Applying Economy-wide Modeling to NextGen Benefits Analysis

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***Abstract*—This paper applies an economy-wide modeling framework (Computable General Equilibrium, CGE) to trace how the Next Generation Air Transportation System (NextGen) could impact non-aviation industries. CGE, also sometimes known as applied general equilibrium, combines supply and demand responses across aggregated industries taking into account how commodities are used as inputs to produce other commodities as well as to satisfy final demand. The specific model used is an adaptation of Monash University's USAGE (U.S. Applied General Equilibrium) model known as USAGE-Air. Modeling results presented here are based on a simple notional representation of NextGen costs and benefits. The initial results highlight industries that could be most affected by NextGen, and describe a 0.2% (or $46 billion) increase in gross domestic product (GDP) associated with the notional air traffic modernization scenario for year 2025 measured in 2005 dollars.**

Keywords- economics, investment, NextGen, computable general equilibrium, CGE

I. Introduction

The Next Generation Air Transportation System (NextGen) is a collection of technologies, procedures, infrastructure, and concepts that will modernize the National Airspace System (NAS). The NextGen modernization is being carried out by the Federal Aviation Administration (FAA), along with a group of agencies working with the Joint Planning and Development Office (JPDO). Agencies such as the National Aeronautics and Space Administration (NASA), the Department of Transportation (DOT), the Department of Defense (DOD), the Department of Homeland Security (DHLS), and the Department of Commerce (DOC) are involved. Private industry and airspace user groups, including airlines and general aviation (who face future investment to realize NextGen), have significant involvement in NextGen as well, through involvement with organizations like JPDO and RTCA, Inc.

Most proponents of NAS modernization cite the direct benefits of investing in NextGen, including delay reduction, and resource savings from flights using airspace more efficiently, increased system reliability during bad weather, safety improvements, and other potential gains. Many NextGen benefits are only possible with significant investment costs, both public and private. As a result, JPDO and the FAA have been building the case quantitatively to justify the cost of investment to Congress and other stakeholders. Benefit analyses have focused on operational improvements such as fuel savings, delay reduction, the value of expanded traffic, and improved traveler experience. Environmental impacts are also being examined for noise, emissions, and climate change. Thus, the NextGen analyses to date have been on impact to the aviation system users and consumers, including airlines, the FAA, the traveling public, consumers of air cargo services or military aviation.

Given this industry-level focus on NextGen, additional benefits beyond the aviation industry have not yet been fully studied. The focus of this research is to describe the economic benefits of a notional representation of NextGen to the broader economy outside the aviation industry. This work includes quantifying the impact on other industries in the economy, and describing the impact on such macroeconomic values as Gross Domestic Product (GDP) as well. This puts the NextGen benefits in a broader, economy-wide context and quantifies significant benefits accruing beyond the aviation industry that decision makers, such as Congress, should take into account. It is intended that this research be complementary to ongoing aviation-specific benefits analyses, as the industry level analyses represent and important input for this effort.

II. Economic Responses—Shifts in Supply and Demand

NextGen will potentially reduce the costs of operating at current levels of traffic through fuel saving advances enabled by capabilities such as Required Navigation Performance (RNP)/Area Navigation (RNAV) optimized routes and by optimizing constrained resources associated with delay. The capacity gains (resulting in delay reductions) would also reduce the cost of expanding traffic levels, since the marginal cost of incrementally adding additional flights to a system whose demand is well below capacity can be much less than adding flights when demand is already nearly at capacity. In economics terms, increasing system capacity could lead to an expansion of airline industry supply. This is illustrated in Fig. 1 as the shift from supply curve S1 to S2, showing that at any given price, the supplier (the air carrier) would be willing to sell more. Notionally, in Fig. 1, the quantity is represented as revenue passenger miles (RPMs) and the price could be in terms of yield, fare, or some other form of price.

