Technical Appendix 3: Economic Impact of the U.S. Airport System on the U.S. Economy

ACRP 03-28: The Role of U.S. Airports in the National Economy

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1 INTRODUCTION

This appendix describes the economic impact approach to trace the national economic footprint of airports in terms of airline and aviation services, on-airport support activities for aviation, on-airport concessions, on-airport construction, off-airport spending of international visitors and the contribution that airports make to the national economy as international cargo gateways. The "top-down" approach can be described as the "economic footprint" of airports on the United States' economy.

This appendix also describes the efforts of the Research Team to estimate the economic impacts of airports by regression analysis for airports in the Federal Aviation Administration's National Plan of Integrated Airport Systems (NPIAS). The database developed by the Research Team combines the facility characteristics, aviation performance data, socio-economic data from counties and metropolitan statistical areas for the 3,330 active NPIAS airports[1] with results from economic impact studies conducted over the years 2006-2011.

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[1] Federal Aviation Administration, 2013-2017 National Plan of Integrated Airport Systems (NPIAS)

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2 THE ECONOMIC FOOTPRINT OF U.S. AIRPORTS – DIRECT EFFECTS

The 3,330 airports in the National Plan of Integrated Airport Systems (NPIAS) include 499 commercial airports (139 hubs and 360 non-hubs) and 2,831 non-commercial airports (268 reliever airports and 2,563 general aviation facilities). Overall, almost 100 million operations of aircraft of various sizes departed and landed at these airports in 2011. Commercial airports carried more than 723 million enplaned passengers. Moreover, an additional 78 million round trips are taken on general aviation and air taxi operations, if the number of passengers is an estimated modest two and three passengers per operation (including pilots). Using this assumption implies that a national total of 800 million passengers flying in 100 million air operations to and from NPIAS airports in 2011. (See Table 1.)

Table 1. National Passenger and Operation volumes at NPIAS Airports

	Number of Passengers / Operations
Total Enplanements	723,122,905
% Domestic	*88.55%*
% International	*11.45%*
Commercial Operations	18,625,601
% Domestic	*92.81%*
% International	*7.19%*
All Cargo Airline Operations	1,099,927
Air Taxi Operations	5,908,512
General Aviation	69,135,917
% Local	*51.86%*
% Itinerant	*48.14%*
Military Operations	3,964,463
Total Operations/All Traffic	**98,734,420**

Sources: U.S. DOT O&D Survey, YE 2Q 2012; U.S. DOT, T-100 Database; IATA, PaxIS Database; U.S. DOC, International Air Travel Statistics, 2011; FAA ATADS

Components that comprise the national contribution of NPIAS airports to the economy of the United States include airport administration and operational activities, spending of international visitors, the value of international air cargo shipments and terminal concessions.

Domestic visitor spending and concession spending by domestic travelers are not included because these spending activities shift dollars from one region of the United States to

another. These activities add to gross <u>regional</u> products where the spending takes place, but does not add to the gross <u>national</u> product. Moreover, visitor spending and on-airport concession spending by air passengers subtract income where trips begin and deposit it at trip ends (or at intermediate points in the cases of connecting flights). Thus, the net benefit to any region is the spending in its region minus the spending of local residents who travel elsewhere for business or personal reasons. For domestic travelers, visitor spending nets to zero in the national economy as dollars from one region are transferred to another region.

Spending by international visitors has an effect on the U.S. national economy. The net difference of foreign visitors to the United States and U.S. residents traveling abroad produces either: (1) a net benefit to the U.S. economy if there is more incoming spending than outgoing spending; or (2) a negative benefit (also called a dis-benefit) if there is more spending by U.S. visitors traveling abroad versus the spending of international visitors in the United States. The net (positive) benefits of international spending in 2011 and 2012 international visitor spending are $27 billion and $33 billion, respectively.[2] While not all of this is due to airports (all spending by Canadian and Mexican visitors have been netted out of this calculation in order to account for non-air modes. This is not to suggest that all visits across the U.S.–Canada and U.S.-Mexico borders are by surface modes, but it is an effort not to over-count visitor spending impacts.

2.1 Business Segments

On-airport business segments at airports can be categorized in two segments: 1) operation of the physical facilities of airports and 2) businesses that purchase services that operated from the facilities. Secondly, airports support industries located off-airport through making possible visitor spending and airfreight (national impacts are confined to international passengers and freight). Table 2 below illustrates a division of these categories.

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[2] Source: U.S. Department of Commerce, Office of Travel and Tourism Industries from the Bureau of Economic Analysis (March 2013).

Table 2. Airport Related Business Segments

Airport Operation (airside and groundside)	Businesses that Purchase/ Lease Airport Services	Off-Airport Industries that Directly Benefit from Airport-based Activities
Administration, management and operational services	Airlines	Lodging
Fixed-base Operations	Retail and other terminal services	Food and Beverage
Air Traffic Control	Parking and other ground transportation services	Retail
Ground Handling	Avionics/aircraft repairs other than fixed-base operators	Entertainment and Amusements
		Local transportation services
		Industries that rely on air freight to ship products to long-distance customer markets

Sources: IBISWorld, EDR Group

Not all of these segments apply to airports that support air carrier and general aviation. For example, "airlines", of course, operate exclusively from commercial airports. In addition, while some GA airports have air traffic control towers, most do not.[3] Similarly, while some GA airports have some commercial services for pilots or workers on airports (and transient GA operations lead to visitor spending off airport), the overwhelming majority of retail and terminal services are found at commercial airports with high passenger volumes.

Direct Economic Contribution of Airports.

The findings of this approach are that the direct contribution of airports to the U.S. economy is approximately $638 billion in economic output and $236 billion in value added contributions to the United States' gross national product (GDP). The output and value added support 2.1 million jobs and remunerate $145 billion in compensation to workers and proprietors. This overall contribution is calculated based on the datasets and assumptions described below.

Datasets

Datasets used for the aggregation of national economic impacts of airports are provided by the Bureau of Economic Analysis (BEA)--directly, or through private sector aggregators such as the IMPLAN Group, LLC[4], and Moody's Analytics; the U.S. Department of Commerce Trade Division; County Business Patterns, the Bureau of Labor Statistics, the Federal

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[3] For example, in Massachusetts exclusive GA airports with towers are Hanscom, Beverly and Lawrence (many are contract towers supported by the FAA).

[4] Subsequent to the start of this research project the Minnesota IMPLAN Group, Inc. (MIG, Inc.) changed its corporate name to IMPLAN Group, LLC.

Aviation Administration, the U.S. Census Bureau's Foreign Trade Division, and Airports Council International - North America. Table 3 presents a summary of the datasets. While these datasets establish a baseline for estimating the contribution of airports to the national economy, significant snags in comparing and applying the data are observed, including:

- There are different levels of aggregation. For example, County Business Patterns reports ten sectors for air transportation services, Moody's Analytics reports three sectors and IMPLAN Group, LLC (IMPLAN) reports one aggregated sector. In the same vein, "support services for air transportation" are reported in some of the data sources, and are aggregated within a larger "support services for transportation in other sources. Also, the levels of aggregation within "support service for air transportation" vary from five sectors in County Business Patterns, to two from Moody's and none for BEA.

- The latest year that data are reported varies among the sources—2009, 2010, 2011 or 2012.

- Some datasets include proprietors (which are critical for small businesses at airports, including many of the kiosks found in airport terminals), while others only include employees.

- Employment, payroll (or wages), sales (or output) and value added are not reported in all sets. For example, County Business Patterns reports employment and wages, the United States. The Department of Commerce Trade Division reports international visitor spending and jobs derived from that spending. ACI-NA and the FAA report on-airport construction spending, but not jobs, wages or value added generated by construction activities. Ratios aggregated from national datasets by IMPLAN, LLC are used to fill in missing metrics when necessary.

