come from an effective reduction in airfares, and the remaining 60 percent come from increased demand effects via quality improvements in air travel, which take the form of increased flight frequency.

The benefit of quantifying the effect of air passenger liberalization using a single statistic in the form of an ad-valorem equivalent effect is that it allows us to perform consumer welfare calculations. Using two different approaches to measuring consumer welfare – the compensating variation approach and the change in consumer surplus approach – we find that the consumer gains accruing to the African travelers in our sample amount to between US$330.3 million and US$424.4 million in 2019 (or between 29% and 37% of air travel expenditures for that year). Again, these values point to large consumer benefits from air transport liberalization in Africa. It is important to note however that a missing piece from our welfare analysis is an assessment of the producer surplus. Data and methodological constraints limit our ability to measure the impact of air transport liberalization on air carriers and the supply side of the market. For this reason, our consumer welfare results should not be taken as a statement on the total welfare effects attributed to liberal BASAs.

Our work is related to a growing literature on the welfare effects of air liberalization. Winston and Yan (2015) and Cristea et al. (2017) evaluate the impact on U.S. consumers of Open Skies Agreements (OSA), which are the most liberal form of bilateral air service agreements signed by the U.S. with its international aviation partners. Piermartini and Rousova (2013) use a gravity equation framework and bilateral passenger data for a large cross-section of countries from around the world to study the impact of air passenger liberalization, including the role played by particular provisions and liberalization clauses. Other studies focus on air transport liberalization in specific regions of the world such as Southeast Asia (Forsyth et al., 2006), the Middle East (Cristea et al., 2015) or the European Union and its specific trade partners (Button, 2009; Bernardo and Fageda, 2017). Perhaps the work that is most closely related to our study is Ismaila et al. (2014), Abate (2016) and Abate and Kincaid (2018), who specifically study air liberalization in Africa. We extend this line of work by employing a larger data sample with a broader intra-Africa country coverage, and a more in-depth examination of consumer welfare effects of air transport liberalization. It is worth mentioning that this kind of policy analysis focused on the performance of the aviation industry in Africa is scarce because of data limitations regarding both aviation market outcomes as well as the continental policy landscape.

The remainder of the paper is organized as follows. The next section briefly describes the liberalization of air transport markets in Africa. Section 3 discusses the econometric models as well as the estimation methodology employed to evaluate the effect of liberalization on air transport market outcomes. Section 4 presents the main data sources, the construction of the data sample and some preliminary data trends observed among the countries in our sample. The estimation results are presented in Section 5, together with the proposed robustness checks. Section 6 discusses the construction of the price equivalent effect of air transport liberalization and then derives consumer welfare calculations. Section 7 concludes.

2. Aviation Liberalization in Africa

International aviation markets worldwide operate under a complex web of regulations that are generally set on a bilateral basis. A standard bilateral air service agreement (BASA) can be quite restrictive in that it specifies a limited number of airports that can serve as gateways to destinations in the partner country, with only a limited number of airlines (usually one per signatory country) designated to provide the service. A typical BASA specifies the seat capacity and flight frequency that can be supplied on each aviation route with precise rules for capacity sharing among designated airlines. It specifies the rules to be followed in setting airfares[4] and it delineates the traffic rights granted to designated carriers. In most cases, BASAs restrict the ability of airlines to pick-up or drop-off traffic from intermediary points in third markets when completing aviation routes between the signatory countries (i.e., fifth freedom rights). In summary, a typical BASA includes provisions pertaining to: 1) capacity choices (e.g., flight frequency, aircraft size), to 2) price setting decisions (e.g., extent to which airfares can be set without approval of aeronautical authorities), and provisions pertaining to 3) fifth freedom rights (i.e., ability to pick up or drop of air traffic in third markets as long as these markets are intermediary points on routes with final destination in one of the signatory countries).

As a result of these rigid rules and regulations governing bilateral country pairs, international aviation markets have historically been very fragmented. This has hindered international activity. As globalization took off in the 1980s and 1990s, advanced economies like the United States and the members of the European Union started to deregulate the aviation industry by promoting air services liberalization via Open Skies Agreements (OSAs). OSAs are fully liberal BASAs that remove any restrictions regarding the provision of international aviation services.

Following the global trend towards aviation liberalization, the African continent achieved an important milestone when 44 countries signed the Yamoussoukro Decision (YD) in 1999, a comprehensive reform that proposed a full liberalization of the intra-African aviation market. The YD came into effect in 2001 and called for free entry and market access, free determination of capacity, of airfares and of flight frequency, and the granting of air traffic rights, of which the 5th freedom traffic right has been quintessential for achieving full liberalization.[5]

While the Yamoussoukro Decision was an ambitious deregulation reform that followed closely the framework of the Open Skies Agreements, the unfortunate reality is that the African signatory countries did not follow through with their commitment to implement the YD provisions.[6] Failing to achieve the policy harmonization envisioned by the Yamoussoukro Decision, the international aviation market in Africa continues to be governed by bilateral air service agreements (BASAs). Some African countries have been

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[4] A typical BASA would specify one of three possible provisions regarding airfares: 1) double approval, which is the case where a proposed airfare would be permitted for use when both BASA signatory countries approve it, 2) double disapproval, which is the case where a proposed airfare would be permitted unless both nations veto it, and 3) free fare setting.

[5] See Table A1 for more details on how the YD compares to other bilateral arrangements.

[6] IATA's recent comprehensive study for the African Union Commission reveals that no African country is yet to fully implement the Yamoussoukro Decision. Cabo Verde (76% of BASAs are YD-compliant), Mozambique (75% of BASAs are YD-compliant), Mali (73% of BASAs are YD-compliant), and Senegal (68% of BASAs are YD-compliant) are the top four countries with the highest proportion of YD-compliant BASAs, while Uganda (4% YD-compliant BASAs), Burundi (6% YD-compliant BASAs), Libya (8% YD-compliant BASAs), the Seychelles (8% YD-compliant BASAs), and Morocco (9% YD-compliant BASAs) were the countries with the least proportion of YD compliant BASAs. All in all, 21 countries lie in the low compliance category with 31% or less of their total BASAs being YD compliant, while 29 are in the medium compliance range of 33%-68% (IATA 2021).

proactive in pursuing unilaterally air services liberalization, investing effort in renegotiating their BASAs with other African partners to achieve either partial or full liberalization status. In our analysis, we consider as partial liberalization of BASAs the removal of one major category of restrictions among capacity, price or traffic rights restrictions (e.g., fifth freedom rights). Full liberalization of BASAs consists of the elimination of rules and regulations for most if not all key agreement provisions.

The desire to implement the Yamoussoukro Decision at continental level has not disappeared, however. In 2018 the African Union launched the Single African Air Transport Market (SAATM) initiative, enrolling 34 member countries, whose aim is to achieve the full liberalization goals set by the YD. The success of the SAATM initiative remains to be evaluated at future dates, but the multilateral effort and political capital invested towards the goal of full liberalization have set the stage and the appropriate framework for countries to follow. Although trade in air transport services lies outside of the purview of the African Continental Free Trade Area (AFCFTA), it is expected to give further momentum to liberalization efforts, especially as it relates to the opening-up of the air cargo market.

This study, similar to the recent analyses by the IATA (2021) and the African Development Bank (2019), intends to shed more light on the economic impacts of air service liberalization in Africa. It investigates the specific channels through which deregulation affects the provision of air travel in Africa and quantifies the effects of all these mechanisms into a single cumulative impact measure. This measure serves as sufficient statistic to calculate consumer welfare gains from air transport liberalization.

3. Estimation Methodology

In this section we describe our approach in modeling the mechanisms through which air services liberalization may impact aviation markets in Africa. The proposed estimation methodology builds on the work of Winston and Yan (2015) and Cristea et al. (2017).

We begin from the assumption that air liberalization has an immediate and direct impact on the supply side of aviation markets by influencing the operation decisions of active airlines. The demand side of aviation markets responds only indirectly to air service liberalization. Consumers are impacted by air liberalization because of its effects on the price and quality of aviation services. This modeling approach is in line with Winston and Yan (2015) and with Abate and Kincaid (2018), and is based on the fact that bilateral air service agreements provide freedoms of the air that relax market access (i.e., the end points from the signatory countries), the frequency with which flight departures are offered (i.e., capacity restrictions), the entry barriers for new airlines (i.e., designation restrictions), the rules for setting airfares (i.e., pricing restrictions), among others.

Figure 1 illustrates graphically the channels through which liberal air service agreements may impact the aviation markets and the consumers, ultimately generating consumer welfare benefits.[7]

Our empirical analysis aims to capture the linkages illustrated in Figure 1. We allow our BASA policy variable to directly affect the frequency of flights connecting the two signatory countries, to affect the equilibrium number of air carriers operating flights between the two countries, as well as the average airfare charged for such a travel itinerary. Market competition further impacts the flight frequency and the average airfare for travel between the signatory countries. So, air liberalization impacts the supply side of aviation markets both in a direct way, as well as indirectly via its impact on competition.

The volume of air passenger traffic between two countries depends on the cost of air travel, as well as on the quality of the travel experience. The cost of air travel is measured by the average level of airfares, while the quality of the travel experience is captured, in part, by the frequency of air service, which directly influences the availability and directness of air service. The BASA policy variable is assumed to not have a direct impact on the demand for air travel. Nevertheless, the regulatory environment may still have a substantial effect on bilateral air passenger travel through the impact on airfares and on flight frequency.

In our econometric analysis we plan to estimate all these mechanisms through which BASAs impact bilateral aviation markets in Africa. We will then use the magnitude of the estimated effects to calculate the direct and indirect effects of BASAs, which we will cumulate in an ad-valorem equivalent measure. The ad-valorem equivalent measure of liberal BASAs should be interpreted as the "tariff" imposed on air travel by a restrictive regulatory regime. This modeling approach is frequently used in international trade analyses to quantify the ad-valorem tariff equivalent of non-tariff barriers to trade (Anderson and Van Wincoop, 2004; Hummels, 2007). Ultimately, the resulting ad-valorem price equivalent measure of liberal BASAs is going to determine the size of the consumer welfare effects.

Given the level of aggregation of our data, we define an aviation market as a pair of two African countries connected by air service. We will denote the two end points by superscripts i, respectively j. Note that the order of the superscripts is irrelevant as our data is not directional. Our four estimation equations of interest focus on the determination of: 1). passenger volume, 2). average airfare, 3). flight frequency, and 4). number of airlines operating routes between the two countries.

3.1. Demand Equation

The demand equation for air travel, as measured by the volume of air passengers traveling between countries i and j, is given by the following regression equation:

[7] Oum et al. (2019) provide a similar flow chart (their Figure 1) to illustrate the impact of Open Skies Agreements (OSAs) on aviation markets and passenger growth, and through that on services trade.

$$\ln Q_{ijt} = \beta_1 \ln P_{ijt} + \beta_2 \ln Freq_{ijt} + \beta_3 \ln PcGDP_{it} + \beta_4 \ln PcGDP_{jt} + \beta_5 \ln Pop_{it} + \beta_6 \ln UrbanDens_{it} + \\ + \beta_7 \ln Pop_{jt} + \beta_8 \ln UrbanDens_{jt} + \beta_9 \ln Trade_{ijt} + \beta_{10} \ln Distw_{ijt} + \beta_{11} \ln Contig_{ijt} \\ + \beta_{12} Lang_{ijt} + c_i + c_j + u_t + \varepsilon_{ijt} \quad (1)$$

where *Q* denotes the total number of air passengers flying in both directions, *P* denotes the average airfare (in USD) for a flight connecting the two countries, *Freq* denotes the frequency of flights between the two countries, and the rest of the control variables are either capturing the size of air travel expenditures (e.g., population, per-capita GDP, urban density, volume of bilateral trade), or the size of (non-monetary) frictions hindering air travel (e.g., bilateral (population-weighted) distance, shared language or shared border). Given the panel nature of our data, all the regression equations are going to feature country and year fixed effects, as denoted by c_i, c_j, and u_t, respectively.[8]

It is important to be cognizant that both the average airfare and the flight frequency variables are endogenous in the demand equation (1). Unobserved demand factors captured by the error term ε_{ijt} are likely to affect the equilibrium market price, and the frequency with which flights are offered between the two countries *i* and *j*. Endogeneity is a concern because, if left uncorrected, it leads to inconsistent coefficient estimates. To mitigate this problem, we are going to estimate equation (1) by instrumental variables (2SLS). We use information on the aviation policy environment and on the cost of air travel to instrument for airfares, and we use information on the structure and density of the aviation network to instrument for flight frequency. More precisely, we instrument for the average airfare using the cost of fuel, the average airplane size, the number of airlines operating in a market, as well as information on each country's overall aviation policy (i.e., total number of BASAs in effects and the extent of their YD compliance). The aviation policy, the average airplane size and the number of airlines operating in a market (i.e., market competition) are also likely to affect the flight frequency. In addition, we use information on the number of connections (both domestic and international) offered by each country in order to capture the importance of each endpoint as an aviation hub. All else equal, countries that are better connected within the overall African aviation market are more likely to offer frequent air services to a particular destination.

3.2. Airfare Equation

The regression equation modelling the average airfare for a flight connecting countries *i* and *j* is given by the following equation:

[8] We cannot use country pair fixed effects because of the insufficient number of country pairs experiencing changes in BASAs during our sample period. Of the 71 country pairs observed over 2011-2019, only 15 country pairs changed BASA status during our sample period (they account for 25 percent of the observations in our sample).

$$\ln P_{ijt} = \alpha_1 \ln Q_{ijt} + \alpha_2 Partial\_Lib_{ijt} + \alpha_3 Fully\_Lib_{ijt} + \alpha_4 \ln Fuel_{ijt} + \alpha_5 \ln Distw_{ijt} + \\ + \alpha_6 \ln AircraftSize_{ijt} + \alpha_7 \ln NoAirlines_{ijt} + \alpha_8 \ln PcGDP_{it} + \alpha_9 \ln PcGDP_{jt} + \\ + c_i + c_j + u_t + \varepsilon_{ijt} \quad (2)$$

Average airfares depend on: 1) the demand size, Q_{ijt}; 2) consumers' ability to pay for travel (i.e., per-capita GDP in each country); 3) the regulatory regime (i.e., how restricted is the market environment); 4) flight cost factors; and 5) market competition (through its impact on the price mark-up over the marginal cost). As before, c_i, c_j, and u_t denote country *i*, country *j*, respectively year *t* fixed effects.