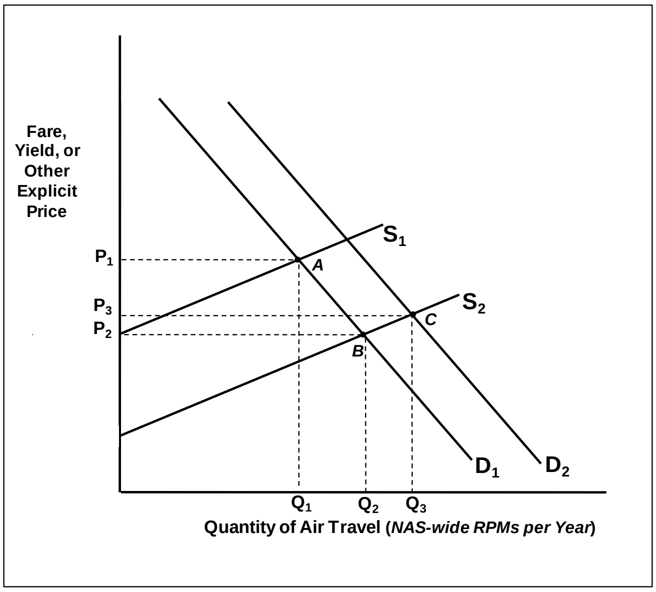

FIGURE 1. NOTIONAL SUPPLY AND DEMAND RESPONSES TO NEXTGEN

Moving along the original demand curve, D1, this expansion in supply would put downward pressure on prices. Note that demand refers to people buying air transport services from the air carrier (not demand for air traffic services on the part of air carriers). If consumers of air transport services only respond to NextGen by responding to a decrease in prices, their response is captured by the existing D1 demand curve. However, if enhanced safety, reduced delay, increased reliability, or any other perceived features of the NextGen enhancements prompt them to want more air travel at any given price, then the demand response would reflect an increase in demand, as illustrated by the shift from D1 to D2.

With or without the extra demand shift response to NextGen, the amount of air travel expands, as both the increase in supply and increase in demand would put upward pressure on quantity. The increase in supply puts downward pressure on price, while the demand shift, if it takes place, would put upward pressure on prices, making the final impact on prices ambiguous (it would depend on the magnitude of the shifts and the relative slopes of the curves).

III. ECONOMIC RESPONSES—ACROSS THE ECONOMY

In considering how NextGen and the resulting changes to demand and supply inside the aviation market translate into economy-wide impacts, consider Fig. 2. First, NextGen itself would change the resource utilization of the air carriers. This is easy to understand in the case of fuel savings, but other resources that are time dependent may also experience changes as well.

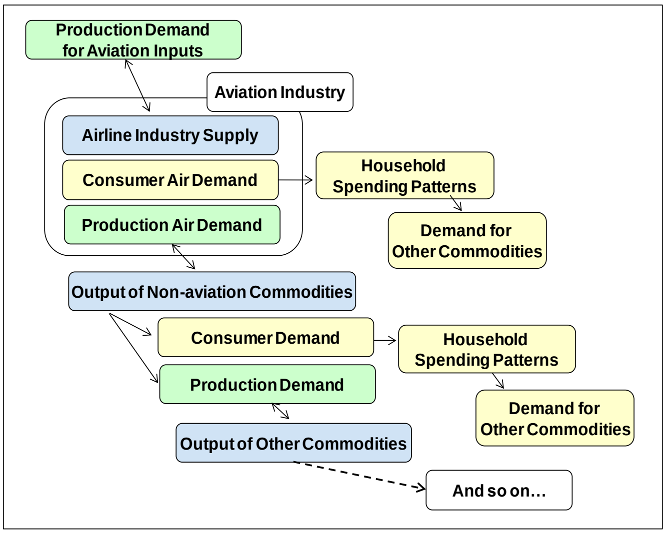

FIGURE 2. THE CONCEPT OF ECONOMY-WIDE LINKAGES

An expansion in supply in the aviation industry may also imply that airlines will use more of the resources necessary for producing air transport services. Both of these effects are illustrated as the relationship between the Airline Industry Supply and the Production Demand for Aviation Inputs.

Whether or not the demand response to NextGen includes a shift in the entire demand curve or not, if fares fall, a change in broader household spending patterns of consumers will result, potentially having an impact on household spending on other commodities. Beyond household demand for air travel, part of the pool of air travel is consumed by businesses (Production Air Demand in Fig. 2). This could take the form of employees flying to work sites, or movement of inventories, or receipt of shipped supplies. Through this Production Air Demand, the NextGen improvements could have an impact on the output of other commodities, which could cycle through another round of consumer demand impacts and production demand impacts and so on.

There are two general techniques known for capturing quantitative cross-industry impacts: Input-Output (I-O) modeling and Computable General Equilibrium (CGE) modeling (often referred to as applied general equilibrium). I-O models rely on detailed data covering the resource flows between industries. Generally, for the United States, this data comes from the Bureau of Economic Analysis (BEA) in the DOC. In operation, if an increase in output in one industry is fed into an I-O model, it will produce the increase in gross output (which is not the same as value added or gross domestic product—that carefully exclude counting output used as intermediate inputs) due to inputs required to produce it. I-O models, however, do not usually include price implications necessary for consistency. For example, in a pure I-O framework, one might be able to greatly expand a particular industry while never encountering the inhibiting effect of driving up the cost of its material or labor inputs even though scarcity would dictate that this is impossible. CGE models use the same detailed commodity flow data as I-O models, but add a degree of behavior in the form of price responses through demand and supply relationships, and thus achieve a more realistic and consistent result.

Even labor in the model is subject to market clearing. In the short-term labor employment may be able to rise in the CGE model temporarily until wages adjust (consistent with the macroeconomic concept of "sticky wages"), long run employment levels are considered a function of demographics in the model—markets clear at equilibrium levels and unemployment associated with business cycles is not considered. This is not a shortcoming of CGE, but rather is reflective of its purpose looking at long run trends and relationships amongst industries rather than modeling business cycles such as the recent recession.