Also, the government datasets that report employment and other metrics by industry code have different approaches to how data are accumulated and reported (see Table 3). Some of the key differences include:

- Bureau of Economic Analysis reports employment (full-time jobs, plus part-time jobs) on an annual basis—including employees, proprietors and farm owners. Personal income includes employee compensation, proprietors' income, and farm income, rents, and transfer payments. For this analysis, "labor income" does not include transfer payments but does include these other concepts listed by BEA.

- Bureau of Labor Statistics (BLS) Current Employment Statistics (CES) program. CES excludes data of all private households and farms, with the exception of logging. CES also excludes proprietors, the unincorporated self-employed, unpaid volunteer or family employees, and domestic employees. However, salaried officers of corporations are included. For Government industry, the CES program includes employment from any NAICS industry that is owned by a government entity (Federal, State or Local) and whose employees are paid directly by the government

entity (i.e., does not include contractors). CES Government employment covers only civilian employees; military personnel are excluded, as are employees of national security agencies. CES average earnings do not represent employers' total compensation costs because they exclude items such as employee benefits, irregular bonuses and commissions, retroactive payments, and the employer's share of payroll taxes

- BLS Quarterly Census of Employment and Wages (QCEW). QCEW excludes proprietors and partnerships not covered by the unemployment insurance (UI) tax program. Non-covered employment results from a difference in scope between the CES and QCEW programs. Most firms are required to pay UI tax for their employees; however, there are some types of employees that are exempt from UI tax law, but are still within scope for the CES estimates. Examples of the types of employees that are exempt are employees paid by state and local government and elected officials; independent or contract insurance agents; employees of non-profits and religious organizations (this is the largest group of employees not covered); and railroad employees covered under a different system of UI administered by the Railroad Retirement Board (RRB). This employment needs to be accounted for in order to set the benchmark level for CES employment. QCEW provides total wages, which include bonuses, stock options, severance pay, profit distributions, cash value of meals and lodging, tips and other gratuities, and, in some States, employer contributions to certain deferred compensation plans such as 401(k) plans. Covered employers in most States report total compensation paid during the calendar quarter, regardless of when the services were performed.

- County Business Patterns (CBP) of the U.S. Census is an annual series that provides economic data by industry. This series includes the number of establishments, employment during the week of March 12, first quarter payroll, and annual payroll. Starting with 2008, CBP publishes U.S.-level data by the following legal forms of organization: all establishments, corporations, s-corporations, sole proprietorships, partnerships, non-profits, government, and other.

  While CBP covers most of the country's economic activity, the series excludes data on self-employed individuals, employees of private households, railroad employees, agricultural production employees, and most government employees. Payroll includes all forms of compensation, such as salaries, wages, commissions, dismissal pay, bonuses, vacation allowances, sick-leave pay, and employee contributions to qualified pension plans paid during the year to all employees, but not employer paid benefits. For corporations, payroll includes amounts paid to officers and executives; for unincorporated businesses, it does not include profit or other compensation of proprietors or partners. Payroll is reported before deductions.

- IMPLAN, LLC and Moody's Analytics are private-sector vendors that primarily follow BEA definitions for employment and compensation. IMPLAN incorporates BEA, BLS CEW and CBP data, along with U.S. Department of Agriculture and other specialized sources to account for agriculture, construction, state, local and federal

governments. Moody's Analytics bases its data on sets provided by BLS, the Bureau of Census, Federal Reserve Board, The Conference Board, National Association of Realtors, Dow Jones, and various other government and private sources

- Annual Survey of Public Employment and Payroll published by the U.S. Census lists public sector employment by government function, including air transportation and the transportation services administration. Air transportation is not separated in the databases noted above that include public employment. Information regarding on-airport TSA employment is augmented by the Consolidated Appropriations Act, 2012, passed by the U.S Congress and signed into law by the President.

Based on the complete annual data displayed in Table 3, 2011 is the most common data point for aggregating national impacts. Therefore, the analysis began by examining 2011 on-airport datasets (including air services, airlines and support services for air transportation), and then looked at datasets that provide guidance for visitor spending, on-airport concessions, on-airport construction and the contribution of air freight to the national economy.

Table 3. Metrics and Sources

Sector	Source	Number of Sub-Sectors	Metrics				Latest Year
			Jobs	Payroll / Wages	Value Added	Output (sales)	
Air Transportation Services[1]	Moody's Analytics	2	X	X	X		2012
Air Transportation Services[1]	CBP	9	X	X			2011
Air Transportation Services	IMPLAN Group, LLC	0	X	X	X	X	2011
Air Transportation Services	BEA	0	X	X	X	X	2011
Air Transportation Services[1]	BLS CES	2	X	X			2012
Air Transportation Services[1]	BLS QCEW	0	X	X			2011
Airline Employment	FAA	0	X				2011
Supporting Activities for Air Transportation[1]	Moody's Analytics	2	X	X	X		2012
Supporting Activities for Air Transportation[1]	CBP	4	X	X			2011
Supporting Activities for Air Transportation[1]	BLS CES	1	X	X			2012
Supporting Activities for Air Transportation[1]	BLS QCEW	0	X	X			2011
Public Sector Air Transportation	Bureau of the Census	0	X	X			2013
Consolidated Appropriations Act, 2012	U.S. Congress		X			X	FY 2012
International Visitor Spending	U.S. Department of Commerce Trade Division	5	X			X	2011
On-airport Construction	FAA NPIAS and Form 127	0				X	2012
Non-Aeronautical	ACI-NA Concessions Benchmarking Survey	0				X	2011
International Air Freight[1,2]	WISER Trade from U.S. Department of Commerce Trade Division	1081 / 2502				X	2012
Domestic and International Air Freight[3]	Freight Analysis Framework, U.S. DOT	43				X	2011 provisional

Note: Data for federal government are available for 2012. The most recent year for federal, state and local governments is 2011

[1] *Sectoring based on North American Industrial Classification System (NAICS)*

[2] *Harmonized System (HS) Commodity Codes*

[3] *Standard Classification of Transported Goods (SCGT) Commodity Codes*

2.2 Aviation Services

For 2011, counts of national employment in aviation services (corresponding to NAICS sector 481) range from 426,000 workers to 478,000, depending on source. The lower end is represented by County Business Patterns of the U.S. Census and the high end is from IMPLAN, LLC, a private sector vendor. Meanwhile the U.S. Bureau of Economic Analysis (BEA), U.S. Bureau of Labor Statistics (BLS), and Moody's Analytics (a private sector vendor) reports similar 2011 employment in the rage of 455,000 – 457,000.

Subsectors of "Scheduled Air Transportation" refer to commercial service, and "Unscheduled Air Transportation" refers to general aviation. As shown in Table 5, commercial air transportation services accounts for more than 90 percent of all Air Transportation employment, while GA services account for about eight to nine percent. This ratio is consistent among reporting data bases (i.e., CBP, Moody's Analytics and BLS-CES).

Patterns of dollar concepts differ much more widely than employment among the available sources. IMPLAN, LLC and BEA report $39-$40 billion in personal income is 2011, while, BEA, BLS and Moody's Analytics report between $23 billion and $30 million. Fewer data sources report value added and output. Moody's Analytics, IMPLAN, LLC and BEA report national value added for the air transportation sector in a narrow range of $65-$70 billion. IMPLAN, LLC and BEA report that air transportation generates $152 billion and $162 billion, respectively, of national output. CBP and Moody's Analytics report personal income for scheduled and unscheduled air services. In both datasets, 89.8 percent of all personal income is ascribed to scheduled air transportation services (commercial), while the balance is non-scheduled (GA). Moreover, using employment and personal income datasets provided by CBP and Moody's Analytics shows average wages per worker of Scheduled Air Transportation to be 58,000 and 65,000 respectively, while personal income of nonscheduled air transportation workers average $76,000 (CBP) and $74,000 (Moody's Analytics). The differences in per-worker income are due to the total labor compensation in BEA and IMPLAN, LLC concepts, and are shown in Table 4.