The regulatory regime is captured by two indicator variables: the *partial liberalization* variable ($Partial\_Lib_{ijt}$) equals 1 if the two countries have a BASA in force where at least one key class of provisions is considered liberal, ensuring unconstrained choices about either capacity or airfares or route entry or fifth freedom rights. The *full liberalization* indicator ($Fully\_Lib_{ijt}$) equals 1 if the two countries have a BASA in force that ensures full freedom in two or more of the key categories of the agreement.[9]

Airfares also depend on the cost of air transport. A significant fraction of the operating cost of flights consists of fuel costs. In our analysis we measure fuel costs by an interaction term between the (log) price of kerosene (a variable that changes over time but is taken as given and is common to all the countries in the sample) and the (population-weighted) bilateral (log) distance between the two countries *i* and *j*. We also include in equation (2) the distance term on its own to account for any other operating costs that may vary with the distance flown, such as, for example, labor costs with flight crew or on-board flight services.

An important source of cost savings for airfares comes from economies of density achieved whenever large capacity airplanes are being used on particular routes. We capture the role of economies of density in the pricing equation (2) by directly controlling for the average size of aircrafts used for travel between countries *i* and *j* (calculated by dividing the total number of seats by the number of departures offered). Market competition, as captured by the number of airlines operating between two countries, is another important determinant of average airfares. Increased market competition leads to a lower price mark-up over the marginal cost, thus reducing the level of airfares.

The endogeneity of quantity demanded, lnQ_{ijt}, in equation (2) is an important concern than needs to be addressed in the empirical analysis. Once again, we are going to use instrumental variable methods (2SLS) and exploit information on exogenous demand shifters identified by the demand equation (1). In

[9] We considered further gradation of the regulatory regime by looking at each of the liberalization provisions separately, but our sample size did not allow to capture meaningful variation. Capturing the heterogeneous effect of liberalization in this manner requires a much larger data set, as was done by Pierrmartini and Rosova (2013) at a global scale.

particular, we are going to instrument for air passenger travel using data on the ease of air travel as captured by the two countries sharing a common language ($Lang_{ijt}$).[10]

3.3. Flight Frequency Equation

We model the frequency of flights between countries i and j using the following regression equation:

$$\begin{aligned}\ln Freq_{ijt} = {} & \gamma_1 \ln Q_{ijt} + \gamma_2 Partial\_Lib_{ijt} + \gamma_3 Fully\_Lib_{ijt} + \gamma_4 \ln NoAirlines_{ijt} + \\ & + \gamma_5 \ln AircraftSize_{ijt} + \gamma_6 \ln AirLinks_{it} + \gamma_7 \ln AirLinks_{jt} + \gamma_8 \ln Distw_{ijt} + \\ & + c_i + c_j + u_t + \varepsilon_{ijt} \qquad (3)\end{aligned}$$

where c_i, c_j, and u_t denote country i, country j, respectively year t fixed effects.

The size of the aviation market measured by the number of air travelers is a key determinant of the number of departures offered between countries i and j. More paying passengers can accommodate more frequent departures, assuming that: i). the airlines can ensure an efficient scale of operations (as captured by the average size of aircrafts) and ii). the regulatory environment is such that capacity decisions are not constrained by restrictive BASAs (i.e., countries i and j have in effect partial or fully liberalized agreements).

Flight frequency also depends on the number of operating airlines. Conditional on the demand size and the regulatory regime, a larger number of airlines generally means more possible routes between the two countries and/or more departure times per route.

Cost effectiveness is also an important concern in determining the optimal flight frequency, and the geographic distance between countries may help in capturing some of these costs. On one hand, bilateral distance may decrease flight frequency because of increased fuel costs. On the other hand, air transport has fewer substitutes over longer distances justifying an increased number of departures.

Finally, flight frequency depends on the size of the airports connecting the two countries i and j. Airports that are well integrated in the structure of the African aviation network, that act as hubs and offer many flights to many destinations, may find it easier to add one more flight to a given destination. This is because such airports already have the infrastructure (e.g., runways), the operators (e.g., air carriers and auxiliary services), the equipment (e.g., airplanes), etc. to add one more flight to a given destination. In our

[10] We left out from the 2SLS estimation information on population size or urban population density for each country i and j because of the limited time variation available in these two variables, which may create a 'weak instruments' problem. We also opted against using information on the bilateral volume of trade as exogenous instrument for the air passenger flows because there could be unobserved factors that influence both shipping charges and airfares, which would create a connection between trade flows and the average level of airfares, thus invalidating the exogeneity assumption that must be satisfied by the excluded instruments.

analysis we capture this idea by controlling for the total number of domestic and international connections (*AirLinks*) offered from each country in the pair *ij*.

Once again, we need to be cognizant of the endogeneity between the size of the aviation market, as captured by the volume of passengers (lnQ_{ijt}), and the frequency of flights. Unobservable factors that influence the total number of departures may also influence the total number of air passengers traveling between the two countries. Like before, we mitigate endogeneity concerns by using instrumental variable methods (2SLS) and by exploiting information on the exogenous demand shifters identified in the demand equation (1). In particular, we are going to instrument for air passenger travel using data on: i) the ease of air travel as captured by the two countries sharing a common language ($Lang_{ijt}$), and ii) the existence of a regional trade agreement (RTA) between the signatory countries.[11]

3.4. Market Competition Equation

Lastly, we model market competition on aviation routes involving the end-point countries *i* and *j* using the following estimating equation:

$$\begin{aligned} \ln NoAirlines_{ijt} = {} & \delta_1 Partial\_Lib_{ijt} + \delta_2 Fully\_Lib_{ijt} + \delta_3 lnAirLinks_{it} + \delta_4 lnAirLinks_{jt} + \\ & + \delta_5 lnTrade_{ijt} + \delta_6 lnGDP_{it} + \delta_7 lnGDP_{jt} + \delta_8 lnDistw_{ijt} + \\ & + c_i + c_j + u_t + \varepsilon_{ijt} \end{aligned} \tag{4}$$

where c_i, c_j, and u_t denote country *i*, country *j*, respectively year *t* fixed effects.

The type of BASA in effect between the two countries is a crucial determinant of market competition.[12] When air carriers are free to make market entry decisions and offer flights between any two points connecting the signatory countries, competition is expected to rise. In addition to the degree of air liberalization, another important determinant of market competition is the size of the airports located in the two countries, as measured by the total number of domestic and international connections offered from each country (i.e., *AirLinks*). Hub airports are generally attracting many airlines. So, when the opportunity arises for a lucrative route between two cities, the airlines that already have operations at those airports are better equipped at seizing such opportunities due to lower fixed costs of entry. Thus, airports with a large number

[11] We only use the information on the bilateral trade policy (i.e., RTA indicator) to instrument for air passenger flows in the flight frequency regression. We are not considering this excluded instrument when estimating the airfare regression in equation (3). We make this distinction because of statistical performance in the two estimation exercises, and because of potential endogeneity concerns in the airfare model arising from the fact that trade policy, through its impact on trade flows, may directly influence freight and flight costs.

[12] Dobruszkes (2009) discusses the impact of air liberalization on market competition in the context of the European market and finds heterogeneous but generally positive effects.

of connections are more likely to see an increase in the number of airlines operating on a given route, all else equal.

The GDP of each country and the bilateral distance between them account for the total potential revenue and the variable cost, respectively, associated with operating air service between the two countries. The attractiveness of a particular aviation market depends on the prospects for maximizing profits on the routes connecting the two countries.

4. Data Sources and Descriptive Statistics

The empirical analysis in this paper is based on an unbalanced panel data set covering 71 country pairs within Africa observed over the period 2011-2019. We define an international aviation market at the country-pair level and collect data that combine information for both directions of air travel (so, the data set is *not* directional). The main sources of data are described below.

4.1. Aviation Data

Air traffic volume data are sourced from the Sabre Market Intelligence database. They measure the total number of passengers flying in both directions between the two countries in a bilateral pair. The average airfare data also comes from the Sabre Market Intelligence database and measures the average price (in nominal US dollars), excluding taxes and fees, for an economy-class round trip flight between the two countries in a bilateral pair (averaged over both directions of travel).

Flight frequency is defined as the number of (non-stop) flight departures operated between the two countries in a bilateral pair in either direction. Average aircraft size is defined as the average number of seats per departure calculated at the country pair level. Both variables are collected from the OAG flights database. The same data source is used to collect information on the total number of airlines offering seats between the two countries in a bilateral pair in a given year.

The OAG flights database also provides information on the number of direct routes to domestic destinations as well as on the number of direct routes to international destinations from the airports of a country. We combine the domestic and international routes into a single variable which we define as the total number of *AirLinks* per country for each of the countries in a bilateral pair.

The main aviation policy variables that we use in our analysis are two indicator variables characterizing the degree of liberalization enforced by the BASAs covering the country pairs in our sample. All BASAs include provisions pertaining to: 1) capacity choices (e.g., flight frequency, aircraft size), to 2) price setting decisions (e.g., extent to which airfares can be set without approval of aeronautical authorities), and to 3) fifth freedom rights (i.e., ability to pick up or drop of air traffic in third markets as long as these markets are intermediary points on routes with final destination in one of the signatory countries).

Information on the content and characteristics of the BASAs was collected from surveys administered by the World Bank to Civil Aviation Authorities and Ministries of Transportation for the African countries in our sample. This information was used to construct a *Partial Liberalization* indicator variable that equals 1 if at least one of the key provisions of the BASA in effect was identified as liberal. The *Full Liberalization* indicator variable equals 1 if the BASA provisions are identified as liberal in two or more of the key categories described above.[13]

In addition to the liberalization policy variables constructed from BASA-specific information collected from the World Bank surveys, for our robustness exercises we also employ information on the overall air transport regulatory environment of the countries in our sample gathered from a study by IATA (2021) on YD/SAATM implementation in Africa.[14]

From the IATA study, we collect several time-invariant country-specific aviation measures. One such variable is the total number of BASAs that each country in our sample has in effect with other African countries (irrespective of whether these countries are in our data sample). We then assign a value of 1 to the bilateral pairs in our sample where *both* countries have above median number of BASAs signed. The goal of this variable is to capture the general openness of countries in a bilateral pair to establish international aviation services within the African continent.

Notice that while this openness variable measures the above median number of BASAs per country, it does not consider how liberal the signed BASAs actually are. It just measures how proactive each country has been in establishing aviation agreements with other African countries. So, to refine this measure, we collect additional information from the IATA (2021) study on the extent of air liberalization achieved by a country. Specifically, we count the number of Yamoussoukro Decision (YD) compliant BASAs signed by each African country. We then construct an indicator variable at the bilateral pair level that is equal to 1 if *both* countries are above median in the number of YD compliant BASAs.

Another variable sourced from the IATA (2021) study is a rank indicator that takes the values 1, 2 or 3 depending on whether the aviation policy environment in a country is successful for the implementation of the Yamoussoukro Decision (YD), with 1 being successful and 3 needing significant improvements. We use this information to construct an indicator variable at the bilateral country pair level that equals 1 if both countries have successful policy environments and 0 otherwise. The goal is to identify country pairs that have the necessary regulatory apparatus, including safety oversight capabilities, to successfully implement

[13] Because of concerns associated with multicollinearity among BASA provisions, and because of the limited number of BASAs that get renegotiated during our sample period, we cannot construct more nuanced BASA liberalization variables.
[14] Data associated with the IATA (2021) study is available at: https://www.saatmbenefits.org/.

liberalization policies. As is often the case, it is the operationalization and implementation of the liberal provisions in aviation agreements that matter the most when reforming the industry.

One last variable sourced from the IATA (2021) study records the number of airlines per country that are certified by the IATA Operational Safety Audit (IOSA) program. IATA's certification is an international standard sought by all airlines around the world, so countries with no IOSA certified airlines most likely have small enough aviation markets and regulatory oversight capacity to not support a designated flag carrier. Based on this information, we construct an indicator variable at bilateral level equal to 1 if either one of the countries in the bilateral pair has no IOSA certified flag carriers.

4.2. Country Level Economic Data

We supplement our aviation data with country specific information on economic size, as measured by the total population, the average per-capita GDP level (2010 US dollars) and the urbanization rate (i.e., urban population as a fraction of total population). All three variables are sourced from the World Development Indicators database maintained by the World Bank.

From the Gravity database maintained by CEPII, we source bilateral information on the total volume of trade at the country pair level, on the (population-weighted) geographic distance, and on whether the two countries share a common language or a land border.

Finally, information on the annual average price of kerosene in the Gulf coast of the US – a measure of fuel costs for airlines – is collected from the U.S. Energy Information Administration.

4.3. Descriptive Statistics

Table 1 reports the sample summary statistics for all the variables that we described above and that we will use in our estimation analysis. The variables are reported in natural log format to reflect the format they will be used in our regression models.

Figure 2 provides a map of all the African countries included in our sample. The color gradient depicts the size of each country's aviation market as measured by the volume of international intra-Africa air passenger flows reported by the IATA for year 2019.[15] South Africa, Kenya, Morocco, the Arab Republic of Egypt and Ethiopia are the top 5 countries accounting for the largest volume of intra-Africa air travel in 2019. Our estimation sample includes a subset of all the possible bilateral pairs formed between the countries represented in Figure 2. Importantly, some of the largest air transport markets in Africa are included in our sample.

[15] Intra-Africa air passenger data comes from: https://www.saatmbenefits.org/passengers_number/.

Figure 3 reports the growth in passenger traffic observed in our data sample over the period 2011-2019. Passenger traffic almost doubled during the 9 years of available data. Since our panel is not balanced, the number of country pairs observed each year varies over time, so part of the reported growth could come from compositional changes in country pairs. For transparency, the value in parentheses reported on top of each bar indicates the number of country pairs observed each year that contributes to the total passenger traffic reported in our sample. While changes in country composition are not very big year-on-year, it is useful to look *within* country pairs over time. In that regard, the median country pair in our sample sees an average growth rate in air passenger traffic of 6.3 percent per year.

Figure 4 replicates the same bar chart as reported in Figure 3 but using flight frequencies as our aviation market variable of interest. Here, we observe a much smaller growth in the total number of departures of about 23 percent over the period 2011-2019. To some extent, it makes sense for flight frequency to grow at a slower rate since airlines can respond to positive demand shocks by: 1) increasing their load factors (i.e., the number of passengers per available seats on a plane), and 2) re-allocating their capacity to assign larger planes on busier routes, before adding new flight departures. When looking within country pairs over time, the median country pair sees flight frequency growing at an average rate of 3.4 percent per year.