Fig. 3 offers the classic, simple circular flow diagram of the economy. Obviously, the economy is significantly more complicated, but the circular flow diagram captures the big picture of the flows between the consumers and industries, both in the form of demand for final goods and services, but also in the form of labor and other primary factors of production provided by households. Further, Fig. 3 illustrates industries buying outputs amongst each other (outputs traded among industries are called "intermediate" commodities). Foreign trade is a necessary component for consistently capturing all of the economic activity. Finally, Fig. 3 also shows the government related flows in the form of government services and taxes. The circular flow diagram essentially describes the conceptual structure of an economy-wide CGE model.

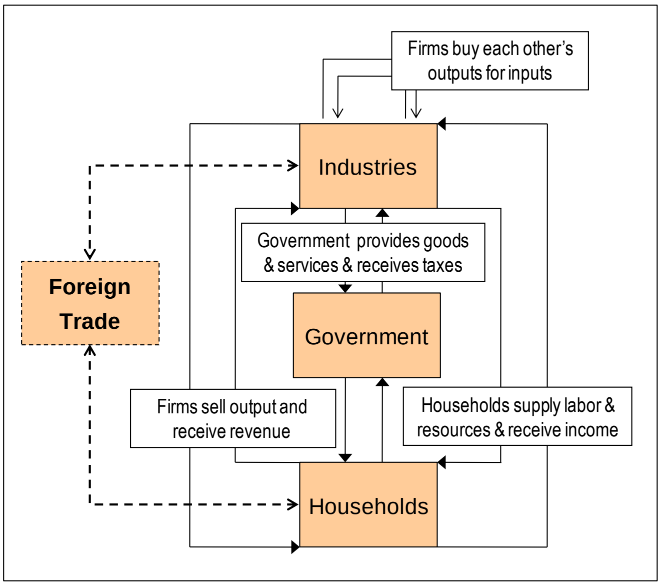

FIGURE 3. A SIMPLE CIRCULAR FLOW DIAGRAM

While there are many CGE models across the academic economic literature, government agencies, and other sources, a smaller number of CGE models are particularly relevant to the economic analyses of US federal agencies. The one that this research focuses on is a variant of the US Applied General Equilibrium Model (USAGE) developed and maintained by the Monash University Centre of Policy Studies [2, 3]. It has been used in analyses for the U.S. International Trade Commission [4], the U.S. Department of Agriculture [5], and other federal agencies.

The full USAGE model has a level of detail that includes almost 500 industries. There are two more widely circulated "Mini-USAGE" models [6]—one has almost 40 industries and the other only 5, but neither includes an air transport industry distinct from the broader transportation industry, as does the full USAGE model. We have worked with Monash University to bring about "USAGE-Air" which capitalizes on the best, most relevant features of the full and "mini" USAGE versions tailored to analysis of national aviation issues. Currently with 59 industries and 62 commodities, USAGE-Air offers the ease of reasonable run times on a standard PC with a tractable number of variables to work with, but offers significant disaggregation of the air transport industry more like the detail available in the full model. Appendix A has a full list of these industries.

IV. REPRESENTING NEXTGEN IN AN ECONOMIC MODEL

Translating operational impacts to inputs for the CGE model runs involves applying quantitative changes to the detailed patterns of resource use for the industry being examined. In the model and in the study of economics in general, this pattern of resource use is known as a production function. The production function reflects inputs required to produce output given the state of production technology. Fig. 4 contains a notional representation of this production function relationship, combining labor, facilities, equipment, materials, and services to generate output.

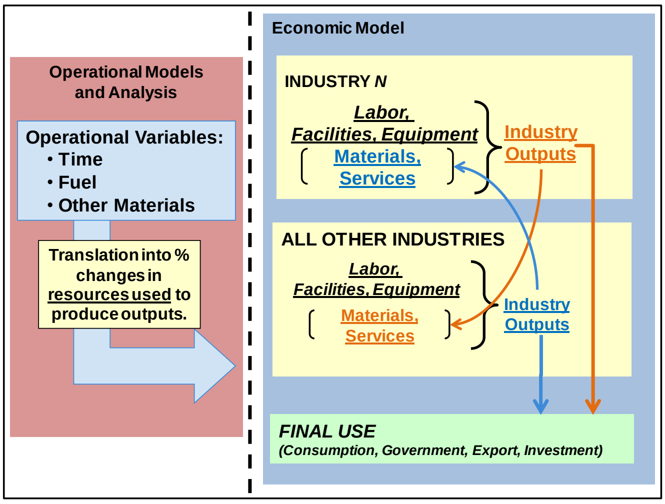

FIGURE 4. PUTTING OPERATIONAL CHANGES INTO THE ECONOMIC MODEL

Fig. 4 also illustrates the relationships between industries' production functions, as one industry's output may be used as input to make another kind of good or service. This kind of connection, one industry's output being used as an input by other industries, is one of the ways effects of NextGen could propagate across the economy.