Table 4. Per worker income in the Air Transportation Sector.

		CBP	Moody's	IMPLAN, LLC, Inc	BEA	BLS- CES	BLS-QCEW
481	Air transportation	$59,531	$65,533	$81,197	$87,135	$51,097	$63,252
4811	Scheduled air transportation	$58,129	$64,693				
4812	Nonscheduled air transportation	$75,585	$74,005				

Calculations by EDR Group.

Blanks indicate that data for specific subsectors shown in the row headers are not available from the data source listed in the column headers.

In addition to Air Transportation Services (NAICS 481), Support Activities for Air Transportation (NAICS 4881) also delineate on-airport employment. The latter sector is part of NAICS 488, Support Activities for Transportation, which includes all modes. Unfortunately, IMPLAN, LLC and BEA do not report the disaggregation of the general sector into its mode-specific components. Sector 4881 includes airport operations, air traffic control, as well as other support operations. Overall personal income in this sector ranges widely according to reporting agencies and companies, $6.1-$10.7 billion. County Business Patterns, Moody's Analytics and BLS-CES reports that labor income per worker is $26,000-$30,000 for airport operations, while CBP and Moody's Analytics report incomes per worker for Support Activities for Air Transportation as $54,000 and $57,000, respectively.

As shown in Table 5 and Table 9, employment for Air Transportation and Support Activities For Air Transportation total 579,000 to 664,000 by companies and government agencies that tabulate and report both sectors[5]:

- CBP — 579,176

- Moody's Analytics — 615,892

- BLS CES — 616,000

- BLS QCEW — 664,316

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[5] In addition, the FAA reports airline employment at 579,000 full time and part time workers (528,000 as FTE). This total does not match the data reported by the public and private databases reviewed. (Airline Employees, FAA Schedule P1A)

Table 5. Employment by Sector and Subsector

		CBP	Moody's	IMPLAN, LLC, Inc	BEA	BLS- CES	BLS-QCEW
481	Air transportation	425,787	456,642	478,143	458,000	456,900	455,189
4811	Scheduled air transportation	391,587	415,474			415,500	
48111	Scheduled air transportation	391,587					
481111	Scheduled passenger air transportation	379,536					
481112	Scheduled freight air transportation	12,051					
4812	Nonscheduled air transportation	34,200					
48121	Nonscheduled air transportation	34,200	41,168			41,300	
481211	Nonscheduled chartered passenger air transportation	25,556					
481212	Nonscheduled chartered freight air transportation	3,985					
481219	Other nonscheduled air transportation	4,659					

Table 6. Personal Income by Sector and Subsector

		CBP	Moody's	IMPLAN, LLC, Inc	BEA	BLS- CES	BLS-QCEW
481	Air transportation	$25,347,433,000	$29,925,000,000	$38,823,662,000	$39,908,000,000	$23,346,347,000	$28,791,682,000
4811	Scheduled air transportation	$22,762,429,000	$26,878,327,300				
48111	Scheduled air transportation	$22,762,429,000					
481111	Scheduled passenger air transportation	$21,874,543,000					
481112	Scheduled freight air transportation	$887,886,000					
4812	Nonscheduled air transportation	$2,585,004,000	$3,046,672,700				
48121	Nonscheduled air transportation	$2,585,004,000					
481211	Nonscheduled chartered passenger air transportation	$1,949,640,000					
481212	Nonscheduled chartered freight air transportation	$302,126,000					
481219	Other nonscheduled air transportation	$333,238,000					

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Table 7. Value Added by Sector and Subsector

		CBP	Moody's	IMPLAN, LLC, Inc	BEA	BLS- CES	BLS-QCEW
481	Air transportation		$69,625,000,000	$65,040,548,000	$69,600,000,000		
4811	Scheduled air transportation		$62,536,500,000				
4812	Nonscheduled air transportation		$7,088,500,000				

Table 8. Output by Sector and Subsector

		CBP	Moody's	IMPLAN, LLC, Inc	BEA	BLS- CES	BLS-QCEW
481	Air transportation			$151,904,748,000	$161,800,000,000		

Table 9. Employment by Sector and Subsector

		CBP	Moody's	BLS- CES	BLS-QCEW
4881	Support activities for air transportation	153,389	159,250	159,100	209,127
48811	Airport operations	77,993	63,917	64,000	
488111	Air traffic Control	1,921			
488119	Other airport operations	76,072			
48819	Other support activities for air transportation	75,396			

Table 10. Personal Income by Sector and Subsector

|		CBP	Moody's	BLS- CES	BLS-QCEW
4881	Support activities for air transportation	$6,258,968,000	$7,416,205,800	$6,093,782,300	$20,685,715,000
48811	Airport operations	$2,175,311,000	$1,934,901,000	$1,682,903,000	
488111	Air traffic Control	$119,768,000			
488119	Other airport operations	$2,055,543,000			
48819	Other support activities for air transportation	$4,083,657,000	$5,481,304,800		

Airlines reporting to the FAA by completing *Form 41: Financial Reports* offer another perspective of airport-based employment. In 2011, 93 airlines reported employment of 538,300 workers by job classification. The largest three job classifications, each with about 86,000 jobs, are "passenger handling", "transport related" and "general services and administration". While employment data from Form 41 bridges sectors 481 and 4881 (air transportation and support activities for air transportation), it undercounts each sector because it is limited to airline employment, and does not include other private employment. Also, comparing the two data sources shows a high proportion of airline workers to the total of the NAICS data. This is because Form 41 counts airline jobs off-airport.[6]

In addition to Form 41, air carrier airports report employment for airport operations to the FAA in Section 16.6 of *Form 127: Operating and Financial Summary*, not including general aviation or reliever facilities. Combined, the two FAA collection processes report 633,000 employees in 2011, which exceed the totals of CBP, Moody's Analytics, and BLS-CES, and almost equal to BLS-QCEW (the only datasets that isolate Sector 4881 from all modal transportation support services reported in sector 488). Airport operations account for 15 percent of the total employment reported through Forms 127 and 41, while passenger handling, transport related, and general services and administration for airlines account for 14 percent each. The breakout of airline employment job classification and airport administration is shown in Figure 1.

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[6] Verified through an email exchange with the U.S. Department of Transportation Reference Service