Since the focus of our empirical analysis is on the impact that air liberalization has on aviation markets in Africa, it is useful to get a picture of the distribution of BASAs by regulatory type available in our sample. Figure 5 illustrates, by year, the number of country pairs that are governed by restrictive BASAs, respectively by BASAs that are categorized as partially or fully liberalized.

Although the total number of country pairs varies slightly over time because of the unbalanced nature of our panel data set, Figure 5 still makes it transparent that a growing number of countries in our sample have adopted liberal aviation policies over time. If 30 out of 57 country pairs observed in 2011 had restrictive BASAs in effect, by 2019 this number dropped to 22 country pairs out of 59 observed. The number of fully liberalized BASAs in 2011 was 12 out of 57 BASAs observed, and this number grew to 27 by 2019 out of 59 BASAs observed. The significant growth in fully liberalized agreements is explained both by countries with partially liberal agreements that continued their aviation liberalization effort (e.g., Botswana – Zimbabwe transitioned to full liberalization by 2018), as well as by regulated countries that underwent complete transformations towards full liberalization (e.g., Ethiopia – South Africa air liberalization in 2013).

5. Estimation Results

This section discusses the results from estimating the baseline regression models described in equations (1) through (4) of Section 3 using ordinary least squares (OLS), respectively instrumental variables (2SLS) methodologies. The section also discusses the robustness of our findings to alternative model specifications and data exercises.

5.1. Baseline Results

Table 2 reports the regression coefficients from estimating equation (1). Columns 1-3 report OLS estimates while column 4 reports the 2SLS coefficients. The specification in column 1 includes a limited number of control variables and no country fixed effects. Column (2) adds more control variables, while column (3) adds in country fixed effects. Not surprisingly, the overall fit of the model as captured by the regression R-squared increases with model completeness. Column (4) re-estimates the model specification in column 3 and instruments for the average airfares and for flight frequency using the excluded instruments discussed in the estimation methodology section.

The first result of interest is the price elasticity of demand, which is measured by the coefficient on the (natural log of) average airfares. Across all 4 specifications, the price elasticity of demand is negative and statistically significant at conventional levels. The OLS estimate in column 3 suggests that a 1 percent fall in the average airfare leads to a 0.47 percent increase in the number of passengers traveling between the two countries. One concern with this elasticity estimate is that it suffers from an upward bias due to the endogeneity of prices in demand equations. More specifically, unobservable factors that would cause an increase in air travel demand would also contribute to higher fares in equilibrium, thus creating a positive correlation between airfares and the error term ε_{ijt} from the demand equation (1). The role of the instrumental variables method is to correct for this bias by employing exogenous and independent variation in airfares and flight frequency, respectively. Consistent with expectations, the price elasticity of demand increases in magnitude in absolute value after controlling for endogeneity. The coefficient estimate in column 4 of Table 1 suggests that a 1 percent drop in airfares leads, on average, to 0.88 percent increase in the number of travelers, which represents a less than proportional increase in passenger traffic. While the 2SLS coefficient estimate is almost double the size of the OLS estimate, the magnitude is consistent with price elasticity estimates found in other studies, including studies focused on Africa.[16] Importantly, as reported at the bottom of column 4, the excluded instruments perform reasonably well. The first-stage F statistic (used to test for the weakness of the excluded instruments) is equal to 8.4, which is on the lower side but still within an acceptable range. The Hansen's test for overidentifying restrictions rejects the exogeneity assumption of the excluded instruments, however we rely on economic reasoning and intuition

[16] Abate and Kincaid (2018) find a price elasticity of demand of -0.7 using a sample of countries from the East African Community. Button et al. (2019) find a price elasticity of -0.6 for travel among countries in Sub-Saharan Africa. Brons et al. (2002) conduct a meta-analysis of price elasticities in the aviation sector and find a mean elasticity of -1.15 using information from 37 studies on 207 price elasticity estimates. Gillen et al. (2007) find an average demand elasticity of -1.04 for international long-haul leisure travel.

to argue that the only channel through which the considered variables can influence passenger flows is, in our opinion, through changes in flight costs or flight frequency.

The second coefficient of interest is the elasticity of demand with respect to flight frequency. Across all four specifications reported in Table 2, the estimated coefficient is very stable and statistically significant. The 2SLS estimate suggests that a 1 percent increase in flight frequency leads, on average, to a 1.4 percent increase in air passengers. Among the country pairs in our sample we observe a growth in flight frequency of 14% over the period 2011-2019. Combined with our estimated coefficient on flight frequency, this implies a 19.6% increase in passengers over the 9-year period. The finding that consumers value the frequency with which departures are offered on a route is consistent with the findings from the existing literature. It is suggestive of the fact that the quality of air service, as captured by flexibility in departure times and improvements in flight connections, matters for consumers in Africa.

All the other control variables included in the demand equation (1) and reported in Table 2 perform well and the coefficients are consistent with expectations. For example, when statistically different from zero, the population size and the average per-capita GDP of each country in the bilateral pair have a positive effect on the number of passengers traveling between the two locations. The volume of bilateral trade has a further positive, albeit insignificant, effect on the demand for air travel (Cristea, 2011; Startz, 2021). Larger distances are associated with a reduction in air travel, indicative of the time and effort necessary to reach farther destinations.[17] Sharing a common border also reduces the demand for air travel, which is consistent with the view that air passenger transport may have more substitutes over short distances (e.g., neighboring countries) compared to longer distances. Perhaps the control variable with a surprising coefficient estimate is the urban density variable, which has a negative and sometimes significant effect on the demand for air travel. A possible explanation for this inconsistent result is the potential collinearity between the per-capita GDP of a country and the fraction of its population living in urban areas. In our sample, this correlation coefficient is around 0.80.

Moving on to the estimation model for airfares, Table 3 reports the coefficients from estimating equation (2). Columns 1 and 2 report OLS results without, respectively with country fixed effects. Column 3 reports the 2SLS coefficients obtained after instrumenting for the volume of air passengers using the excluded instrument discussed in the estimation methodology section. As expected, the coefficient for air passengers is negative and weakly significant (10 percent level) in our preferred specification (column 3), with a magnitude that is consistent with previous studies (e.g., Abate and Kincaid, 2018). A 10 percent increase in the volume of air passengers leads to a fall in average airfares of less than one percent (more

[17] Piermartini and Rousova (2013) also find a negative effect of distance on the bilateral volume of air passenger transport.

exactly 0.75 percent). The negative effect points to the economies of scale and density enjoyed by airlines that operate on highly demanded aviation routes.

The results of most interest to us are the air liberalization coefficients reported in Table 3. Both *partial* and *full aviation liberalization* variables have a direct negative effect on the average airfares. This is consistent with expectations as one of the main benefits of liberal BASAs is to allow airlines full freedom in setting airfares. Using our preferred specification in column 3, the estimates suggest that a country pair with a partially liberalized BASA enjoys average airfares that are 16.5 percent lower, on average.[18] A country pair with a fully liberalized BASA enjoys average airfares that are 15.4 percent lower, on average. While slightly smaller in magnitude, the price effect of full liberalization cannot be distinguished statistically from the price effect of partial liberalization.[19] This may seem surprising at first. However, we think that there could be at least three explanations for it. First, there may be non-linear price effects such that the biggest benefits of air liberalization are achieved as soon as international aviation restrictions start to be eased, which happens under partial liberalization. Second, the African aviation industry may be in its infancy and markets may be insufficiently developed for the benefits of full liberalization to be materialized even if such agreements are in effect. Lastly, it may be the case that fully liberalized BASAs are only agreed to on paper, with actual implementation lagging behind. In that case, fully liberal BASAs are not going to have any additional impact on prices since they effectively act as partially liberalized BASAs.[20]

Magnitude aside, it is important to highlight the finding that countries that make an effort to initiate air service liberalization enjoy significant price effects. It is reassuring to see that in the absence of policy restrictions average airfares respond optimally to market forces. It may be the threat of entry that "disciplines" price mark-ups, or it may be the potential increase in airline efficiency that translates into lower airfares following market liberalization. A more effective capacity utilization could generate economies of density that would lower average operating costs.

The estimated price effects also suggest that in regulated aviation markets prices are forced to stay at artificially high levels, perhaps as a way for governments to protect inefficient state-owned flag carriers.

The negative and significant effect of aviation liberalization on average airfares operates independently from the effect of market competition (i.e., number of airlines) or the effect of capacity (i.e., aircraft size) on airfares. Both of these control variables have the expected negative sign, with the capacity

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[18] Given that partial liberalization is a 1/0 indicator variable, the percent change in average airfares associated with a partially liberal BASA is equal to exp(-0.180) -1.

[19] The Chi-squared statistic for the equality between the partial and full liberalization coefficients is 0.05 with a p-value of 0.81. So, we fail to reject that the coefficients are equal to each other statistically.

[20] We cannot exclude the possibility that the coefficient estimate for full BASA liberalization not being larger than the partial liberalization one is influenced by the limited number of country pairs that adopt fully liberalized BASAs during our sample period. Of the 71 country pairs observed in the data, 12 of them change status to become fully liberalized.

choice having a large and significant price reduction effect. A 10 percent increase in aircraft size leads, on average, to a 3.63 percent reduction in airfares. This highlights an important channel through which aviation markets in Africa can become more efficient as they grow and mature: market growth could support the use of larger planes with better capacity utilization.[21] All the other control variables from the price regression equation (2) estimated in Table 3 are consistent with expectations even if insignificant. Distance has a large and positive effect on prices, which is in line with operating costs increasing in geographic distance, while fuel costs and per-capita GDP have positive but insignificant price effects.

Moving on to the model for flight frequency in equation (3), Table 4 reports the coefficient estimates. Columns 1 and 2 report the OLS results without, respectively with country fixed effects. Column 3 reports the 2SLS coefficients obtained after instrumenting for the volume of air passengers using the excluded instrument discussed in the methodology section. Looking across model specifications, the coefficient estimate for the volume of air passengers is positive, statistically significant and very similar in magnitude. Using the 2SLS estimates reported in Column 3, a 1 percent increase in air passenger travel leads, on average, to a 0.43 percent increase in the number for flight departures.

To our surprise, we find no evidence that the regulatory environment has a direct effect on flight frequency once we control for the size of air travel demand. Neither partial nor full liberalization of air services seem to affect the frequency of flights offered between the country pairs in our sample. This finding differs from Abate and Kincaid (2018), perhaps because our sample is larger and more heterogeneous than theirs. Even so, this result is somewhat surprising given that one of the main objectives in renegotiating BASAs is to ensure free capacity determination. So, how can we reconcile our findings with the stated objectives of liberalized BASAs? There are two potential explanations that we can think of. First, it is possible that our sample includes a fair number of "thin" aviation markets where the existing restrictions on flight frequency may have not been binding. So, the removal of such restrictions would not change the equilibrium number of departures being offered. Second, it could also be the case that some of the liberal BASAs look great "on paper" but lag behind in operationalization and execution. As stated previously, some governments may have strategic interests (e.g., state-owned flag carriers) in delaying the liberalization process. Other countries may struggle with market or institutional rigidities (e.g., limited capacity or heavily regulated airports) that may infringe on airlines' ability to make free capacity determination. Nevertheless, even if air liberalization does not have a direct effect on flight frequency, it is still possible for it to have an indirect effect on flight frequency that operates through the liberalization-induced changes in passenger volumes. We will discuss the magnitude of this channel in the welfare calculation section.

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[21] One concern in Africa is a suboptimal fleet size. This may lead to a misallocation of seat capacity across international markets where big aircrafts are employed in thin markets. Air liberalization may mitigate this problem by increasing capacity utilization through the growth of air travel.

Overall, the regression model for flight frequency defined in equation (3) seems to be well specified. Several of the control variables turn out to be important determinants of the number of departures offered per country pair. Specifically, market competition – as captured by the number of operating airlines – has a positive and significant effect on flight frequency. The average aircraft size, on the other hand, has a negative and significant impact on flight frequency, which is consistent with intuition. Bilateral distance further increases the number of departures in a market, which is consistent with the view that passenger aviation is less substitutable as a mode of transport over long distances. Lastly, the total number of domestic and international connections available from the airports of each country matter to a weaker extent for flight frequency.

Table 5 reports the results from estimating the market competition model described by equation (4). All three specifications reported in Table 5 are estimated by OLS. Column 1 reports a parsimonious model with fewer control variables and no country fixed effects. We then gradually add country fixed effects (column 2) and additional control variables to capture the attractiveness and business potential of an aviation market (column 3). The air liberalization variables of interest have an insignificant impact on the number of airlines operating flights in a country pair *ij*. The full liberalization dummy is positive and statistically significant in the parsimonious model of column 1 but then loses significance as we add country fixed effects.

The insignificant effect of air transport liberalization on market competition seems surprising since one of the main goals of the renegotiated BASAs is to facilitate free entry and to increase market competition. We think that, similar to the flight frequency results, the lack of a response in market competition could be explained by: i) the small size of aviation markets in Africa (which may not sustain more airline entry following liberalization); ii) a slow implementation of liberal BASAs; and even possibly iii) unforeseen constraints "on the ground" that may hinder airline entry (e.g., airport capacity limitations, additional airline certification before market entry, increased airport controls and fees, etc.).

Interestingly, bilateral distance has a large negative and significant effect on market competition. As distance increases, so do the costs of operating aviation routes. In the presence of less developed aviation markets, profits may not be large enough to justify an increased number of airlines. What seems to raise market competition is the number of domestic and international connections offered from the airports of each country. More connections potentially means more airlines operating at those airports, so the cost of entering a new route are much smaller for those airlines, hence the increased competition.

5.2. **Robustness Checks and Heterogeneity Analyses**

The estimation results discussed so far point to a direct effect of air liberalization on airfares, but no direct impact on flight frequency or market competition. To further investigate the robustness of these findings, we proceed in this subsection by describing alternative model specifications. In particular, we ask whether some of the insignificant effects of air liberalization are due to heterogeneities among country pairs in our sample. For example, it could be the case that some country pairs do not have the infrastructure and organization to successfully implement liberal BASAs even if such agreements are signed. Alternatively, some countries do not have their own flag airlines and so face less protectionist pressures coming from domestic sources. This may make them more open and more willing to implement liberal BASAs.