Changes to the production function are applied as percent changes. In some cases, applying a resource-saving change could result in an absolute increase in resources used. For example, if resources savings result in an expansion of output, an industry could end up using more resources in total. In the model, units of output are measured in 2005 dollars, rather than physical units. These are capable of representing absolute changes in output because changes in prices are tracked in a separate index.

Presently, analyses of NextGen benefits and costs are in a state of being continually updated and refined. A consequence of this ongoing work is that the results of these studies are not yet published and widely available. For this reason, we chose for these model runs to use a loose, notional representation of NextGen that could be widely discussed.

As stated previously, benefits are focused on resource savings. While we have the flexibility to input different percentage resource savings for every commodity used by the air transport industry, we chose a single uniform savings for these model runs. In other words, after NextGen is implemented in our notional case, the reduction in delays and overall improvements in efficiency imply 9% fewer resources are consumed to produce any given level of output. While there could be significant difference between fuel savings and the saving of block time sensitive resources, such detailed specifications of benefits will be the subject of futures studies carried out in closer coordination with ongoing NextGen studies. Explicit government resources savings (air traffic management or otherwise) are not included in this analysis.

Significant investment will be required to make NextGen a reality. This will include equipage by operators as well as investment in ATM on the part of the FAA and the government. We assumed a cost of $40 billion dollars. A more detailed estimation may suggest higher or lower costs and will no doubt depend on which user groups are targeted for equipage and when. Given the $40 billion estimate, we assume that this will be distributed as approximately a 50-50 split between aviation industry investment in the form of equipage and government investment in air traffic infrastructure.

In the model, investment takes place to build capital, which is a feature in the production function. Here, capital refers to the types of physical resources required to produce output that are not entirely consumed in the production of the output—meaning they last for continued reuse over time, with some amount of depreciation (or wearing out) as they are used over time. Investment decisions are based on expected earning associated with buying more capital (expected rate of return), the existing current capital stock, and the rate of depreciation. To achieve the NextGen investments in our scenarios, we alter the amount of navigation equipment (the commodity and industry that would include all of the avionics and ATM-related equipment) in the investment profile for the government and/or aviation industry. The percents associated with the increased navigation equipment investment were chosen to result in approximately $40 billion in real spending (as opposed to nominal, which would include inflation). Achieving the cost target of $40 billion in the model required "tuning" a percentage of increased navigation equipment that results in about $40 billion in spending.

In our simple notional scenarios, we assumed NextGen implementation, for both benefits and investment costs, would begin in 2010 and concluded by 2025. Benefits were assumed to accelerate ("ramp up") continuously over this period to reach the 9% in 2025. Investment costs ramp up from 2010 to 2014 to reach a steady level maintained from 2015 to 2023 and then decline to zero across 2024 and 2025 ("ramp down").

While our comprehensive model runs for this phase of our work consisted of 35 different scenarios, for this paper, we present two scenarios for NextGen implementation. The difference between the two scenarios is in who bears the $40 billion in investment costs. In the first scenario the carriers and the government are financially responsible for their own direct portions of the NextGen investment (meaning carriers pay for equipage in the previously discussed 50-50 split) and in the second scenario, the government pays for the entire investment through deficit spending.

In addition to these two scenarios runs, a base case is also run. The base case represents the course of the economy absent any of the NextGen changes. It draws on growth forecasts from the Congressional Budget Office (CBO), U.S. Department of Energy (DOE) Energy Information Administration (EIA), U.S. Department of Labor Bureau of Labor Statistics (BLS), U.S. Department of Agriculture (USDA), as well as trends in historic data describing consumer preferences, technology, world demand for U.S. exports and U.S. demand for imports [4, 7]. The focus of this base case forecast and application of the model in general is for understanding the overall, long run, equilibrium movement in the economy (equilibrium characterized consistent with the economic definition—market clearing). This means that we do not address business cycles—including the present recession. It is not that this is not an important focus of economic analysis in general nor is it an insufficiency of this work—it is just not a feature of the questions this research addresses.

V. ECONOMY-WIDE NEXTGEN IMPACT

Fig. 5 describes the high-level output from the two scenarios. These results are presented in terms of cumulative percent deviation from the base case.