Figure 1. Airline Employment and Commercial Airport Administration in 2011
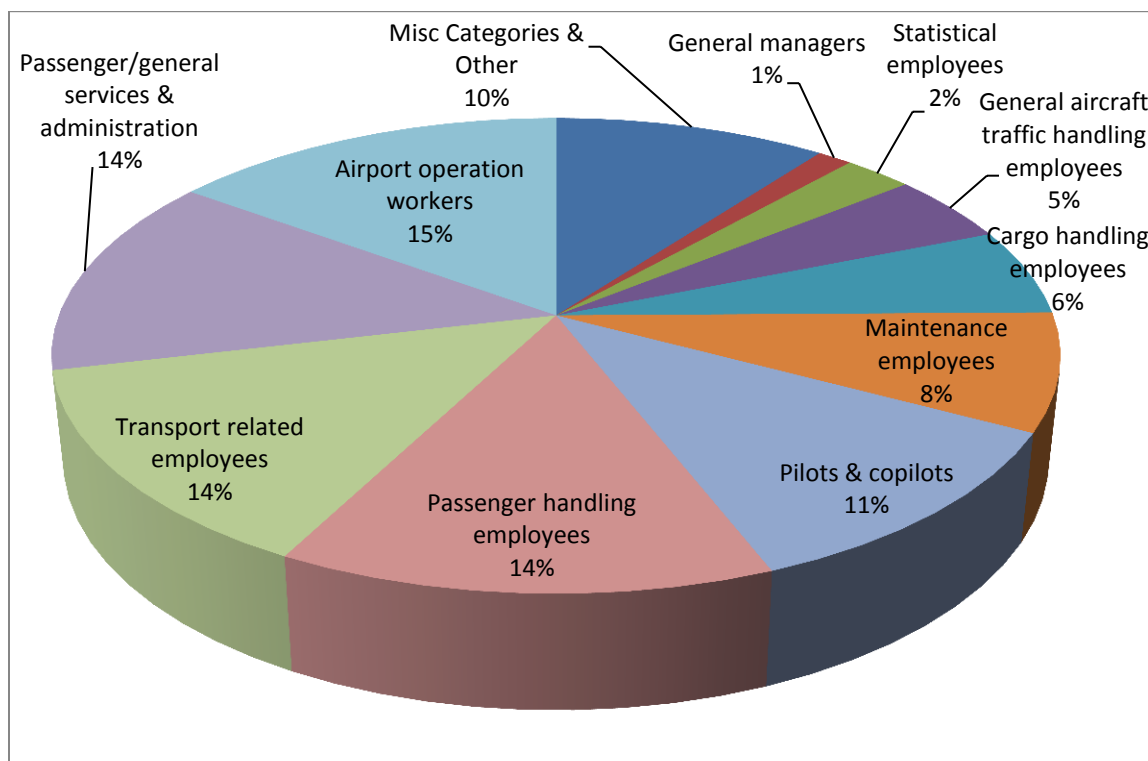
"Miscellaneous" includes aircraft traffic handling group1 employees, trainees and instructor, traffic solicitors, aircraft control employees and other flight personnel.

Source: Research and Innovative Technology Administration (RITA), U.S. Department of Transportation (U.S. DOT), Schedule P-10 of Form 41 Financial Reports; and Federal Aviation Administration Form 127, Operating and Financial Summary – 2011, Airport Financial Reports Compliance Activity Tracking System (CATS).

2.3 Public Employment on Airport

The 2011 Annual Survey of Public Employment and Payroll estimates that almost 97,000 federal, state, regional and local public sector employees work on airports in air transportation and earn close to $8 billion annually. As expected, federal workers earn the highest average wage ($109,000), followed by state and local government employees whose average annual earnings are $63,000 and $56,000, respectively (See Table 11).[7] Moreover, estimates of TSA and other homeland security employment on airports added 54,000 jobs.[8]

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[7] The Survey of Public Employment provides wages for the month of March, and annualized by multiplying by 12.

[8] This estimate is based on appropriations for TSA specifically targeted for airport passenger screenings ($5.3 billion and 47,000 workers); air freight screening ($164 million and 1,000 workers) and federal air marshals ($966 million and an estimated 6,200 employees based on IMPLAN calculations).

Table 11. Public Sector Air Transportation Employment

Government Jurisdiction	Employees	Total Wages ($millions)	Average Wages/ Employee
Local/Regional	45,187	$2,523	$55,854
State	3,133	$196	$62,627
Federal	48,348	$5,256	$108,717
Total	**96,668**	**$7,976**	**$82,513**

Source: 2011 Annual Survey of Public Employment and Payroll. Calculations by EDR Group

The national IMPLAN model for 2012 was applied to estimate the direct economic effects of public sector relationship with airports in terms of supporting air transportation and security of airports and flights. Based on employment and wage values from the Survey of Public Employment and Payroll and appropriations targeted to airports in the Homeland Security budget, IMPLAN was used to fill in values for employment, labor income, output (which, for public sector enterprises and agencies, are budget expenditures) and value added when these factors were not in the two sources. Table 12 shows that the public sector supports 151,000 jobs on airports with an overall budget (output) expenditure of about $22 billion. Labor income generated is about $12 billion, which is the substance of the $14 billion in national value added.

Table 12. National On-Airport Impacts of Public Sector

Impact by Type	Employment	Labor Income	Value Added	Output
Local, State & Federal Aviation Services	97,000	$7,976	$10,081	$15,567
Homeland Security	54,000	$3,644	$3,908	$6,384
Totals	151,000	$11,621	$13,989	$21,951

Note: Dollars in millions ($2011 value) and jobs are rounded to the nearest thousand.

Sources: U.S. Bureau of the Census, 2011 Annual Survey of Public Employment and Payroll and Consolidated Appropriations Act, 2012, United States Government Printing Office. Values calculated through IMPLAN, LLC, Inc., IMPLAN System (2011 version).

2.4 Construction

The Research Team estimates national annual on-airport construction expenditures at $13.3 billion, representing annual averages from 2009 through 2012 and fixed at 2011 dollars. Construction is averaged over multiple years to account for the varying flows of activity that is often dictated by legislative processes, weather conditions (particularly in "snow belt" states) and administrative processes.

Calculations of construction spending are based on Section 10 of Airport Financial Reports Compliance Activity Tracking System (CATS) and the 2009-2013 NPIAS report. CATS reports actual spending by year for commercial airports in the following categories: airfield, terminal, parking, roadways, rail and transit, and other. The NPIAS report was used to

estimate expenditures for reliever and general aviation airports, which are not covered in the CATS system.[9]

From 2009 through 2012, annual construction spending at commercial airports averaged $9.7 billion nationally in constant 2011 dollars. As seen in Table 13, investment in construction activities totaled approximately $11 billion in 2009 and 2010, fell to approximately $9 billion in 2011 and under $7 billion in 2012

Table 13. Construction Spending at Commercial Airports, 2009-2012

Year	Section 10 of FAA Form 127	
	Nominal Dollars	**Fixed 2011 Dollars**
2009	$11.06	$11.59
2010	$10.88	$11.23
2011	$9.17	$9.17
2012	$6.95	$6.81
Total Construction Expenditures	$38.06	$38.80
Average Annual Expenditures	$9.52	$9.70

Source: Compliance Activity Tracking System (CATS) Airport Financial Reports;
http://cats.airports.faa.gov/Reports/rpt127Totals.cfm. Calculations by EDR Group.

The Research Team used cost projections reported in the 2009-2013 NPIAS report to estimate the value of construction at GA and reliever airports. NPIAS is a needs projection and is more narrowly defined than the actual airport spending reported on Form 127.[10] With this understanding, the following steps were taken to estimate the value of construction projects at GA and reliever facilities:

- 2009-2013 NPIAS-projected construction needs were totaled by category and averaged over the five year plan. Dollars were adjusted to 2011 value. NPIAS annual averages in 2011 values are $7.48 billion for commercial airports, $2.01 billion for GA airports and 0.74 billion for relievers.

- Annual spending derived from Form 127 was compared to NPIAS for the annual average for commercial airports using 2011 value. Average construction spending reported on Form 127 over the years 2009-2012 exceeded the average annual needs for commercial airports in the 2009-2013 NPIAS by 30 percent. ($9.7 billion compared to $7.48 billion).

- A 30 percent "premium" was assumed for NPIAS assessments of GA and reliever airports 2009-2012 as the estimate of construction spending in these categories. .

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[9] Both data sources are maintained by the FAA.

[10] Form 127 includes spending by federal government, state grants and airport sponsors. NPIAS projections are for AIP eligible projects.

Table 14 below shows the calculations for the $13.3 billion annual construction expenditures.

Table 14. Profile of Annual Average Construction Expenditures

	FAA Form 127 Annual Average - 2009-2012	NPIAS Annual Average - 2009-2013	Estimated Construction Spending	Notes Regarding Estimated Construction Spending
Commercial	$9,700.43	$7,479.35	$9,700.43	Form 127 total is used
GA	N/A	$2,006.69	$2,602.60	Based on NPIAS and the percent difference between NPIAS and Form 127 for commercial
Reliever	N/A	$740.73	$960.70	
Total	**$9,700.43**	**$10,226.77**	**$13,263.73**	

Calculations by EDR Group.