In what follows, we collect country-level information from a study on the Single African Air Transport Market (SAATM) conducted for the African Union Commission by IATA Consulting (2021) and use it in our analysis to investigate whether our main coefficient estimates for partial and full air liberalization are heterogeneous across country pairs. We construct two new variables to use as alternative measures of air transport liberalization. The first variable is a 1/0 indicator variable that measures a country's openness to international air services. To construct this measure, we first calculate how many bilateral BASAs each country has in effect with all the other African countries. We then assign a value of 1 to all countries with *above median* number of BASAs signed. Notice that this measure does not take into account how liberal the signed BASAs are, just how proactive a country has been in establishing aviation agreements with other African countries. To the extent that countries who are more effective at negotiating lots of BASAs are also more willing to liberalize their international aviation markets, then such a variable may be an alternative way to measure openness to aviation liberalization.

We construct a second variable that aims to add more information on the extent of air liberalization achieved by a country. Using again IATA (2021) compiled data, we count the number of Yamoussoukro Decision (YD) compliant BASAs signed by each African country. Since the goal of the Yamoussoukro Decision was the full liberalization of air transport services, countries with a large number of BASAs that are YD compliant can be considered active proponents of aviation liberalization. Based on this assessment, we construct an indicator variable equal to 1 if an African country is above median in the number of YD compliant BASAs.

We use these two new variables – the extent of BASAs signed with other African countries and the degree of liberalization of BASAs – as an alternative way to capture aviation liberalization. To get bilateral country-pair variation, we multiply the country-specific indicators for the two countries in a bilateral pair. We then re-estimate equations (2) through (4) and replace both the partial and full liberalization dummies with these two alternative policy variables. The results are reported in Table 6. Column 1 reports the 2SLS estimation results for airfares, column 2 reports the 2SLS estimation results for flight frequency, and column 3 reports the OLS the estimation results for the number of airlines as dependent variable. Each column reports the estimates from the preferred model specification, which includes all sets of fixed effects and control variables. In the interest of space, we only report the coefficients for the policy variables of interest, but we confirm that all the control variables display similar effects as in the baseline regressions.

Overall, the results in Table 6 confirm the findings from the baseline regressions. We find that air liberalization has a direct impact on airfares but an insignificant effect on the frequency of flights. Interestingly, we do find some supportive evidence on the positive effect of air liberalization on the number of airlines operating within a country pair.

Focusing on column 1 of Table 6, the estimates suggest that a country pair where each country has an above median number of BASAs in effect and an above median number of BASAs that are YD compliant enjoys airfares that are, on average, 45 percent lower than countries that are below the median in both categories.[22] This effect is much larger in magnitude than the price effect of full liberalization estimated in Table 3, however a direct comparison may not be entirely justified. It is possible that countries with a large number of BASAs that are YD compliant are more effective in overseeing the implementation of these agreements to make sure they achieve the desired outcomes. Nevertheless, it is reassuring to see that the pattern of results identified previously remains the same even when we use different measures for the policy environment. This gives us confidence in using the baseline results for consumer welfare calculations.

Because airfares seem to have the most robust response to aviation liberalization, in our next robustness exercise we will only focus on airfares. In doing so, we try to shed more light on the heterogeneity behind the impact of aviation liberalization on prices. More specifically, we ask: 1) how does a country's ability to undertake a major policy reform such as air liberalization impact its effect on airfares? and 2). are countries that own flag carriers more protectionist and less likely to facilitate price liberalization?

To carry out these exercises, we first collect information on each African country about its potential for a successful implementation of the Yamoussoukro Decision (YD). Countries are classified by IATA (2021) in one of the following three categories: 1 = favorable environment for YD implementation, 2 = country "needs improvement" for successful YD implementation, and 3 = country "needs *significant* improvement" for achieving a successful YD implementation. We use this information to construct an indicator variable called YD_{ijt} that equals 1 if both countries i and j are classified as having a favorable environment for YD implementation.

Next, we construct a dummy variable called "No IOSA" which equals 1 if at least one of the countries in the bilateral pair do not have airlines that are registered with the IATA Operational Safety Audit (IOSA) program, a necessary registration and evaluation system to maintain IATA membership.[23]

[22] We calculate the total marginal effect as: exp(-0.407 - 0.194) -1 = -0.452.
[23] IATA data on the number of registered airlines by African country is available from**:** https://gadart.com/iata/. As of January 2022, only 46 airlines in 28 African countries are registered under the IOSA program. For context, in 2017, 65 African airlines held an Air Operator Certificate and provided international commercial air transport services (ICAO, 2019).

By having no flag carriers with strategic interests in aviation policy decisions, a country may be more opened towards liberalization. At the same time, it is also possible that having no flag carriers may be indicative of countries with weak or thin aviation markets, and hence with less opportunities to capitalize on the gains from liberalization. In spite of the multiple meanings of the "No IOSA" indicator variable, it is still worth understanding how it may influence the impact of air liberalization on airfares.

Table 7 reports the results from estimating the airfare equation (2) and interacting the main aviation policy variables – partial and full BASA liberalization – with the indictor variables for favorable *YD* implementation (columns 1 and 2), respectively for *No IOSA* (columns 3 and 4). Notice that because we have two policy indicators that each gets interacted with a 1/0 variable, the model specifications reported in Table 7 end up having 4 interaction terms of interest. For completeness, we report both OLS and 2SLS results, although for reasons already discussed in the paper, the 2SLS estimations reported in column 2, respectively column 4, remain our preferred results.

Interestingly, the estimates from column 2 of Table 7 suggest that the price reducing effect of air liberalization is to a large extent driven by country pairs that *do not* have a favorable environment for YD implementation. This finding may seem counterintuitive. However, one could interpret the results as suggesting that the country pairs who benefit the most from partial, respectively full BASA liberalization are those that lack progress towards aviation reform. For such sluggish economies, the existence of a liberal BASA may be the absolute necessary environment to allow airlines the freedom to set lower airfares. By contrast, countries with a favorable policy environment may already allow airlines the flexibility to set airfares even in the absence of a formal document such as a liberal BASA.

Turning now to the results in column 4 of Table 7, the pattern of results suggest that the price reduction effect of air liberalization is driven in large part by country pairs that own at least one airline that is IATA certified. This may be expected as these are the country pairs with more mature and more developed aviation markets. At the same time, one could argue that these could also be the countries where strategic political interests may play out more and restrict the progress towards liberalization. However, our estimation results do not seem to support this hypothesis. The results in column 4 further suggest that country pairs with smaller aviation markets and with no certified IATA airlines could also benefit from reduced airfares when implementing partial liberalization. The effects are insignificant, however, in the case of full liberalization.

The findings reported in Table 7 are interesting and informative, however a word of caution seems necessary. Our data sample is relatively small (515 observations) and only a subset of the observed country pairs is subject to a partial, respectively a full BASA liberalization. When interacting the "treated" country pairs with additional indicator variables, we are further reducing the number of observations that are used in identifying the relevant coefficients. This raises potential concerns about the robustness of our findings from the heterogeneity analysis. So, further analyses seem important to solidify the patterns of our results.

6. Consumer Welfare Analysis

In this section we provide consumer welfare calculations that are informed by the estimated coefficients discussed in the results section. Consumers gain from air liberalization by having access to cheaper flights, and conditional on airfares, by enjoying higher quality air transport services.

Figure 6 illustrates the consumer gains resulting from more liberal BASAs. Air liberalization is expected to generate two effects: 1) a move along the demand curve (e.g., from point A to point B), which captures the total price effect of air liberalization; mathematically, this corresponds to the total derivative *dlnP/dPartial_Lib*, respectively *dlnP/dFull_Lib*; and 2) a shift in the (log) demand curve (e.g., from point B to point C), which corresponds to an increase in air travel demand due to quality improvements in air service. In our analysis, we have measured quality by the frequency of flights between two countries. So, mathematically, this second effect can be written as *(dlnQ/dlnFreq)x(dlnFreq/dPartial_Lib)* for partial liberalization agreements, respectively *(dlnQ/dlnFreq)x(dlnFreq/dFull_Lib)* for full liberalization agreements.

Ultimately, we want to combine the two effects into one cumulative value. However, the first effect is in price units while the second effect is in quantity units. To transform the quality effect into a price-equivalent measure, we divide it by the price elasticity of demand. Thus, the cumulative price equivalent effect of air liberalization can be calculated as follows:

$$\text{Price equivalent effect of air liberalization} = \frac{\text{dlnP}}{\text{dPolicy}} + \frac{\varepsilon^{\text{Freq}} * \text{dlnFreq/dPolicy}}{\varepsilon^{\text{P}}} \qquad (5)$$

where *dPolicy* denotes a switch in the policy environment to a partial, respectively a full BASA liberalization, $\varepsilon^{Freq} \equiv dlnQ/dlnFreq$ denotes the demand elasticity with respect to flight frequency (reported in Table 3), and $\varepsilon^{P} \equiv dlnQ/dlnP$ denotes the price elasticity of demand (reported in Table 3 as well).

The advantage of the price-equivalent calculation from equation (5) is that it captures in a single statistic the *total* or *cumulative* percent change in average airfares that can be attributed to the change in aviation policy. The statistic parallels the way tariff liberalization is measured in the case of traded goods, i.e., as a percent reduction in the price of the imported goods. This methodology of calculating the price equivalent of air liberalization has been implemented in Cristea et al. (2017), and it borrows from the trade literature on non-tariff barriers. This literature has developed the necessary tools to quantify the tariff-equivalent of barriers to trade that are not naturally expressed in ad-valorem terms.

We proceed with the rest of the section in two steps. First, we calculate the total derivatives of key market outcomes (i.e., air travel demand, airfares, flight frequency and market competition) with respect to partial, respectively full BASA liberalization. We need these total derivatives to calculate the price equivalent effect of air liberalization according to equation (5). In the second step, we use the cumulative price effect of air liberalization to calculate the total consumer welfare using the: 1) compensating variation approach, and 2) the change in consumer surplus approach. The compensating variation welfare measure corresponds to the change in income necessary to keep the same level of utility as before liberalization at the new prices for air travel estimated after liberalization. The change in consumer surplus corresponds to the difference between consumers' marginal benefit from air travel and the price they pay for it. The bigger the difference between what consumers are willing to pay to enjoy the benefit of air transport and what they end up paying based on market prices, the larger consumer surplus is.

It is worth mentioning that the welfare analysis in this study focuses entirely on the consumer side and leaves out the producer side. Data and methodological constrains limit our ability to calculate the changes in producer surplus. Since we cannot integrate this side of the air transport market into our welfare analysis, it is important to emphasize that our results cannot speak for the overall welfare effect of BASA liberalization.

6.1. Price Equivalent Effect of Air Liberalization

As illustrated in Figure 1 and estimated in the regression equations (1) through (4), the effect of liberalization on aviation markets operates via multiple channels: price reduction, increased market competition and increased flight frequency. Each of these direct effects has implications for the demand for air travel, which may increase due to both a reduction in prices and an increase in flight frequency. Furthermore, increases in air travel demand have subsequent implications for prices via economies of density, and for flight frequency via economies of scale effects. All of these interdependencies captured by the direct and indirect effects of aviation liberalization need to be aggregated into a cumulative effect.

Table 8 reports these calculations in detail. Appendix A1 describes all the steps performed in deriving the results. The calculations are done for partial liberalization (columns 1-2) and full liberalization (columns 3-4), using coefficients from both OLS estimations (columns 1 and 3) and 2SLS estimations (columns 2 and 4). Given that the 2SLS methodology mitigates an important estimation issue with significant success in implementation, in what follows we only focus on price equivalent calculations using the preferred 2SLS estimates but reports the OLS calculations for comparison purposes.[24]

[24] Apart from the debatable concerns about the exogeneity of the excluded instruments used in estimating the demand equation (1), our 2SLS methodology satisfies all the statistical tests validating its performance. Furthermore, as can

The first row in Table 8 reports the cumulative price effect of air liberalization (mathematically, the total derivatives *dlnP/dPartial_Lib* and *dlnP/Full_Lib*, respectively). The total reduction in airfares attributed to aviation liberalization in Africa equals 19.4 percent (i.e., exp(-0.216)-1 = 0.194) in the case of partial liberalization, and 18.1 percent (i.e., exp(-0.200)-1) in the case of full liberalization. Liberalization has a *direct* effect on airfares coming from reductions in costs and/or price mark-ups. This direct effect is estimated by the regression coefficients reported in Table 3 and is reflected in the values entered in row 2 of Table 8. Air liberalization also has an *indirect* effect on prices operating through changes in the volume of air traffic, which is captured by the entries in row 3.

A decomposition of the total price effect of air liberalization suggests that more than three-fourths of the effect is driven by the direct effect of liberalization on airfares.[25] The remaining (less than) one-fourth of the price effect can be attributed to the indirect effect of liberalization on airfares operating via demand effects. Note that air liberalization could impact prices also via its effect on flight frequency and market competition. However, our estimation results reported in Table 4, respectively Table 5, suggest that both of these effects are statistically indistinguishable from zero.[26]

Next, we calculate the cumulative effect of air liberalization on flight frequency and report the results in line 5 of Table 8. Mathematically, the reported values correspond to the total derivative *dlnFreq/dPartial_Lib* or *dlnFreq/dFull_Lib*. Based on the calculated effect, partial liberalization leads to a 22.6 percent (i.e., exp(0.204)-1 = 0.226) increase in flight frequency, while full liberalization leads to a 21 percent (i.e., exp(0.190)-1=0.21) increase in flight frequency. Note that the calculated effects come entirely from the indirect effect that liberalization has on air travel demand, which in turn affects flight frequency. The direct effect is zero, as suggested by the insignificant effects of air liberalization reported in Table 4.

The total frequency effect of air liberalization calculated so far has been expressed in percent changes of flight departures. To translate these numbers into passenger changes, we multiply them with the flight frequency elasticity of demand, i.e., $\varepsilon^{Freq} \equiv dlnQ/dlnFreq$ estimated in Table 2. We further divide the calculated demand effects by the price elasticity of demand estimated in Table 2 to derive the *price-equivalent effect of flight frequency*, i.e., $(\varepsilon^{Freq}/\varepsilon^{P})$(dlnFreq/dPolicy), which is reported in line 7 of Table 8, and ranges from -0.304 to -0.326 in log price-equivalent units.

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be seen from the last row of Table 8, the total price reduction effects of air liberalization calculated using OLS coefficients are smaller in magnitude, which is expected given the direction of the bias affecting these estimates.

[25] Specifically, -0.180/-0.216 = 0.83 or 83 percent in the case of partial liberalization, respectively -0.167/-0.200 = 0.84 or 84 percent in the case of full liberalization.

[26] The coefficients reported in Table 3 suggest that flight frequency does not have a statistically significant effect on airfares. Similarly, the coefficients reported in Table 5 suggest that air liberalization does not have a statistically significant effect on market competition (even if market competition does matter for airfares).