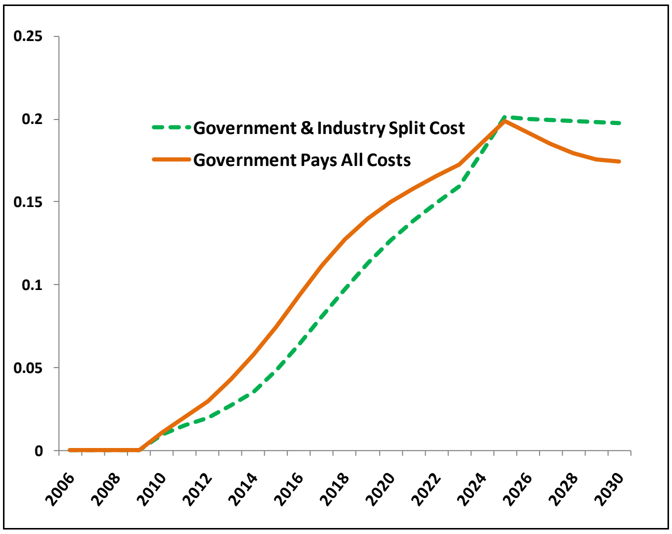

FIGURE 5. PERCENT INCREASE IN GROSS DOMESTIC PRODUCT ASSOCIATED WITH EACH *NOTIONAL* SCENARIO.*

*NOTE: 0.01 ON THE VERTICAL AXIS IN FIGURE 5 IMPLIES 0.01%

The specific variable presented in Fig. 5 is Gross Domestic Product (GDP). GDP is a measurement of the final output of the economy, not counting goods and services used as intermediates to produce other goods (no double counting). It essentially represents the amount of economic output available to support an economy's standard of living. While the impact on GDP is measured in fractions of a percent, the magnitude of GDP means that these fractions translate to large absolute amounts. The approximate level of both scenarios in 2025 is $46 billion 2005 dollars.

It is notable that both scenarios result in about one-fifth of a percent increase in GDP by 2025. This seems to indicate that at the broad economy level, it makes little difference in the long run whether the government pays for NextGen or the carriers do, though in the mid-term, there is a difference in the path to that result. After converging at 2025, the scenarios diverge moving forward toward 2030. The industry and government split case is high after 2025 relative to the government only scenario. This is driven by the investment dynamics and the model's equilibrium characteristics with respect to labor, capital, and their respective factor payments. The investment pattern is shocked over a period of time changing the relationship between capital and labor [2]. When the investment shocks ramp down in 2025, there is a temporary adjustment period to achieve the long run equilibrium that results in a fleeting boost to GDP. It is expected that running these models out further into the future would achieve greater convergence in the cumulative GDP impact.

Despite this issue with the investment costs, separate cost only and benefits only model runs reveal that both scenarios are primarily dominated by the benefits aspect of the scenarios. Understanding the smaller impact of the cost requires understanding the difference between industry level analysis and economy-wide analysis. In an industry level study, the $40 billion in assumed investment costs counts as a whole. When examining GDP changes here, the $40 billion of extra spending on navigation equipment represents a deviation of resources and government debt (depending on the scenario), but is not gone. This can be seen by examining the navigation equipment industry in the industry level results.

Fig. 6 is a plot of the specific industries included in the model with their cumulative percent deviation in output (gross output, including outputs used as intermediates) year by year for the scenario in which government and industry share the $40 billion of investment. The industries are roughly organized in the plot by their type—starting with agriculture and natural resource-oriented industries to the right, then manufacturing toward the middle and services toward the left.