Based on the observed value of $13.3 billion in construction expenditures, IMPLAN was used to calculate direct jobs, labor income and value added contributed by construction activities on-airports to the national economy. The results show that construction expenditures generate 116,000 direct jobs per year and $7.3 billion in value added as a contribution to the national gross domestic project (see Table 15).

Table 15. Annual Direct Construction Impacts Based on 2011 Values

Impact Type	Direct Effects
Construction Value	$13,264
Value Added	$7,316
Employment	116,000
Labor Income	$6,468

Note: Dollars in millions ($2011 value) and jobs are rounded to the nearest thousand.

Sources: Annual construction values calculated through IMPLAN, LLC, Inc., IMPLAN System (2011 version).

On-Airport Concessions Spending

Retail expenditures on airports are not divided into special sectors. Instead they are subsumed in national, state and county retail industry data. As a consequence, the databases cited in developing aviation transportation estimates (such as County Business Patterns, Bureau of Labor Statistics, etc.) cannot be applied for this segment of the analysis.

The best source of obtainable data is the *Non-Aeronautical Concessions Benchmarking Survey* of Airports Council International - North America (ACI-NA). Data reported by ACI-NA estimates terminal spending by air travelers and airport/tenant employees to be $7.5 billion in 2011. It should be noted that this total is an undercount because it applies to commercial airports, and does not include GA or reliever facilities.

Data reported from the survey included seven identified concessions categories (rental cars, parking and ground transportation, retail, food and beverage, services, hotel, and land and non-terminal sales) and "other". To estimate direct economic impacts of airport concessions, this spending was applied to the national IMPLAN model for 2011. However, to include expenditures listed under "other", the $764 million in that category were spread proportionately among the seven identified spending types. The spending categories are shown in Table 16. The results of the direct impact derived through IMPLAN are shown in Table 17. Retail expenditures were margined and regional purchase coefficients were applied to exclude economic activities not occurring in the United States. Thus, "output" generated by the economic concessions spending at airports is less than the actual spending. The results show that $7.5 billion in non-aeronautical concessions generated about 98,000 direct jobs in 2011 per year and $7.0 billion in output and $5.2 billion is value added as a contribution to the national gross domestic project.

Table 16. Spread of Non-Aeronautical Concessions Revenues on Commercial Airports in 2011

Sector	Non-Aeronautical Concessions	Non-Aeronautical Concessions for modeling.*
Rental cars	$1,479	$1,647
Parking and ground transportation,	$3,068	$3,416
Retail	$603	$671
Food and beverage	$526	$586
Services	$378	$421
Hotel	$114	$127
Land and non-terminal	$574	$639
Other	$764	N/A
Total	**$7,506**	**$7,507**

* "Other" spread proportionally among other sectors

Note: Dollars in millions ($2011 value)

Source: 2012 ACI-NA Concessions Benchmarking Survey. Calculations by EDR Group

Table 17. Direct Impacts of 2012 ACI-NA Concessions Benchmarking Survey (2011 data)

Impact Type	Direct Effect
Gross Concessions Revenues	$7,507
Output	$7,014
Value Added	$5,189
Employment	98,000
Labor Income	$3,484

Dollars in millions ($2011 value) and jobs are rounded to the nearest thousand.

Sources: 2012 ACI-NA Concessions values calculated through IMPLAN, LLC, Inc., IMPLAN System (2011 version).

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2.5 Off Airport

National impacts generated by airports include spending by international visitors who arrive in the United States via U.S. airports. This spending brings new income into the national economy; as opposed to spending by domestic travelers who transfer money between regions of the country, and recirculate dollars on a national basis. Secondly, the value of air freight that is shipped overseas represents business sales to foreign customers, which in turn brings income from those sales into the United States from other nations.

Visitor Spending

In 2011, tourism was an $800 billion industry in the United States, according to the Trade Division's U.S. Travel and Tourism Satellite Account (TTSA), published by the U.S. Department of Commerce. However, the TTSA reports domestic and international travelers in a single category. The Department of Commerce also publishes an annual report on travel exports and imports (United States Travel and Tourism Exports, Imports and the Balance of Trade: 2012), which estimates international tourism on an annual basis—as listed below for 2011:

- Total spending of international visitors in the U.S.: $ 116.1 Billion (excluding passenger fares)

- Total Spending of U.S. Travelers Internationally: $ 78.7 Billon (excluding passenger fares)

- Net Trade Surplus $ 37.5 Billion

Adjustments to the net trade surplus are needed to reflect non-aviation modes. To make these adjustments, the Research Team used data from the International Trade Administration[11] to document the percent of visitors arriving by air. For the purpose of this analysis, it was assumed that travelers from the U.S. departed by air in the same proportions. Aviation travel of visitors from Canada, Mexico and the rest of the world was profiled and applied to adjust the visitor trade surplus. These adjustments are profiled in Table 18. Receipts (spending by visitors arriving in the U.S.) and payments (spending by U.S. residents traveling abroad) were adjusted by the proportion of arrivals by air from Canada (33.5 percent), Mexico (12.1 percent) and the rest of the world (93.1 percent). By this approach, the surplus contributed by foreign travelers to the U.S. economy is adjusted to $29.3 billion.

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[11] Summary of International Travel to the United States, October 2010 and Year to Date, International Trade Administration, Office of Travel and Tourism Industries. This is the most recent data available.

Table 18. Visitor Spending Revenues in the United States

Origin/Assumed Destinations by Air	World other than Canada/ Mexico	Canada	Mexico	World Total
Receipts (Visitor to U.S.)	$90,325	$19,366	$6,424	$116,115
Payments (U.S. residents to international destination)	$62,971	$7,064	$8,616	$78,651
Net (Receipts-Payments)	$27,354	$12,302	-$2,192	$37,464
Percent Air Travelers	93.1%	33.5%	12.1%	
Receipts (Visitor to U.S.)	$84,070	$6,492	$780	$91,342
Payments (U.S. residents to international destination)	$58,611	$2,368	$1,045	$62,024
Net (Receipts-Payments)	**$25,460**	**$4,124**	**-$266**	**$29,318**

Note: Dollars are in millions

Sources: Office of Travel and Tourism Industries, U.S. Department of Commerce, International Trade Administration: United States Travel and Tourism Exports, and the Balance of Trade: 2012; Summary of International Travel to the United States, October 2010 and Year to Date. Calculations by EDR Group.

OTTI is unable to disaggregate the balance of payments data to show other expenditures, aside from the aggregate receipts that are reported.[12] However, the Department of Commerce publishes a demand table in the *Travel and Tourism Satellite Accounts* that would showcase 'non-resident demand' and has expenditure breakouts.[13] However, due to the timing of when the balance of payments/expenditure data pass through the input-output accounts, data for total non-resident demand cannot precisely line up with total travel and tourism exports. The totals are close but not exact; however, they can be used to estimate types of expenditures by percent.[14] The satellite accounts indicate that 29 percent of international visitor expenditure is spent on lodging, 23 percent on retail purchases and 22 percent at restaurants and drinking establishments, while 26 percent are spent on local surface transportation, intra-national air transportation, travel agents and entertainment/amusement.

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[12] This is consistent with the IMF's Balance of Payments Manual and BEA's System of National Accounts (SNA: 2008).

[13] Demand for Commodities by Type of Visitor, 2011

[14] The satellite account reports spending at $115.4 billion compared to the $116.1 billion shown in Table 18.