Finally, combining the total price effect of air liberalization (i.e., the movement along the demand curve from point A to point B in Figure 6) with the price-equivalent effect of flight frequency (i.e., the demand shift from point B to point C in Figure 6, converted in log price units), we can derive the total price-equivalent effect of air liberalization as defined in equation (5). According to our calculations, partial liberalization is associated with a cumulative elasticity of -0.542, corresponding to a 42 percent reduction in airfares, while full liberalization is associated with a cumulative elasticity of -0.504, corresponding to a 40 percent reduction in airfares.[27]

How do our price-equivalent calculations for air liberalization in Africa compare to other results? While it is not easy to find comparable statistics, Cristea et al. (2017) identify a price-equivalent effect of Open Skies Agreements of 17 percent for selected US city-pairs. Methodologically, this statistic is the closest to our calculations and so more fit for a direct comparison. However, given how mature and competitive the U.S. aviation market has been even before the introduction of Open Skies Agreements, and given that important extensive margin route effect are ignored from city-pair calculations, it is not surprising that the price equivalent effect of air liberalization in Africa is almost three times as large as the value for the U.S.

The IATA (2021) study on aviation liberalization in Africa does not estimate fare reduction effects from the data but imputes them from observed increases in passenger traffic using price elasticities of demand taken from the academic literature. The study identifies price reduction effects averaging 26.4 percent and ranging between 18.6 percent and 39.7 percent. Notice that OLS price-equivalent effects are very close to these estimates (in spite of the fact that we do a more detailed accounting of the mechanisms driving the price-equivalent effects). Our preferred 2SLS values are larger for reasons already explained in the estimation section, which have to do with eliminating endogeneity biases.

6.2. Consumer Welfare Calculations

There are different ways to calculate the consumer welfare effects associated with policy changes such as the liberalization of aviation services. In this study we propose two methods: 1) compensating variation, and 2) the changes in consumer surplus.

Compensating Variation Measure. The first consumer welfare measure that we consider is the compensating variation measure, which quantifies the adjustment in income necessary to keep consumers at the *original* level of utility while facing the new prices induced by air liberalization. Figure 7 illustrates graphically the compensating variation welfare measure. Essentially, this calculation allows us to understand the dollar value that consumers place on the benefits of aviation liberalization.

[27] The derived percent reductions in airfares come from calculating: exp(-0.542) -1 = -0.418 for partial BASA liberalization, respectively exp(-0.504)-1 = -0.396 for full BASA liberalization.

Under a general enough set of consumer preferences, welfare can be defined as $U = {}^{Y}\!/_{P}$, where *U* stands for consumer utility, *Y* measures the expenditure on aviation services and *P* measures the airfare price index. To keep utility constant at levels prior to the aviation liberalization, we need to impose *dU=dY-dP=0*. This means that the change in income needed to keep utility at the same level as prior to liberalization must equal the change in the aviation price index. Using the previously calculated ad-valorem equivalent measure of air liberalization, we can then derive the compensating variation measure associated with air liberalization in Africa.

Table 9 reports the compensating variation values by year for the sample period 2011-2019, which are calculated based on our 2SLS coefficient estimates. Column 2 reports the aggregate expenditure on air travel observed in our sample *in the absence of air liberalization*. We need the total air travel expenditures to construct the percent change in income associated with air liberalization. To calculate these values, we multiply the number of passengers traveling between two countries by the average airfare on that route, and then sum by year across all country pairs in our sample. For country pairs connected by liberal BASAs, we calculate the counterfactual air travel expenditure prior to liberalization.[28]

Columns 3 and 4 report the compensating variation values in millions of USD calculated based on the 2SLS ad-valorem price equivalent effect of air liberalization for the case of partial liberalization, respectively full liberalization. Using the result that *dY=dP* in order to keep consumer utility constant, we calculate the compensating variation by multiplying the pre-liberalization expenditure level associated with partial liberalization routes, Y_0, by the price change induced by partial liberalization, *dP=-0.42* (our estimate from Table 8). We repeat the same calculation using the pre-liberalization expenditure level associated with full liberalization routes and the ad-valorem price equivalent effect of full liberalization, *dP=-0.40.*

To interpret the compensating variation calculations, we focus on the last row of Table 9 that reports the most recent values (for year 2019) and argue that African consumers in our sample need to give up US$84.2 million of their expenditures on air travel to stay at the same level of utility as prior to liberalization. Put differently, the consumer welfare associated with partial liberalization that is measured in the form of compensating variation amounts to US$84.2 million in 2019. For the case of full liberalization, the consumer welfare gains amount to US$246.1 million in 2019.

Column 5 combines the consumer welfare gains from the partial and full liberalization of aviation services covered by the country pairs in our data sample, and column 6 reports the percentage represented by the income value of air liberalization in the total air travel expenditure (for the countries covered by our

[28] Counterfactual airfares pre-liberalization are calculated as: $P_0 = P_1/(1+dP)$, where P_1 is the observed airfare charged for travel between liberal country pairs and dP denotes the ad-valorem price equivalent measure of air liberalization. Similarly, the counterfactual level of passenger traffic pre-liberalization is calculated as: $Q_0 = Q_1*(1+dP)^{\varepsilon}$, where Q_1 is the observed traffic level on liberalized country pair routes and ε denotes the price elasticity of demand.

African sample). We find that the consumer welfare gains from air liberalization range between US$217.4 million and US$343.7 million, which in percentage terms correspond to between 21 and 29 percent of the pre-liberalization expenditure level on air services.

Change in Consumer Surplus Measure. An alternative measure of consumer welfare is the change in consumer surplus resulting from the liberalization of aviation services. The change in consumer surplus is calculated as the area under the demand curve that corresponds to the change in the price level caused by the policy liberalization. Figure 8 illustrates the change in consumer surplus, using the grey shaded areas A and B.[29] Compared to the compensating variation measure of welfare, the change in consumer surplus is larger in magnitude for price decreases like the ones generated by aviation liberalization.

Table 10 reports the calculations for the change in consumer surplus associated with a fall in airfares equal in magnitude to the values reported in Table 8. Column 4 reports the total change in consumer surplus cumulated across all partial and full liberalization country pairs. Compared to the consumer welfare values reported in column 5 of Table 9, these values are almost 30 percent larger on average. To better understand the sources of these gains, we can decompose the change in consumer surplus into the total fare savings accruing to existing passengers (Column 2) and the gains generated by the increase in the number of passengers as a result of the policy-induced reduction in airfares (Column 3). We label the latter component as new passenger gains. Interestingly, the values in column 2 of Table 10 match the compensating variation values from column 5 in Table 9. So, the difference in magnitude between the two consumer welfare gain measures is driven by the "triangle area" corresponding to new passenger gains. For small changes in prices, this welfare value is small in magnitude. However, in our case, given the large price-equivalent effect of air liberalization, the contribution of new consumer gains is important. Focusing on the last row of Table 10, the change in consumer surplus associated with partial and full air liberalization amounts to US$424.2 million in 2019, of which 78% represents savings to existing passengers and 22% represents gains to new passengers.

7. Discussion and Conclusions

The air passenger transport market in Africa operates at traffic levels well below its potential. The continent accounts for 17% of the world's population, yet it only generates 2%-3% of global passenger flows. This underperformance is ever more surprising given the lack of alternative transportation

[29] Mathematically, area B and area C in Figure 8 are equal. This simplifies both the illustration and the calculation for the change in consumer surplus, which becomes the area A + C. In other words, by converting the quality induced shift in demand into a price equivalent term, we can define the change in consumer surplus from air transport liberalization using a simple large price decrease.

infrastructure on the continent, such as major highways and railway networks. All this has a direct negative impact on market connectivity between countries, which ultimately slows down economic growth and development.

While there could be many explanations for the underdevelopment of the intra-African aviation markets, this study focuses on the role played by regulations and government restrictions. Historically, international air passenger transport has been governed by a complex web of rules set via bilateral air service agreements (BASAs). A typical BASA can be restrictive in terms of airline entry, market access, flight capacity, flight frequency or pricing decisions. Yet concerted efforts have been made at all levels – global, regional and country level – to advance an agenda of liberalization of air passenger transport. While this agenda is still a work in progress across the globe, it is very much one of the central initiatives of the African Union as indicated by the Yamoussoukro Decision and the establishment of the Single African Air Transport Market. At the moment, however, countries in Africa differ in their extent of air transport liberalization as they enforce BASAs that range from restrictive agreements to partially or fully liberalized agreements.

Using data for 71 bilateral country pairs in Africa over the period 2011-2019, and information on the degree of air transport liberalization for the corresponding BASAs, we estimate several difference-in-differences models explaining the impact of aviation liberalization on: 1) passenger travel, 2) average airfares, 3) flight frequency, and 4) the number of airlines operating within a country pair. In our analysis we pay close attention to endogeneity concerns coming from the simultaneity and reverse causality surrounding pricing, demand, and frequency decisions.

Our results indicate that both partial and full BASA liberalization have a direct negative effect on airfares, and, respectively, indirect positive effects on flight frequency and air travel demand (no direct effects however). We find no evidence that market competition, as measured by the number of operating airlines, increases with air liberalization. We think that some of the insignificant effects of liberal BASAs on aviation market outcomes in Africa could be explained by the non-binding nature of policy restrictions in thin aviation markets. Liberal policies, however, could still bring lower fares by making aviation markets more contestable, allowing airlines to exploit scale economies from higher volumes and facilitating cooperative arrangements with non-African airlines.

After quantifying all the channels through which air transport liberalization can affect ai service provision in Africa, we find that liberal BASAs generate consumer benefits that are equivalent to a 40 to 42 percent drop in average airfares. This ad-valorem price equivaled measure of air liberalization amounts to large consumer welfare gains, in the range of 29% to 37% of air travel revenues among the sample countries for the last year of our sample, 2019.

Finally, it is important to note that the liberalization of the international air transport market in many parts of the world came about as a natural consequence of deregulated domestic airline markets (Abate and Christidis 2020; Borenstein and Rose 2007; Kahn 1988). The coexistence of a regulated domestic market alongside liberal international policies, such as the Yamoussoukro Decision (YD), is the main policy dilemma facing many African countries.[30] This policy duality has prevented them from having an organic transition from domestic deregulation to regional and continental open skies. To realize the full benefits liberalization brings, policy makers should also aim at leveling the playing field for all players and achieve meaningful private sector participation and competition both in the domestic and international markets.

[30] According to Article 7 of the YD, its provisions take precedence over all previous Bilateral Air Services Agreements aviation safety agreements signed between African countries. However, so far, the practice has been that individual countries negotiate bilaterally on the basis of the YD provisions, which results in a limited openness. Each country has control of the pace and extent of its air transport market openness. That countries still have the ultimate discretion on fifth freedom rights, which are crucial to the thin intra-African market, has resulted in a 'limited open skies regime' in Africa (Abate 2016; Schlumberger 2010).

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9. Figures and Tables

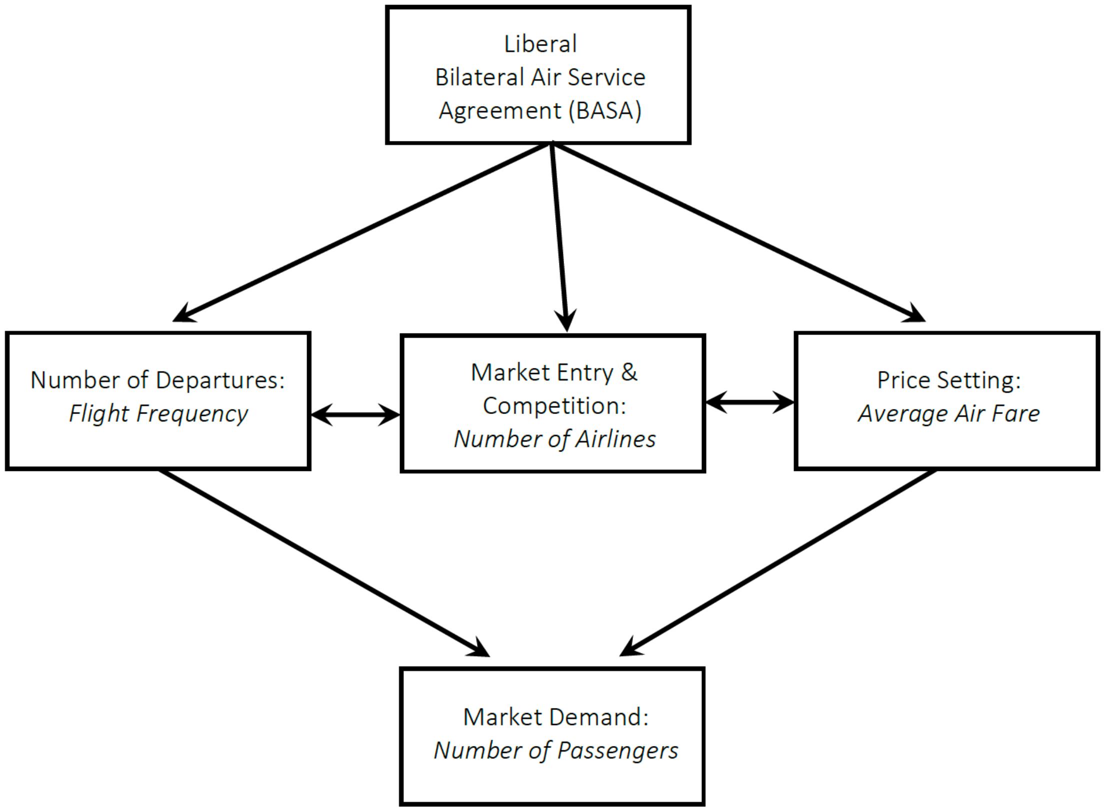

Figure 1: Flow chart for the impact of liberalization on aviation markets in Africa

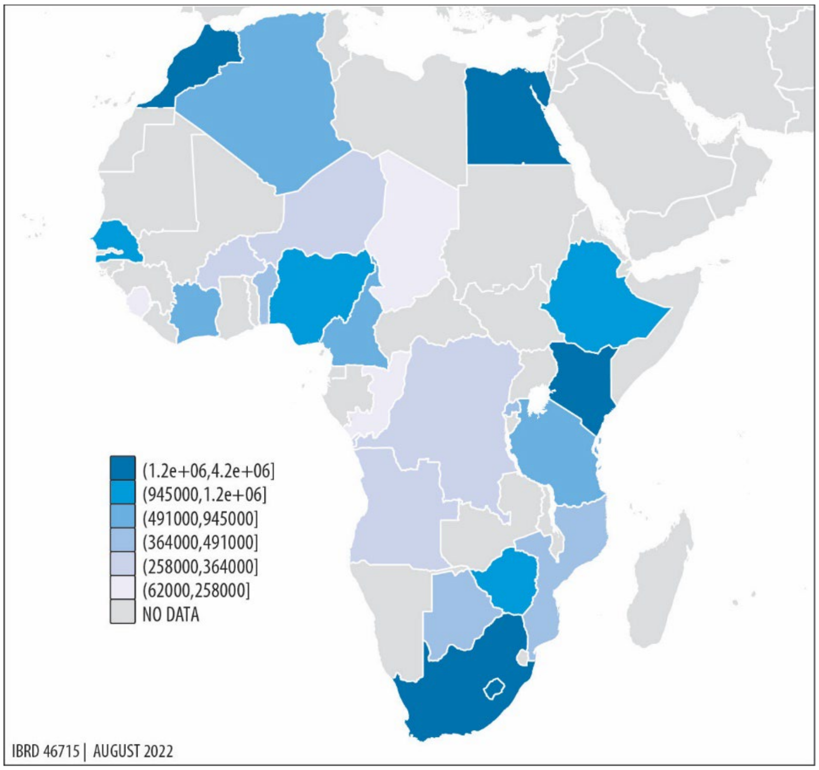

Figure 2: Map of Intra-Africa Passengers by Country for Year 2019

Notes: The map graphs the distribution of air passenger traffic by origin country in 2019. The air passenger data only accounts for international traffic within Africa. The original data comes from IATA. The total air traffic volumes by origin country that are reported in this map are more comprehensive than the bilateral passenger flows included in our estimation sample. This is because the traffic totals reported here include bilateral passenger flows to all other African destinations (not only to countries in our estimation sample).