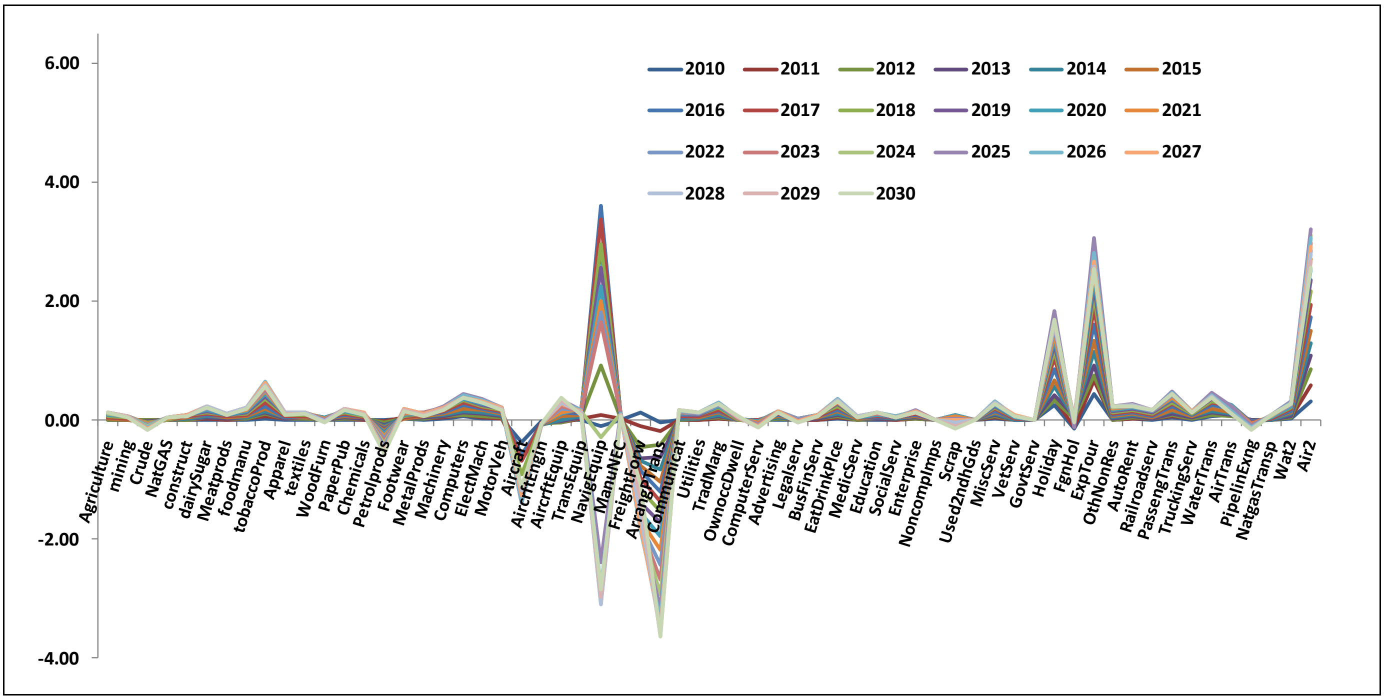

FIGURE 6. PERCENTAGE DEVIATION FROM BASE INDUSTRY OUTPUT IN THE GOVERNMENT & INDUSTRY INVESTMENT *NOTIONAL* SCENARIO.*

*NOTE: 1 ON THE VERTICAL AXIS IN FIGURE 6 IMPLIES 1%.

Navigation equipment is the industry directly driven by the investment cost assumptions in the two scenarios. In the years between 2010 and 2025, the level of investment in navigation equipment is pushed artificially high relative to the base case. Once the investments are complete, there is a recoiling to below the original investment level for years like 2026 reflecting the larger amount of relatively new navigation equipment in the capital stock. This is a possible area for tuning the scenario inputs to be more realistic, if we think navigation equipment will permanently represent an increased share of the air transport industry's investment profile. Referring back to the discussion of costs—the $40 billion in spending is still part of GDP, any reduction in GDP associated with the investment spending is in the form of consequences of deviating the $40 billion, rather than the amount of the investment itself.

The increase in air transport ("AirTrans") appears small, given this is the industry directly impacted by the resources savings in the scenario. It should be noted that the scenarios created for this paper did not include a demand response to decreased delays and improved safety and reliability (see the discussion of the shift from D1 to D2 in relation to Fig. 1). This demand response would result in a larger air transport increase. Investigation into the parameterization of the model reveals the likely cause of this—even without an additional demand response, the efficiency gains imply a change in the supply of AirTrans for a given demand curve. The own price elasticity of demand here for AirTrans is -0.779. This is inelastic, meaning for every one percent the price of AirTrans falls, there is about eight-tenths of a percent increase for AirTrans demanded by consumers. There is a broad literature that estimates and describes the elasticity of demand for air transport, a great deal of which is summarized in Gillen, et al (2002) [8]. Of the studies summarized and reviewed by Gillen and his co-authors, elasticity for air travel demand has been estimated as elastic as -3.2, with a median of -1.22. These are both elastic (less than -1) which implies a greater than proportional quantity response for price changes—unlike the current -0.779. The choice of elasticity in the current specification of USAGE Air was driven by Monash's broad treatment and parameterization of the whole economy, as this was a parameter calculated in common with other modes of transportation. Future model runs will use elasticity estimates from the literature and include sensitivity analysis.

While the increase in air transportation industry was mild, the increase in domestically produced Air 2, the industry that represents international flights by U.S. flag carriers experiences a much larger increase in output. Further, Air2's elasticity is -1.5 (meaning a 1.5% increase in quantity demanded for a 1% increase in price). This effect may be strengthened by Air2 being subject to foreign competition. Their resource savings make them relatively more competitive and they divert some international traffic away from foreign carriers. This is another area for using industry specific studies to tune the model.

Other spikes that might seem unusual to the casual observer are also present—for instance, aircraft. When we introduce blanket resource savings to the air transport industry, we see a small increase in air transport output relative to those resource savings, so resources purchased in aggregate actually decline—producing a reduction in output in the aircraft industry. This is also observed for petroleum products and other supporting industries as well. Inclusion of a demand response, described above, could result in an absolute increase in absolute resource consumption.