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Figure 2. Profile of International Visitor Spending
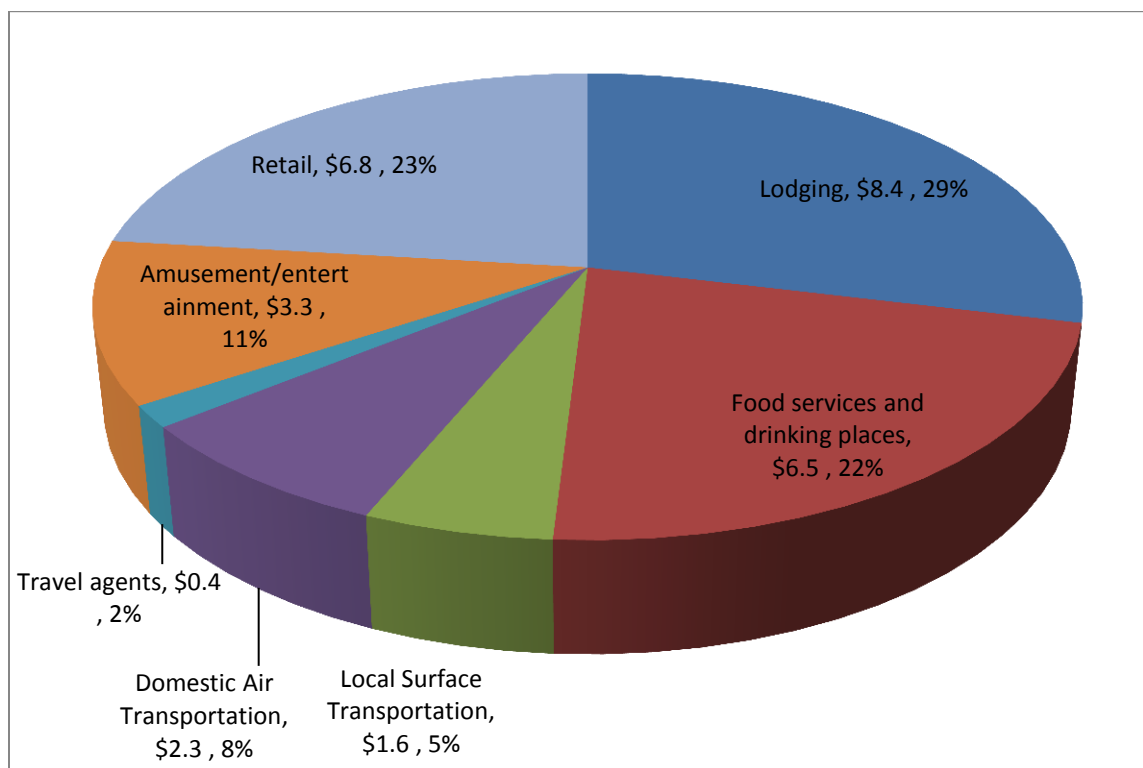
Note: Dollars are in billions, based on a total of $29.3 billion.

Source: U.S. Bureau of Economic Analysis, Travel And Tourism Satellite Accounts, Demand for Commodities by Type of Visitor, 2011, Table 3.

Based on the calculated surplus, the Research Team used IMPLAN to calculate direct output, value added jobs and labor income generated by this visitor spending.

This spending was first calculated including the estimated $2.3 billion that was spent on air travel within the U.S. by international visitors. Spending on domestic air travel, however, double-counts the direct on-airport data reviewed above (NAICS sector 481). Therefore air travel expenditures of international visitors were excluded from the analysis of visitor spending.

The results show that the $27 billion surplus spending in the national economy in 2011 generated about $22.3 billion in output(after deducting the $2.3 billion generated by domestic air transportation), of which almost $13 billion was in value added contribution to the national GDP and 284,000 direct jobs that returned $8.6 million to workers in labor income. Results for total direct jobs, labor income, value added and output are shown in Table 19. A profile of direct jobs by sector is illustrated in Figure 3.

Table 19. Direct Impacts of International Visitor Spending Surplus in the U.S. (Excluding Air Transportation)

Impact Type	Direct Effect
Total Net Visitor Spending	$27,004
Output	$22,337
Value Added	$12,865
Employment	284,000
Labor Income	$8,580

Note: Dollars in millions ($2011 value) and jobs are rounded to the nearest thousand.

Sources: Data from U.S. Department of Commerce Agencies (OTTI and BEA) calculated through IMPLAN, LLC, Inc., IMPLAN System (2011 version). Calculations by EDR Group

Figure 3. Profile of Direct Jobs Generated by International Visitor Spending in the U.S. (Excluding Air Transportation)
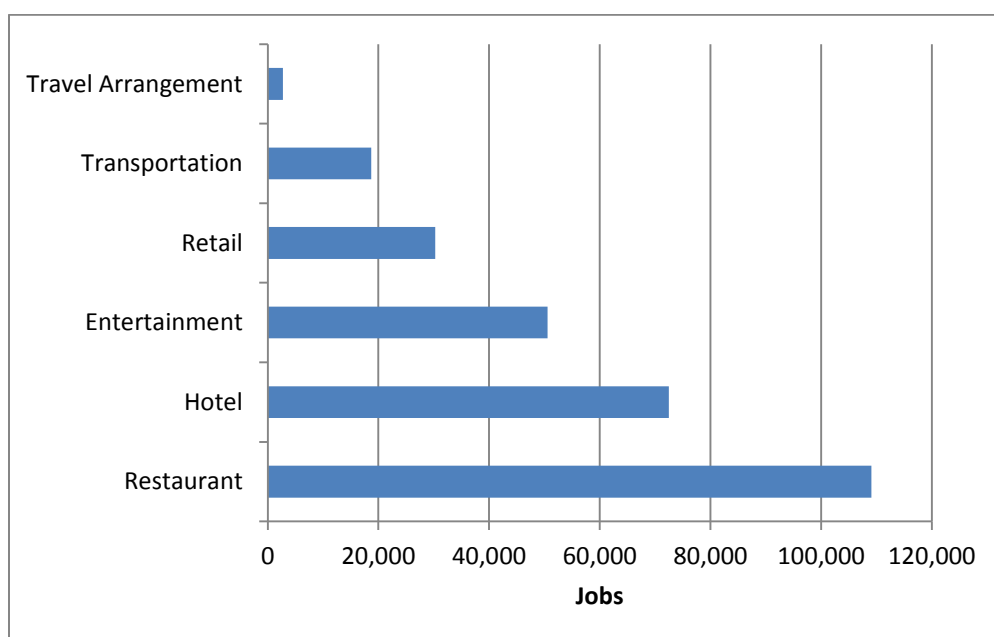
Sources: Data from U.S. Department of Commerce Agencies (OTTI and BEA) calculated through IMPLAN, LLC, Inc., IMPLAN System (2011 version). Calculations by EDR Group

International Exports

Airports play a critical role in the national economy by enabling manufacturers and agricultural producers to transport commodities and finished goods to customers in both domestic and international markets. This section on air-reliant activities signifies the contribution of airports to national economic development by enabling U.S. based producers to sell products across the world, and thereby maximize shares of international trade. Without the freight services offered at airports, U.S companies would find markets limited and market shares curtailed. In turn, economic activities across the nation that are

associated with production of goods shipped through airfreight would be reduced. In addition to exports, there are other benefits of air freight on a local or regional scale:

- Domestic air shipments move products throughout the United States. The value of these shipments on a national level is reflected by the time and cost differences of air versus shipments by truck or rail. Unlike domestic shipments there is not an effective substitute for international air freight given the value of commodities shipped by air and the time difference between marine and aviation modes, including the extended time it takes to truck goods from points of production to seaports and on arrival from seaports to final destinations.

   The difference in commodities shipped by air and marine modes are exemplified by the gap in average value per ton of the two modes. While the average value per metric ton of U.S. commodities exported by ship is almost $1,000, the average value per metric ton of air-shipped exports is more than $117,000 (Table 20). On the other hand, for every metric ton of cargo shipped by air, 159 metric tons are exported by sea.