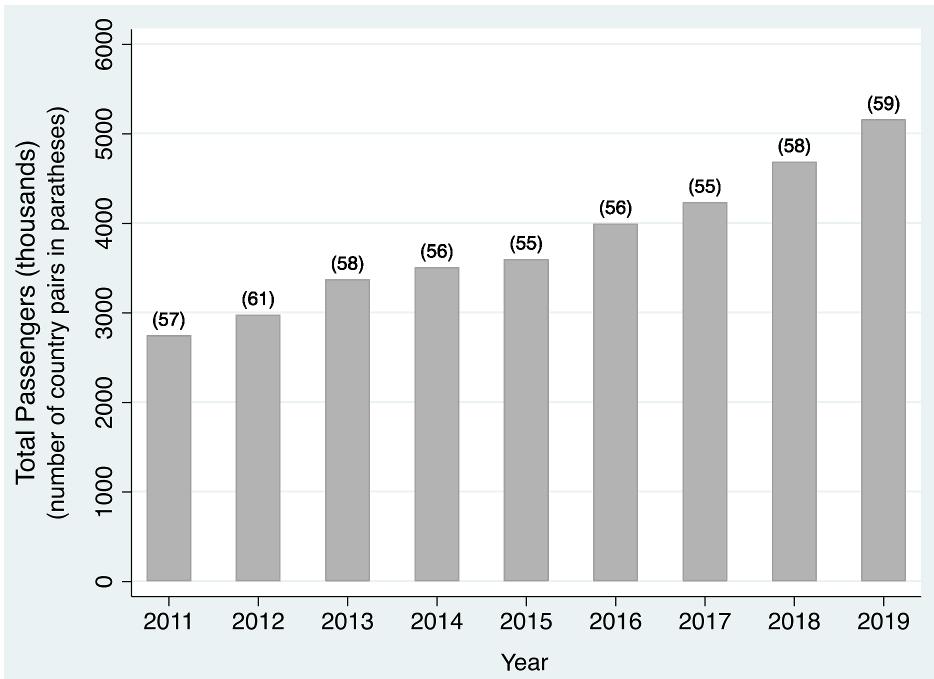

Figure 3: Total Number of Passengers over the Sample Period

Notes: The figure reports the total number of international air transport passengers observed in each year between the African country pairs in our data sample. The value reported on top of each bar represents the number of bilateral country pairs contributing passenger data to the traffic totals, highlighting the unbalanced nature of our estimation sample. The total volume of passengers is measured in thousands. The original data comes from the Sabre Market Intelligence database.

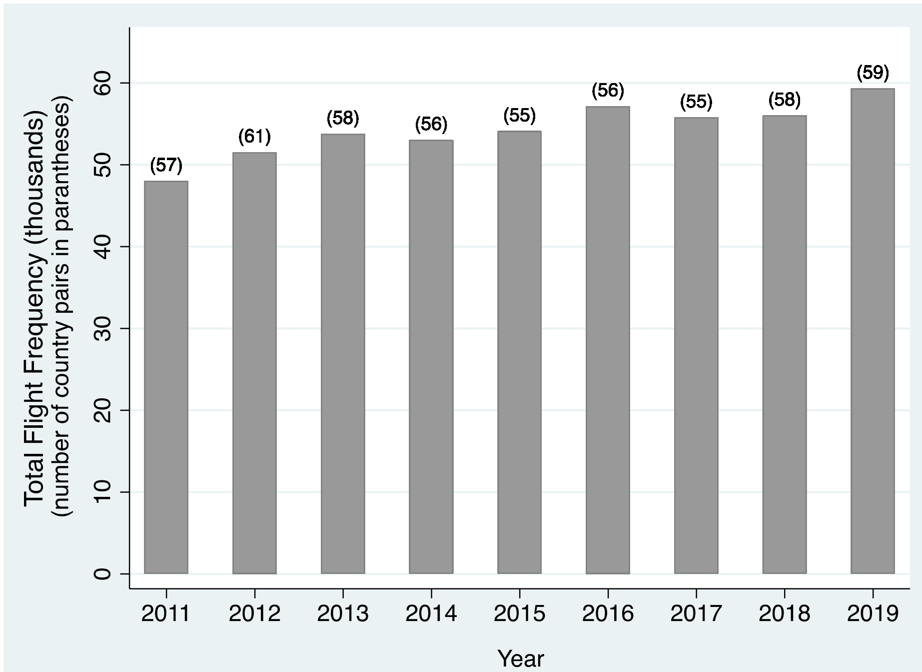

Figure 4: Total Number of Flight Departures over the Sample Period

Notes: The figure reports the total number of international flight departures observed in each year between the African country pairs in our data sample. The value reported on top of each bar represents the number of bilateral country pairs contributing departures data to the reported totals, highlighting the unbalanced nature of our estimation sample. The reported number of international departures is measured in thousands. The original data comes from the OAG flights database.

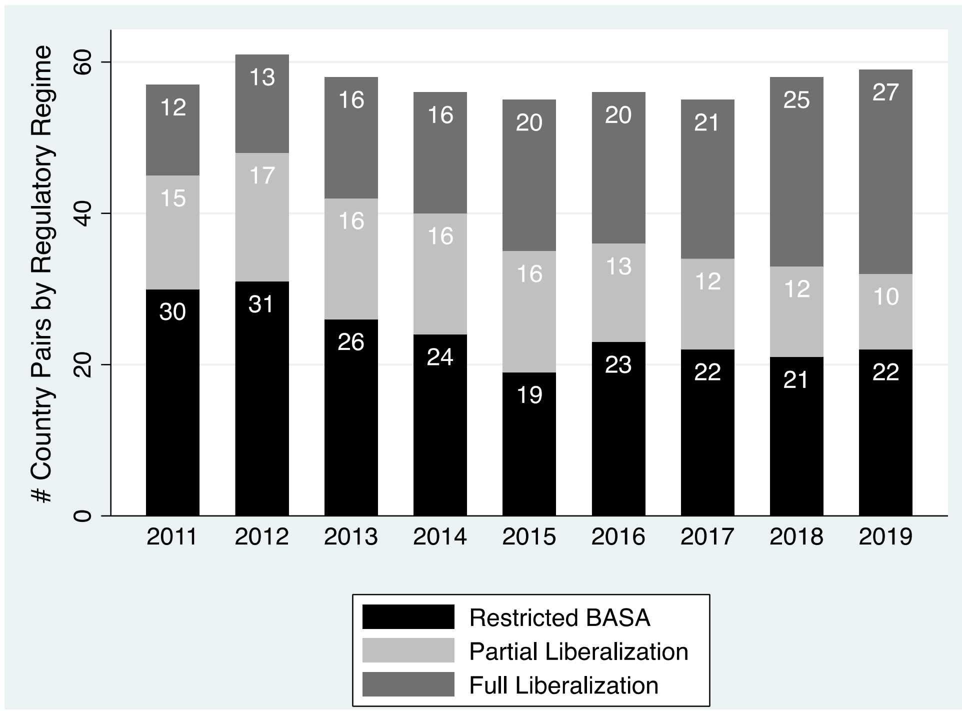

Figure 5: Distribution of Country Pairs by Regulatory Regime Over Time

Notes: The figure reports the distribution of country pairs in our estimation sample by type of bilateral air service agreements (BASA) that are in effect at each point in time during our sample period. We distinguish between restricted BASAs, partial liberalization BASAs and full liberalization BASAs and provide a characterization of each type of BASA in the aviation data subsection 4.1. The original data comes from surveys carried out by the World Bank with the corresponding aviation administrations. Summing up the number of countries across all BASA types gives the total number of bilateral country pairs in our sample observed in each year.

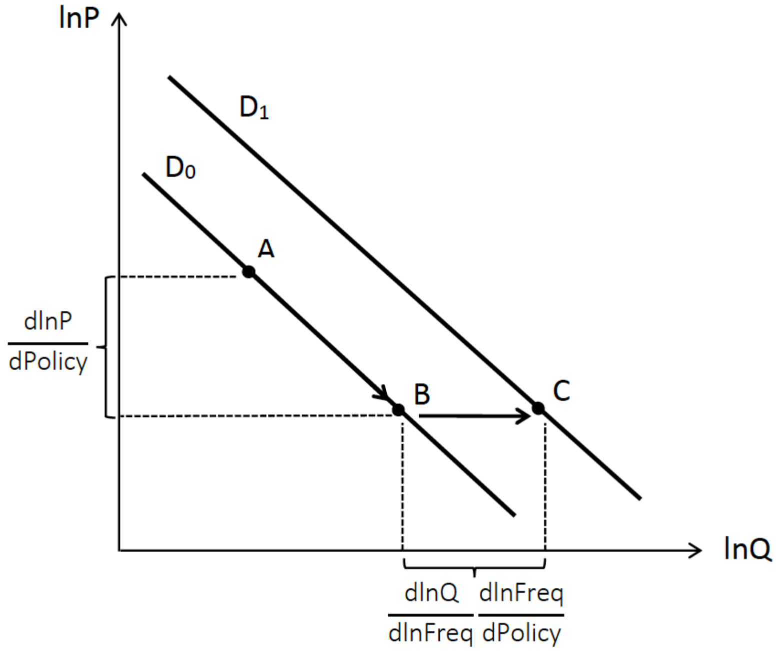

Figure 6: Total Demand Effect of Air Liberalization

Notes: The figure depicts the simplest (log) inverse demand function for international air travel to show graphically the extent to which consumers are impacted by liberalization in air transport services. *dPolicy* denotes the *change* in the nature of the bilateral air service agreements (BASA),e.g., from restrictive to liberal regimes. D_0 denotes the initial air travel demand curve and D_1 depicts the shift in demand corresponding to quality improvements in aviation services caused by BASA liberalization. We hypothesize that the overall effect of BASA liberalization comes from: 1) a price decrease in the cost of air travel (A→B), and 2) conditional on prices, a quality improvement associated with, for example, increased flight frequency (B→C). The empirical analysis of the paper aims to estimate the average size of each effect.

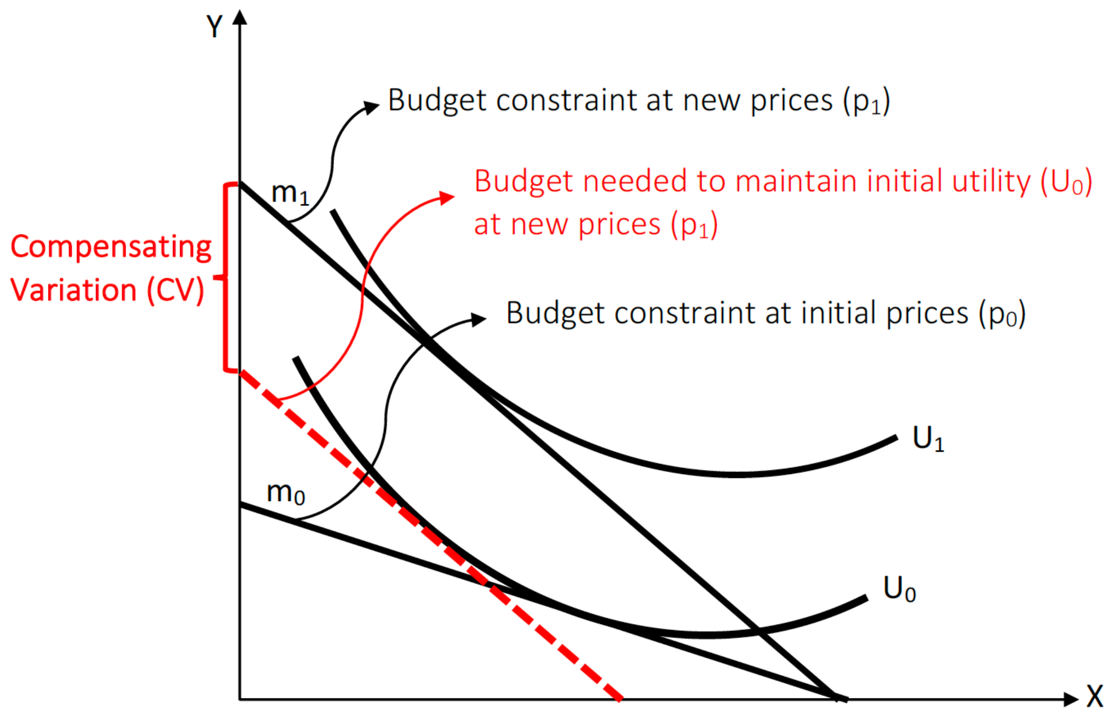

Figure 7: Compensating Variation from a Price Fall

Notes: The figure illustrates graphically the consumer welfare concept of compensating variation. It is defined as the adjustment in income necessary to keep consumers at the original utility level (U_0) given new prices (e.g., the prices observed following BASA liberalization). The graph illustrates two goods, *Y* (e.g., air travel) and X (e.g., non-travel consumption), and the corresponding budget line m_0 that generate utility U_0. If BASA liberalization leads to a drop in airfares, this implies a new budget line m_1 matching the new level of prices, and a new utility level U_1 from increased consumption. The dotted red line depicts the budget needed to maintain the *same utility level* U_0 at the *new prices* for air travel. The difference in budget lines marked as *CV* corresponds to the compensating variation measure of consumer welfare.