Arranging passenger transport experiences a relatively large decline. This may superficially sound like an industry that should experience a benefit from resource savings in the air transport industry, but a little exploration reveals the cause of the decline. Arranging passenger transport is an industry that includes tour operation and tours excluding sightseeing by the various modes, travel agencies, carpool and vanpool arrangement, and ticket offices (airline and other) not operated by transportation companies. While final demand for these services may increase with the small expansion in air transport, about 90% of the output of the arranging passenger transport industry is consumed as intermediates—with 40% total being used as an intermediate in air transport itself. As described for the case of aircraft, with the specification of these scenarios, industries that produce resources used by air transport experience a decline in output associated with the specified resource savings. This is also the case for freight forwarding, which includes different non-air freight, courier, and warehousing services, though to a lesser degree.

Both freight forwarding and arranging passenger transport are relatively small in absolute magnitude. Table 2 contains their base value in millions of 2005 dollars along with the magnitude of some other industries of interest.

TABLE 2. 2005 GROSS OUTPUT IN MILLIONS OF 2005 DOLLARS

Industry	2005 Output
Holiday: An industry with no capital that combines other industries outputs as domestic vacation spending by U.S. travelers	$360,990
Trucking Services	$330,261
Export Tourism: Like Holiday, except that it is consumed by foreign travelers to the United States and is thus an export	$192,736
Air Transportation: Domestic air transportation services including passenger and cargo	$134,509
Foreign Holiday: Like Holiday, but consumed abroad by U.S. travelers	$85,397
Railroad Services	$79,018
Aircraft Manufacturing	$65,558
Air2: Air transportation to/from foreign destinations by U.S. carriers	$52,233
Passenger Transport: Local and intercity passenger transport including taxi, bus, bus charter	$42,631
Water Transportation	$41,706
Navigation Equipment	$37,051
Freight Forwarding: Freight forwarding, warehousing & storage except by air, including local trucking and courier services	$26,903
Arrangeming Passenger Transportation: Includes travel agencies, ticket offices not operated by transportation companies	$25,142

Holiday, foreign holiday (FgnHol), and export tourism (ExpTour) are three further industries of note included in Table 2. Holiday, otherwise known as vacation, represents tourism. Foreign holiday is tourism by U.S. nationals abroad. Export tourism describes tourism by foreign nationals in the U.S., which, because it represents foreign purchase of U.S. goods, counts as an export. These industries have no capital and represent bundled consumption that includes air transport, thus the growth of holiday and export tourism. Foreign holiday experiences a slight decline—which makes sense as we have made domestic tourism more competitive to the foreign and the improvement in productivity leads to favorable terms of trade effect for US goods.

Fig. 7 is a time series plot of the tourism industries, air transport, Air2, and aircraft (as representative of industries that produce air transport inputs). This is the same data plotted in Fig. 6.

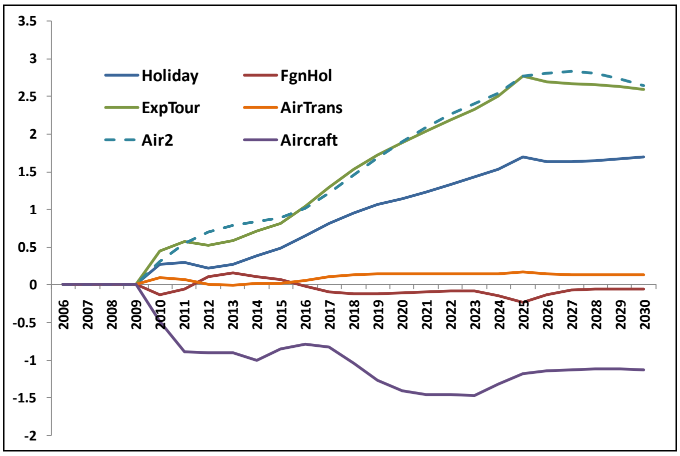

FIGURE 7. INDUSTRY OUTPUT DETAIL IN THE BENEFITS & COSTS (GOVERNMENT & INDUSTRY) *NOTIONAL* SCENARIO*

*NOTE: 1 ON THE VERTICAL AXIS IN FIGURE 7 IMPLIES 1%.

It is even more apparent in Fig. 7 that the deviation from the base for air transport is modest compared to that of holiday and export tourism. This is easily explained in the case of export tourism—it tracks very closely with Air2, the variable describing international flights carried out by U.S. carriers coming or going from the U.S. Explaining the difference in the apparent impact on output for holiday and air transport requires looking at the deviation in the price level from the base case associated with the scenario. These price deviations are presented in Fig. 8.

Air transport is about 11% of total intermediate goods that go into holiday. However, as holiday is an input to export tourism, there is also some Air2 in holiday. The decrease in price in air transport, the price of an input, would stimulate an increase in supply of holiday, as would the decrease in price of Air2. While the proportional increases in air transport output may not seem large enough to support the expansion of holiday, understanding that Air2 is also an input to holiday as holiday is an input to export tourism helps reconcile this.