Table 20. Comparison of International Exports shipped by Marine and Air Modes

Mode	Metric Tons	Total Value	Average Value per Metric Ton
Total Marine Exports	572,948,402	$570,498,003,792	$996
Total Air Exports	3,606,242	$423,381,309,505	$117,402

Source: U.S. Census Bureau Foreign, Trade Division reported by WISER Trade. Calculations by EDR Group

- International imports by air or sea provide benefits by providing goods that are lower cost to manufacturers (for intermediate inputs to production processes). This results in industries that are more competitive internationally.

- Similarly, international imports often supply benefits to households by providing goods that are lower cost than would be paid by consumers for domestically produced commodities. Such lower costs mean that discretionary income is available for additional purchases of goods or services. However, these "additional" purchases replace the cost that would be expended if production were domestic instead of international. So, while low cost imports may allow households to purchase more goods, and lead to more comfort, they do not add to the national economy - it allows the same income to be used to make additional purchases instead of incurring expenditure for more expensive products (and the displacement of national production).

A review of the products exported through U.S. airports shipped through airports to international markets provides an insight into the cross-section of the economy that is reliant on air cargo services. This analysis is based on industry specific data from the

Foreign Trade Division of the U.S. Census Bureau and economic output by industry from the U.S. Bureau of Economic Analysis (collected by the Minnesota IMPLAN Group).[15]

In 2011, U.S. air exports were valued at $423 billion. The top six commodity groups accounted for 84 percent of this value. Air-freight is overwhelmingly concentrated in technology goods produced in the U.S., but also includes jewelry and valuable stones. Combined, industrial machinery, electrical machinery, optical and medical instruments account for over 50 percent of the total value or air cargo. (See Table 21).

Table 21. Top International Exported Industries

Code	Two Digit Harmonized Code Commodity Group Title	Air Export Value	Percent
85	Electrical machinery & equipment & parts, telecommunications equipment, sound recorders, television recorders	$87,341,945,000	21%
71	Pearls, stones, metals, imitation jewelry, coins.	$65,931,541,000	16%
84	Industrial machinery, including computers	$67,455,673,000	16%
90	Optical, photographic, cinematographic, measuring, checking, precision, medical or surgical instruments & accessories	$58,726,831,000	14%
88	Aircraft, spacecraft, and parts thereof	$49,847,635,000	12%
30	Pharmaceutical products	$28,066,792,000	7%
	Subtotal - Leading Commodity Groups	*$357,370,418,000*	*84%*
	91 Other 2-digit commodity groups	*$66,010,892,000*	*16%*
	Total	**$423,381,310,000**	**100%**

Sources: U.S. Census Bureau, Foreign Trade Division collected by WISERTrade. Calculations by EDR Group.

The $423 billion of international exports through U.S. airports provides a significant contribution to the national economy. To gauge the level of impact, the Research Team used the IMPLAN model – and the U.S. Bureau of Economic Analysis (BEA) data imbedded in the model – to estimate the associated jobs, value added and personal income. As shown in Table 22, this analysis indicates that the $423 billion goods exported through airports in 2011 contributed $134 billion to the national GDP, and supported 972,000 jobs that in turn paid $81 billion in personal income.

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[15] At this writing, the most recent year available for both Foreign Trade Division and U.S. Bureau of Economic Analysis information is 2011.

Table 22. Direct Contribution of 2011 International Air Exports in the U.S.

Impact Type	Direct Effects
Total Air Exports/Output	$423,381
Value Added	$134,378
Employment	972,000
Labor Income	$80,832

Note: Dollars in millions ($2011 value) and jobs are rounded to the nearest thousand.

Sources: Data from U.S. Census Bureau, Foreign Trade Division collected by WISERTrade and calculated through IMPLAN, LLC, Inc., IMPLAN System (2011 version). Calculations by EDR Group

The 972,000 jobs supported by air freight operations are concentrated in several key industries, including medical devices, computers and electronics, machinery and transportation equipment. Table 23 below shows the industries that most benefit from air freight exports for employment (based on three-digit NAICS). Note that the nine industries listed in Table 23 account for 896,000 jobs or 92 percent of the total job base supported by U.S. air exports.

Table 23. Jobs in Industry Sectors that are Supported by Production of Goods Exported by Air Mode

Industry Sector	Jobs
Medical supplies and devices, jewelry and other miscellaneous products	209,000
Computers & other electronics	176,000
Food clothing and medical supplies for donations, military clothing and equipment not identified, and other commodities not classified	132,000
Machinery	114,000
Transportation equipment	96,000
Primary metals	57,000
Fabricated metal products	41,000
Chemical Manufacturing	39,000
Electrical equipment & appliances	32,000
Other 19 Industries	76,000
TOTAL	**972,000**

Note: Jobs are rounded to the nearest thousand.

Sources: Data from U.S. Census Bureau, Foreign Trade Division collected by WISERTrade and calculated through IMPLAN, LLC, Inc., IMPLAN System (2011 version). Calculations by EDR Group

When compared to national data for 2011 provided by the Bureau of Economic Analysis, these findings represent a footprint of about 1.7 percent of the national economy in terms of output and GDP, 1.5 percent in labor compensation, and about 1.2 percent when counting jobs. The average compensation level generated by U.S. airports for workers on-

and off-airport facilities is $70,100 compared to $60,400 across the national economy.[16] In terms of productivity, airports generate $111,000 per worker in value added and $295,000 per worker in output, compared to $86,000 per job in national GDP and $155,000 per job in national output.[17]

Figure 4. Footprint of Direct on Airport Contribution to the National U.S. Economy
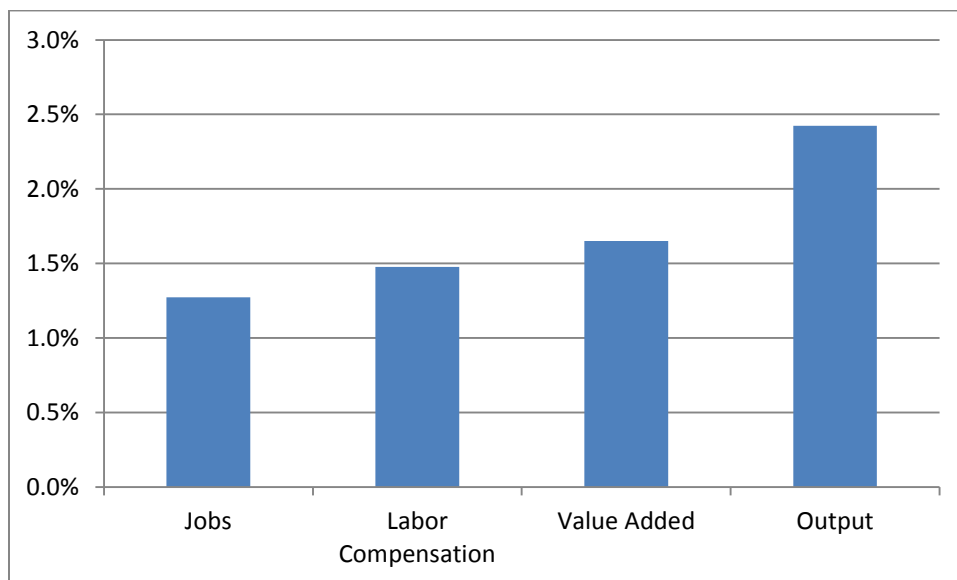
Sources: Data calculated by Research Team to measure direct contribution of Airports. National economy is taken from BEA.

Table 24 summarizes results of the evaluation of data sources for on-airport airside and terminal employment, airport construction, visitor spending, and the value of air cargo.

Measures of employment, labor income, value added and output (business sales) not provided by a core data source were calculated using the federal data aggregated by IMPLAN, LLC. The reason that the Research Team is confident of the national-level industry data assembled by IMPLAN is that the 2011 national metrics of employment, labor income and gross domestic product are very close to the levels reported by the Bureau of Economic Analysis (BEA), ranging from 97 percent to 100.3 percent (see Table 25).