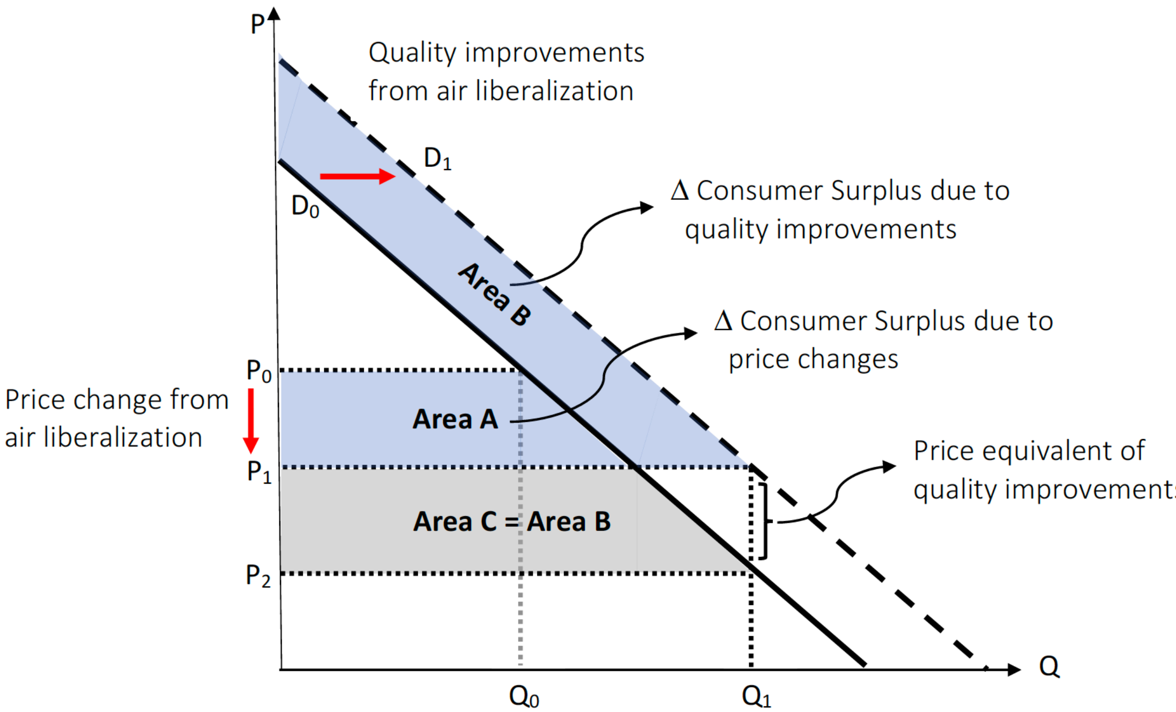

Figure 8: Change in Consumer Surplus from a Price Fall

Notes: The figure illustrates graphically the change in consumer welfare associated with air transport liberalization. If BASA liberalization generates both a fall in prices (i.e., $P_0 \rightarrow P_1$) and an increase in the quality of air travel (i.e., shift in demand from D_0 to D_1), the gain in consumer surplus corresponds to the shaded areas A+B. If the quality gains from BASA liberalization are expressed in price terms by an equivalent shift in prices (i.e., $P_1 \rightarrow P_2$), then it can be shown that consumer surplus area B is equal to consumer surplus area C. Thus, based on the full price equivalent effect of BASA liberalization (i.e., $P_0 \rightarrow P_2$), the corresponding change in consumer surplus becomes area A + C.

Table 1: Summary Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
Aviation Variables					
Ln Passengers	515	9.483	2.707	.223	13.292
Ln Avg Airfare	515	5.961	.727	1.79	7.545
Ln Flight Frequency	515	6.073	1.522	0	9.475
Ln Avg Aircraft Size	515	4.931	.377	3.611	5.946
Ln Number Airlines	515	.411	.629	0	2.398
Ln Total AirLinks c1	515	4.965	.812	3.219	7.029
Ln Total AirLinks c2	515	5.175	.935	2.485	7.029
1 = Partial Liberalization	515	.247	.431	0	1
1 = Full Liberalization	515	.33	.471	0	1
Above Median BASAs within Africa	515	.515	.5	0	1
Above Median YD Compliant BASAs	515	.515	.5	0	1
1 = Successful YD Implementation	515	.14	.347	0	1
1 = No IOSA Certified Carriers	515	.602	.49	0	1
Country Variables					
Ln PcGDP c1	515	7.222	.873	5.844	8.999
Ln PcGDP c2	515	7.139	.813	5.844	8.991
Ln Population c1	515	16.701	1.339	13.12	19.119
Ln Population c2	515	17.08	1.382	12.126	19.119
Ln Urban Density c1	515	-.905	.479	-1.82	-.312
Ln Urban Density c2	515	-1.013	.488	-1.82	-.307
Ln Distance (weighted)	515	7.654	.65	6.165	8.715
Ln Trade	515	15.257	4.796	-.591	23.324
1 = Common Border	515	.171	.377	0	1
1 = Common Language	515	.577	.495	0	1
Ln Fuel Cost	515	5.74	2.478	1.386	9.735

Notes: Data sources and sample variable are defined in section 4 of the paper. The continuous variables are reported in natural log (ln) to reflect the format in which they are employed in the econometric analysis.

Table 2: Effect of Air Liberalization on Air Passenger Travel

	Dependent Variable: Ln Passengers			
	(1)	(2)	(3)	(4)
	OLS	**OLS**	**OLS**	**2SLS**
Ln Avg Airfare	-0.486**	-0.574***	-0.468***	-0.878***
	[0.169]	[0.157]	[0.108]	[0.333]
Ln Flight Frequency	1.350***	1.346***	1.311***	1.404***
	[0.040]	[0.037]	[0.035]	[0.171]
Ln PcGDP c1	0.385***	0.500***	-0.213	-0.388
	[0.069]	[0.068]	[0.546]	[0.828]
Ln PcGDP c2	-0.159	-0.116	-0.143	-0.516
	[0.144]	[0.147]	[0.607]	[0.824]
Ln Population c1	0.190***	0.198***	-2.342	-1.884
	[0.055]	[0.049]	[1.656]	[2.522]
Ln Population c2	0.194***	0.224***	-2.029	-1.503
	[0.047]	[0.041]	[1.684]	[2.521]
Ln Urban Density c1	-0.343	-0.569**	0.126	0.230
	[0.274]	[0.241]	[1.801]	[3.397]
Ln Urban Density c2	-0.229	-0.356	-0.748	-0.366
	[0.237]	[0.222]	[1.916]	[3.354]
Ln Distance (weighted)	-0.333**	-0.520***	-1.290***	-0.862**
	[0.118]	[0.132]	[0.140]	[0.338]
Ln Trade		0.014	0.030	0.031
		[0.012]	[0.021]	[0.023]
1 = Common Border		-0.791***	-1.212***	-1.360***
		[0.142]	[0.152]	[0.255]
1 = Common Language		0.099	0.828***	0.702***
		[0.097]	[0.113]	[0.219]
Country FE	NO	NO	YES	YES
Year FE	YES	YES	YES	YES
Observations	515	515	515	515
R-squared	0.696	0.703	0.780	0.776
F-stat				8.451
Hansen J stat				17.04
Hansen J p-val				0.002

Notes: The table reports the results from estimating the regression model in equation (1). Robust standard errors are reported in parentheses. The estimation sample is an unbalanced panel of 71 bilateral country pairs from Africa observed over the period 2011-2019. The dependent variable represents the volume of air passengers flying between two countries in either direction. The independent variables are described in the text. Columns 1 through 4 differ in the set of control variables and fixed effects (listed at the bottom of the table), as well as in the estimation methodology (listed in the column header). The (log) average airfare and the (log) flight frequency are instrumented in column 4 using as exogenous instruments: the fuel cost, the average airplane size, the number of operating airlines, the total number of (domestic + international) connections and aviation policy IATA variables. The first stage statistics are reported at the bottom of the table.

Table 3: Effect of Air Liberalization on Average Airfares

	Dependent Var: Ln Avg. Airfare		
	(1) OLS	(2) OLS	(3) 2SLS
Ln Passengers	-0.018*	0.001	-0.075*
	[0.010]	[0.010]	[0.045]
1 = Partial Liberalization	-0.053**	-0.112**	-0.180**
	[0.021]	[0.040]	[0.082]
1 = Full Liberalization	-0.110***	-0.147***	-0.167**
	[0.026]	[0.038]	[0.080]
Ln Number Airlines	-0.066	-0.163*	-0.047
	[0.047]	[0.077]	[0.080]
Ln Avg Aircraft Size	-0.535***	-0.525***	-0.363**
	[0.074]	[0.101]	[0.147]
Ln Fuel Cost	0.080	0.065	0.071
	[0.069]	[0.075]	[0.091]
Ln PcGDP c1	0.077***	0.211	0.284
	[0.017]	[0.134]	[0.218]
Ln PcGDP c2	-0.021	-0.025	-0.011
	[0.014]	[0.146]	[0.214]
Ln Distance (weighted)	0.832***	0.827***	0.645***
	[0.062]	[0.084]	[0.131]
Country	NO	YES	YES
Year FE	YES	YES	YES
Observations	515	515	515
R-squared	0.622	0.768	0.728
F-stat			17.41
Hansen J stat			n.a.

Notes: The table reports the results from estimating the regression model in equation (2). Robust standard errors are reported in parentheses. The estimation sample is an unbalanced panel of 71 bilateral country pairs from Africa observed over the period 2011-2019. The dependent variable represents the (log) average airfare for air travel between two countries in either direction. The independent variables are described in the text. Columns 1 through 3 differ in the set of fixed effects (listed at the bottom of the table) and in the estimation methodology (listed in the column header). The (log) number of air passengers is instrumented in column 3 using as exogenous instrument the ease of air travel as captured by the countries sharing a common language. The first stage F statistic is reported at the bottom of the table.

Table 4: Effect of Air Liberalization on Flight Frequency

	Dependent Var: Ln Frequency		
	(1)	(2)	(3)
	OLS	**OLS**	**2SLS**
Ln Passengers	0.445***	0.408***	0.429***
	[0.040]	[0.043]	[0.065]
1 = Partial Liberalization	0.088	0.022	0.041
	[0.072]	[0.194]	[0.157]
1 = Full Liberalization	0.007	-0.043	-0.033
	[0.092]	[0.219]	[0.153]
Ln Number Airlines	0.624***	0.543***	0.512***
	[0.055]	[0.076]	[0.136]
Ln Avg Aircraft Size	-0.353***	-0.472***	-0.515**
	[0.092]	[0.137]	[0.215]
Ln Total AirLinks c1	0.105	0.264	0.270*
	[0.069]	[0.147]	[0.157]
Ln Total AirLinks c2	0.094	0.187	0.195
	[0.060]	[0.142]	[0.150]
Ln Distance (weighted)	0.522***	0.381***	0.428***
	[0.087]	[0.098]	[0.162]
Country	NO	YES	YES
Year FE	YES	YES	YES
Observations	515	515	515
R-squared	0.706	0.772	0.771
F-stat			20.68
Hansen J stat			2.456
Hansen J p-val			0.117

Notes: The table reports the results from estimating the regression model in equation (3). Robust standard errors are reported in parentheses. The estimation sample is an unbalanced panel of 71 bilateral country pairs from Africa observed over the period 2011-2019. The dependent variable represents the (log) number of flight departures between two countries in either direction. The independent variables are described in the text. Columns 1 through 3 differ in the set of fixed effects (listed at the bottom of the table) and in the estimation methodology (listed in the column header). The (log) number of air passengers is instrumented in column 3 using as exogenous instruments the ease of air travel as captured by the countries sharing a common language as well as an indicator for sharing a regional trade agreement. The first stage statistics are reported at the bottom of the table.

Table 5: Effect of Air Liberalization on the Number of Airlines

	Dependent Var: Ln Number Airlines		
	(1) OLS	(2) OLS	(3) OLS
1 = Partial Liberalization	0.028	-0.064	-0.092
	[0.027]	[0.056]	[0.059]
1 = Full Liberalization	0.113***	0.100	0.071
	[0.026]	[0.055]	[0.058]
Ln Total AirLinks c1	-0.024	0.374***	0.353***
	[0.020]	[0.095]	[0.102]
Ln Total AirLinks c2	0.075***	0.233**	0.287**
	[0.020]	[0.090]	[0.114]
Ln Trade			0.010
			[0.006]
Ln GDP c1			-0.036
			[0.118]
Ln GDP c2			-0.107
			[0.147]
Ln Distance (weighted)	-0.586***	-0.554***	-0.547***
	[0.014]	[0.012]	[0.027]
Country	NO	YES	YES
Year FE	YES	YES	YES
Observations	515	515	515
R-squared	0.365	0.672	0.676

Robust standard errors in brackets
*** $p<0.01$, ** $p<0.05$, * $p<0.10$

Notes: The table reports the results from estimating the regression model in equation (4). Robust standard errors are reported in parentheses. The estimation sample is an unbalanced panel of 71 bilateral country pairs from Africa observed over the period 2011-2019. The dependent variable represents the (log) number of air carriers operating between two countries in either direction. The independent variables are described in the text. Columns 1 through 3 differ in the set of control variables and fixed effects (listed at the bottom of the table).

Table 6: Robustness Check using Alternative Measures for Air Liberalization

	Dependent Variable:		
	Ln Air Fares	ln Flight Freq	ln No. Airlines
	(1)	(2)	(3)
	2SLS	2SLS	OLS
Above Median BASAs within Africa	-0.407***	0.205	-0.068
	[0.095]	[0.183]	[0.059]
Above Median YD Compliant BASAs	-0.194**	0.003	0.379***
	[0.089]	[0.198]	[0.054]
Full set of controls	YES	YES	YES
Country FE	YES	YES	YES
Year FE	YES	YES	YES
Observations	515	515	515
R-squared	0.699	0.769	0.686
F-stat	14.45	20.24	n.a.
Hansen J stat	n.a.	2.381	n.a.
Hansen J p-val	n.a.	0.123	n.a.