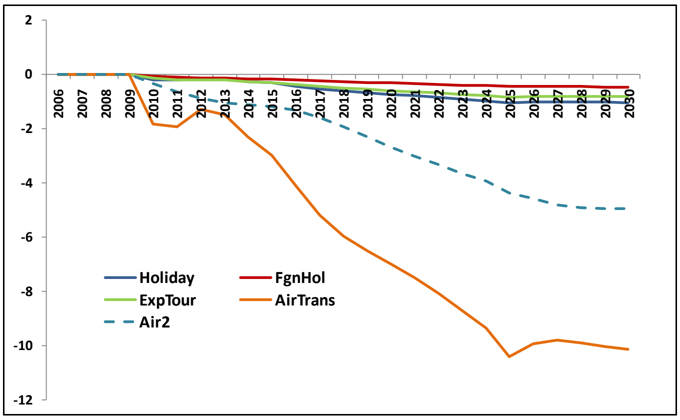

FIGURE 8. CUMULATIVE PERCENT DEVIATION IN PRICE LEVELS IN THE *NOTIONAL SCENARIO* FROM THE BASE*

*NOTE: 1 ON THE VERTICAL AXIS IN FIGURE 8 IMPLIES 1%.

The price decline in air transport is dramatic. A decline in price and increase in output are consistent with the movement from equilibrium point A to equilibrium point B in Fig. 1. The relative magnitude of the price relative to the increase in output implies a relatively steep demand curve—consistent in principle though not magnitude with the elasticity assumptions described previously. This means that further dynamics in the model are at play beyond multiplying an own price elasticity parameter by an estimated price change. The source of part of these dynamics is the relationship between Air2 and air transport, though a comprehensive view of the dynamics is still be traced out and described.

VI. ECONOMY-WIDE NEXTGEN IMPACT

This paper provides a first look at the impact of investment in aviation infrastructure investment on the rest of the U.S. economy. A number of extensions will make this model stronger over the coming months. For instance, the model is calibrated to an economic "status quo" with gradual efficiency gain over time in the production functions. If the amount of resources required for air transport in the NAS is increasing with the level of NAS congestion (i.e. the amount of time, fuel, etc. required increases per flight as congestion mounts, a.k.a. decreasing returns to scale), the current production function understates the excess congestion costs of "do nothing" future base case, absent NextGen. This potentially understates the benefits of the NextGen resource savings. If passengers respond directly to reduced delay, increased reliability, and improved safety, as described by D2 in Fig. 1, results could also be more dramatic. If businesses redesign their distribution networks, relying more heavily on air transport to deliver their goods to market, the broader economic impact would also be altered. Finally, resource savings to the government are also not considered in these model runs.

These major refinements have been planned beginning in autumn of 2009. All have a tendency to intensify the value of NextGen in the analysis. This work is a good example of modeling NextGen-style benefits and costs with Computable General Equilibrium modeling, showing it is capable of estimating the value to the economy of investment in air traffic modernization. The economy-wide benefits in terms of gain in gross domestic product strongly dominate the costs in the scenarios presented here. Additional scenarios not groomed for this paper, demonstrate similar features and a strong, positive economic impact for NextGen, given our notional assumptions.

Gross domestic product is a modest proxy for the actual improvement in well being. It has the advantage of being a familiar concept with a clear explanation, but as measured in models like these, it can be subject to index problems and does not necessarily convey the entire magnitude of the impact. Compensating variation (CV) and equivalent variation (EV) are two concepts in economics used to more thoroughly describe welfare improvements or deteriorations. Compensating variation roughly describes how much money could be taken away from households to leave them just as well off as in the base case, given the policy scenario (assuming a beneficial scenario—given a negative scenario money would be given). Equivalent variation is roughly how much money would have to be given to households in the base case to make them as well off as they would have been in the policy scenario (assuming a beneficial scenario). These concepts are very similar but not the same [2, 9]. In the scenario for industry and government sharing the cost of NextGen, the model estimates the upper bound on equivalent variation at 1.32% of household expenditures, and the lower bound of compensating variation at 1.29% of household expenditures in 2025.

Efficiency gains in the air transport industry, such as those associated with NextGen, could be great. These benefits appear only modestly diminished when modeled with their investment costs, whether the costs are borne jointly by the industry and the government or solely by the government, given the assumptions made for this application. Whether measured in terms of gross domestic product (0.2% higher GDP in 2025 translates to $46 billion in 2005 dollars, or $21 billion 2005 dollars if present discounted at a rate of 5%) or with the technical economic welfare measures like equivalent variation and compensating variation (1.32% and 1.29% of household expenditures, respectively) our scenarios demonstrate the value of applying CGE modeling to capture NextGen benefits across the economy.

ACKNOWLEDGMENTS

We offer special thanks to our colleagues George Solomos, Debra Pool, Glenn Roberts, Felipe Moreno Hines, Joseph Sinnott, and Gene Lin for their criticism, encouragement, review, and support in pursuit of this work.

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