Notes: The table reports the results from estimating the preferred model specifications for air passengers, respectively for airfares and for flight frequency where the variables of interest for BASA liberalization have been replaced by alternative measures of aviation policy. The variable "*above median BASAs with Africa*" represents an indicator variable equal to 1 if both countries in a bilateral pair have above median number of BASAs signed with other African countries. The variable "*above median YD compliant BASAs*" represents another indicator variable equal to 1 if both countries in a bilateral pair have above median number of BASAs that are compliant with the liberal provisions of the Yamoussoukro Decision (YD). All the specifications include the full set of control variables and fixed effects, and are estimated using 2SLS based on the set of excluded instruments previously discussed (see the footnotes of Tables 2, 3 and 4, respectively). The first stage statistics are reported at the bottom of the table.

Table 7: Sensitivity Analysis for the Price Effects of Air Liberalization

	Dependent Var: Ln Avg. Airfare			
	Successful YD		IOSA Certified	
	(1) OLS	(2) 2SLS	(3) OLS	(4) 2SLS
Ln Passengers	0.001	-0.046	0.002	-0.069*
	[0.009]	[0.038]	[0.010]	[0.041]
Partial Liberalization x No YD	-0.154***	-0.179**		
	[0.042]	[0.078]		
Partial Liberalization x YD	0.146	0.058		
	[0.102]	[0.140]		
Full Liberalization x No YD	-0.252***	-0.263***		
	[0.046]	[0.078]		
Full Liberalization x YD	0.094	0.101		
	[0.059]	[0.121]		
Partial Liberalization x No IOSA			-0.112***	-0.167**
			[0.027]	[0.083]
Partial Liberalization x IOSA			-0.172*	-0.240**
			[0.086]	[0.115]
Full Liberalization x No IOSA			-0.062	-0.103
			[0.043]	[0.094]
Full Liberalization x IOSA			-0.236***	-0.227**
			[0.070]	[0.104]
1 = Successful YD Implementation	-0.472***	-0.472***		
	[0.074]	[0.142]		
1 = No IOSA Certified Carriers			-0.231***	-0.185
			[0.055]	[0.134]
Airfare Control variables	YES	YES	YES	YES
Country FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES
Observations	515	515	515	515
R-squared	0.776	0.761	0.771	0.735
F-stat		22.54		21.54
Hansen J p-val		n.a.		n.a.

Note: The table reports estimations of the preferred model specification for (log) average airfares where the variables of interest for BASA liberalization have been interacted with variables capturing different aspects of the aviation industry of the countries in the bilateral pair. The indicator variable *YD* equals 1 if both countries in a bilateral pair have been classified by IATA as having a favorable environment for successful YD implementation. The indicator variable *No IOSA* equals 1 if at least one of the countries in the bilateral pair has no airlines that are registered with IATA. All the specifications include the full set of control variables and fixed effects, and the 2SLS estimations are based on the excluded instrument previously discussed (see Table 3 footnote). The first stage F statistic is reported at the bottom of the table.

Table 8: Ad-Valorem Price Equivalent Effect of Air Liberalization

	Estimated Effects of Air Liberalization			
	Partial Liberalization		**Full Liberalization**	
	OLS	**2SLS**	**OLS**	**2SLS**
Total Price Effect [dlnP/dPolicy]:	−0.112	−0.216	−0.146	−0.200
Of which:				
Direct Effect:	−0.112	−0.180	−0.147	−0.167
Indirect Effect via Quantity:	0.000	0.036	0.000	−0.033
Total Frequency Effect [dlnFreq/dPolicy]:	0.046	0.204	0.060	0.190
Of which:				
Direct Effect:	0.000	0.000	0.000	0.000
Indirect Effect via Quantity:	0.046	0.204	0.060	0.190
Price Equivalent of Flight Frequency Effect:	−0.129	−0.326	−0.168	−0.304
Total Price Equivalent of Air Liberalization	**−0.241**	**−0.542**	**−0.314**	**−0.504**

Notes: The table reports the values of the total derivatives for (log) average airfares, respectively for (log) flight frequency, with respect to the two BASA liberalization variables. The values of the total derivatives are calculated based on the estimated coefficients in the preferred specifications reported in Tables 2 through 5. The total price equivalent of BASA liberalization reported in the last line of the table is calculated based on equation (5) in the text.

Table 9: Aggregate Consumer Welfare Effects of Air Liberalization in Africa

Year	Air Travel Revenue (mil USD)	Welfare Effects: Compensating Variation			
		Partial Liberaliz. (mil USD)	Full Liberaliz. (mil USD)	Total Gains (mil USD)	% of Travel Revenue
2011	1037.539	113.20	104.18	217.37	20.95
2012	1138.599	128.42	103.74	232.16	20.39
2013	1099.392	112.71	144.23	256.95	23.37
2014	1138.051	130.25	195.34	325.59	28.61
2015	1062.553	129.05	171.79	300.83	28.31
2016	1054.070	127.09	173.09	300.19	28.48
2017	998.2566	80.41	203.19	283.60	28.41
2018	1174.156	89.28	254.40	343.68	29.27
2019	1135.406	84.19	246.11	330.30	29.09

Notes: The table reports back of the envelope calculations for the consumer welfare gains from aviation liberalization calculated using the compensating variation approach. The methodology is described in the text (subsection 6.2). For comparison, column 2 reports the total expenditures on international air passenger transport among sample countries, which is obtained by multiplying the average price and quantity of air travel by country-pair and year. Columns 3 reports the compensating variation values calculated based on the (2SLS) price equivalent effect of partial liberalization reported in the last line of Table 8. Column 4 reports the compensating variation values calculated based on the (2SLS) price equivalent effect of full liberalization reported in Table 8. Column 5 sums together the total gains from partial and full BASA liberalization and column 6 reports these total values as a percent of the total expenditures on international air travel reported in column 2.

Table 10: Aggregate Changes in Consumer Surplus from Air Liberalization in Africa

	Welfare Effects: Δ Consumer Surplus		
	Fare Savings to Existing Pax	New Passenger Gains	Total Increase in Consumer Surplus
Year	(mil USD)	(mil USD)	(mil USD)
2011	217.37	63.44	280.82
2012	232.16	67.95	300.11
2013	256.95	74.45	331.40
2014	325.59	94.01	419.60
2015	300.83	87.09	387.92
2016	300.19	86.86	387.05
2017	283.60	81.04	364.63
2018	343.68	97.99	441.67
2019	330.30	94.14	424.44

Notes: The table reports back of the envelope calculations for the consumer welfare gains from aviation liberalization calculated using the change in consumer surplus approach. The methodology is described in the text (subsection 6.2). Column 4 reports the gains in consumer surplus from BASA liberalization using the total price equivalent effects reported in Table 8 and summing across all country pairs in our sample with partial or full liberalization in a given year. Column 2 and 3 decompose the total gain in consumer surplus into the value of fare savings for exiting travelers (i.e., area $(P_0 – P_2)Q_0$ in Figure 8), and the gains from increased air travel demand associated with new passengers (i.e., area between Q_0 and Q_1 that lies below the demand curve and above P_2 in Figure 8).

Appendix A1 – Calculation of the price equivalent effect of air liberalization

This appendix describes the calculation of the total price equivalent effect of air liberalization using the case of two countries signing a partially liberal BASA (i.e., $Partial\_Lib_{ij} = 1$ and $Fully\_Lib_{ij} = 0$). The procedure is identical for the case of full BASA liberalization.

Using the 2SLS estimation results from Tables 2-5, we can write down the following system of regression equations:

$$(A1) \quad \begin{cases} lnQ = (-0.878)lnP + (1.404)lnFreq + lnX'\beta \\ lnP = (-0.075)lnQ + (-0.180)Partial\_Lib + (0.0)lnNoAirlines + lnZ'\gamma \\ lnFreq = (0.429)lnQ + (0.0)Partial\_Lib + (0.512)lnNoAirlines + lnW'\delta \\ lnNoAirlines = (0.0)Partial\_Lib + ln\Pi'\lambda \end{cases}$$

where the vectors X, Z, W and Π capture all the control variables included in each of the estimated equations, respectively. These control variables are orthogonal to the BASA aviation policy, which is why they matter less in the subsequent calculations. The coefficients that are statistically insignificant at conventional levels are entered as zero in the above system of equations. The regression error terms are omitted for simplicity.

Moving all terms on one side and re-arranging, we can re-write the system of equations (A1) as follows:

$$(A2) \quad \begin{cases} -lnQ + (-0.878)lnP + (1.404)lnFreq + lnX'\beta = 0 \\ (-0.075)lnQ - lnP + (-0.180)Partial\_Lib + (0.0)lnNoAirlines + lnZ'\gamma = 0 \\ (0.429)lnQ - lnFreq + (0.0)Partial\_Lib + (0.512)lnNoAirlines + lnW'\delta = 0 \\ (0.0)Partial_{Lib} - lnNoAirlines + ln\Pi'\lambda = 0 \end{cases}$$

Taking partial derivatives with respect to BASA liberalization variable and re-arranging leads to:

$$(A3) \quad \begin{cases} -\frac{\partial lnQ}{\partial PLib} + (-0.878)\frac{\partial lnP}{\partial PLib} + (1.404)\frac{\partial lnFreq}{\partial PLib} = 0 \\ (-0.075)\frac{\partial lnQ}{\partial OSA} - \frac{\partial lnP}{\partial OSA} + (0.0)\frac{\partial lnNoAirlines}{\partial PLib} = 0.180 \\ (0.429)\frac{\partial lnQ}{\partial PLib} - \frac{\partial lnFreq}{\partial PLib} + (0.512)\frac{\partial lnNoAirlines}{\partial PLib} = 0 \\ -\frac{\partial lnNoAirlines}{\partial PLib} = 0 \end{cases}$$

which can be written in matrix format as:

$$(A4) \qquad \begin{bmatrix} -1 & -0.878 & 1.404 & 0 \\ -0.075 & -1 & 0 & 0 \\ 0.429 & 0 & -1 & 0 \\ 0 & 0 & 0 & -1 \end{bmatrix} \begin{bmatrix} \partial lnQ / \partial PLib \\ \partial lnP / \partial PLib \\ \partial lnFreq / \partial PLib \\ \partial lnNoAirlines / \partial PLib \end{bmatrix} = \begin{bmatrix} 0 \\ 0.180 \\ 0 \\ 0 \end{bmatrix}$$

Applying Cramer's rule to solve for the equilibrium solution to this system of comparative statics derivatives, we obtain:

$$\frac{\partial lnQ}{\partial Partial\_Lib} = 0.476$$

$$\frac{\partial lnP}{\partial Partial\_Lib} = -0.216$$

$$\frac{\partial lnFreq}{\partial Partial\_Lib} = 0.204$$

$$\frac{\partial lnNoAirlines}{\partial Partial\_Lib} = 0$$

Once we have solved for the partial derivatives, we can use the equations in (A3) to decompose the impact of liberalization on each variable of interest into direct and indirect effects (via the other endogenous variables), as follows:

$$\frac{\partial lnQ}{\partial Partial\_Lib} = -0.878 \frac{\partial lnP}{\partial Partial\_Lib} + 1.404 \frac{\partial lnFreq}{\partial Partial\_Lib}$$
$$= (-0.878)(-0.216) + (1.404)(0.204) = 0.476$$

So, while BASA liberalization does not have a direct effect on air passenger traffic, it has an indirect effect operating via its impact on airfares (which accounts for 40% of the total 0.476 effect on air passengers) as well as on flight frequency (which accounts for the remaining 60%).

$$\frac{\partial lnP}{\partial Partial\_Lib} = -0.180 - 0.075 \frac{\partial lnQ}{\partial Partial\_Lib} = -0.180 - (0.075)(0.476) = -0.216$$

In this case, BASA liberalization has a direct effect on airfares equal to -0.180. In addition, BASA liberalization affects airfares indirectly via its impact on air passenger traffic (which accounts for 17% of the total effect).

$$\frac{\partial lnFreq}{\partial Partial\_Lib} = 0.429 \frac{\partial lnQ}{\partial Partial\_Lib} = (0.429)(0.476) = 0.204$$

Lastly, BASA liberalization has no direct effect on flight frequency. Nevertheless, it still impacts flight frequency indirectly via its effect on air passenger traffic.

The final step in our calculation procedure is to aggregate all the direct and indirect effects into a single statistic representing the total price equivalent effect of partial air liberalization. To do so, we apply equation (5) in the main paper to get:

$$Price\ equivalent\ effect = \frac{\partial lnP}{\partial Partial\_Lib} + \frac{\varepsilon^{Freq}}{\varepsilon^{P}} \frac{\partial lnFreq}{\partial Partial\_Lib}$$

$$= -0.216 + \left(-\frac{1.404}{0.878}\right)(0.204) = -0.216 - 0.326 = -0.542$$

This value is reported in the last row of Table 8 in column 2. The other rows of Table 8 report the intermediary calculations illustrated in this appendix that have been taken to derive the total price equivalent effect of partial BASA liberalization. These same steps have been repeated using both OLS and 2SLS coefficients for both partial as well as full BASA liberalization.

Table A1: Level of Openness of Key Provisions of the Yamoussoukro Decision (YD)

Provisions	*Traditional Bilateral*	*Liberalized Bilateral*	*YD*
Airline Designation	*One from each contracting state*	*Multiple*	*At least one*
Traffic Right	*Limited 3rd , 4th and 5th (only specified routes in the BASA)*	*Full 5th freedom (open market access that allows flying on any route between two states)*	*Full 5th freedom in Africa, as of 2002*
Capacity	*Equally shared among both designated airlines*	*Free choice of aircraft capacity and frequency*	*Free choice of aircraft capacity and frequency*
Ownership	*Substantially and effectively owned by nationals or government of the contracting states*	*More liberal provision on foreign ownership*	*Substantially and effectively owned by nationals or government of the contracting states, or state parties to the YD*
Fares	*Double Approval*	*Double Disapproval*	*Double Disapproval*

Note. DA-Double Approval is the case where a proposed fare would be permitted when both nations approve it. DD- Double Disapproval is the case where a proposed fare would be permitted unless both nations veto it (this the most permissive form of pricing provision in BASAs). In terms of fare and capacity regulation, the YD is as open as liberalized BASAs. Provisions concerning traffic rights are also very open, but they only cover points in Africa. The YD allows ownership of airlines by third states if they are signatories to the decision, which makes it more liberal than traditional BASAs. The YD is, however, more restrictive than liberalized bilateral regimes that allow flexible airline ownership.

Source: Own summary based on Abate (2016), Doganis (1995) and the YD Articles