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[16] Calculations based on BEA data for 2011, including national employment of full- and part-time jobs and BEA personal income excluding current transfer receipts

[17] National economic data are from BEA.

Table 24. Direct Economic Impacts of Airports Based on National Datasets

Economic Segment	Primary Metric	Value	Year	Source
Air Transportation Services	Jobs	458,000	2011	BEA
	Labor Income	$39,908 (mill)	2011	
	Value Added	$69,600 (mill)	2011	
Support Services for Air Transportation	Jobs	159,000	2011	BLS-CES
	Labor Income	$6,094 (mill)	2011	
Public Sector On-Airport/Airport Security	Jobs	151,000	2011 and 2012	U.S. Census Bureau , U.S. Budget
Construction	Expenditures	$13,264 (mill)	2009-2013 (average)	FAA Form 127 & NPIAS
Concessions*	Expenditures	$7,506 (mill)	2011	ACI-NA
Visitor Spending	Expenditures	$22,337 (mill)	2010-2012	U.S. Department of Commerce
Air Freight	Value	$430,908 (mill)	2013	U.S. Census FTD

* Includes car rental, parking and ground transportation, retail, food and beverage, in-terminal services, on-airport hotels, and land rents and non-terminal concessions

Table 25. Comparison of National Metrics of U.S. BEA and Data Reported by IMPLAN

Metric	U.S. BEA	IMPLAN LLC.	IMPLAN (as Percent of BEA)
Employment	176,341,700	173,732,222	98.5%
Labor Income	$9,433.6	$9,460.5	100.3%
GDP (Value Added)	$15,533.8	$15,075.5	97.0%

Sources: www.bea.gov, Tables 1.12 National Income by Type of Income; US GDP in Current Dollars, updated April 30, 2014, and Total Employment Table SA25N, and the National Dataset of IMPLAN, LLC for 2011.

Results

Following the standard approach of measuring the economic impacts of on-airport activities, visitor spending and air cargo, the total national economic impact of U.S. airports is calculated to be:

- $1.6 trillion in output (the summation of the value of goods and services produced);

- $768 billion in value added (airports overall contribution to the national GDP and to national economic productivity); and

- 7.6 million jobs across the nation, that pay workers $453 billion

These total contributions of airports to the U.S. economy account for 5.8 percent of national output and 4.9 percent of national GDP. Airports generate 4.3 percent of all jobs in the U.S., which, in turn, pay 4.8 percent of labor income earned nationally. Total impacts account for economic activities generated on-airport, by international visitor spending and

by the value of air freight exported to international markets, and include direct, indirect and induced impacts of each activity (Table 26).

Table 26. Total Economic Contribution of Airports to the U.S. Economy

Impact Type	Employment	Labor Income	Value Added	Output
Direct Effect	2,172,200	$147,641,741,000	$247,424,063,000	$637,002,396,000
Indirect Effect	2,422,000	$160,934,429,000	$266,403,253,000	$535,376,204,000
Induced Effect	3,034,600	$143,929,511,000	$254,574,998,000	$425,079,660,000
Total Effect	**7,628,900**	**$452,505,681,000**	**$768,402,314,000**	**$1,597,458,260,000**

Note: Employment is rounded to the nearest 100, and dollars to the nearest $1,000. Dollars are in 2010 value

Sources: BEA, Office of Travel and Tourism Industries of the U.S. Department of Commerce, BLS-CES, U.S. Census Bureau, U.S. Budget, FAA Form 127 & NPIAS, ACI-NA, U.S. Department of Commerce data and other federal data assembled by IMPLAN. LLC. Calculations by EDR Group using 2012 National IMPLAN model.

3 THE NATIONAL ECONOMIC FOOTPRINT OF NPIAS AIRPORTS

Based on the data reviewed in the sections above, the discussion below presents multiple views of the national economic impacts of U.S. airports.

To understand how airports support the national economy, it is necessary to separate the actual air services and activities found on airports (Table 27) with the interaction of airports and the economies of regions and states. In terms of GDP, on-airport activities account for 0.07 percent of the national economy. Economic impacts of U.S. airports are overwhelmingly felt outside of "airport fences" and in the general economy of the United States. Of the total contributions generated by airports, 86-88 percent of jobs, wages, value added and output are off-airport.

Table 27. Direct Impact of On-Airport Activities in the U.S. Economy

Activity	Employment	Labor Income	Value Added	Output
Air Transportation	458,000	$39,139,222,000	$66,986,205,000	$147,403,033,000
Support Activities for Air Transportation	159,000	$5,976,600,000	$6,419,540,000	$11,198,659,000
State, Local and Federal Employment including TSA	150,700	$11,380,311,000	$14,175,671,000	$16,746,516,000
Non-Aeronautical Revenues	87,300	$2,995,511,000	$4,932,607,000	$6,907,625,000
On Airport Construction	84,200	$4,898,218,000	$5,297,665,000	$12,762,214,000
Total	**939,200**	**$64,389,862,000**	**$97,811,688,000**	**$195,018,047,000**

Note: Employment is rounded to the nearest 100, and dollars to the nearest $1,000. Dollars are in 2010 value.

Sources: BEA, BLS-CES, U.S. Census Bureau, U.S. Budget, FAA Form 127 & NPIAS, ACI-NA, U.S. Department of Commerce data and other federal data assembled by IMPLAN. LLC. Calculations by EDR Group.

On-airport impacts are limited to the direct impacts found in "air transportation" and "support services for air transportation" (NAICS sectors 481 and 488 respectively), direct impacts of on-airport construction, direct impacts of public agencies (local, state and federal governments) and security services on airport; and direct impacts of non-aeronautical activities on airport. Overall, these are not insignificant contributions to the national economy. As summarized in Table 27, direct impacts that occur on airport generate over 900,000 jobs that pay employees and business owners more $64 billion in annual labor

income. Moreover, the work that supports airports in the U.S. generates $195 billion in output and almost $98 billion in value added (in 2010 dollars)[18].

Off-airport impacts to the U.S. economy generated by airport activity include the indirect and induced activities of the above sectors, as well as visitor spending and the value of international air cargo. Indirect and induced economic impacts are often referred to as "multiplier" or "spinoff" impacts. Indirect economic impacts are triggered when directly affected industries use their earned business revenues (or budgets in the case of public agencies) to purchase supplies and services, which by definition is virtually entirely off-airport. Similarly induced impacts occur when workers spend wages earned by virtue of revenues generated by directly or indirectly affect businesses.[19] International visitor spending impacts are entirely off-airport as is the value of air cargo. [20] As shown in Table 28, airports generate $1.4 trillion of output outside of the airports in the general economy of the U.S., and contribute $671 billion to the national GDP in 2010 dollars. The off-airport impacts of airports further support 6.7 million jobs and pay $388 million in wages and benefits.

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[18] Dollars here are defined in 2010 terms to be compatible with the multifactor productivity and consumer surplus analyses also developed for ACRP 03-28.

[19] It is understood that employees of commercial airports will eat lunch or otherwise spend some of their income in the terminal. As a result, the induced impacts of airport workers may be slightly overstated in this analysis.

[20] On-airport visitor spending is captured in the analysis of terminal concessions. Also on airport cargo handling services are included in NAICS 488. Cargo flights are part of NAICS 481.

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Table 28. Off Airport Contribution to the National Economy Generated by U.S. Airports

Activity	Employment	Labor Income	Value Added	Output
Direct Impacts				
International Visitor Spending	314,100	8,877,566,000	13,720,831,000	22,002,778,000
Air Cargo	918,900	$74,374,314,000	$135,891,544,000	$419,981,571,000
Subtotal Direct Off Airport Impacts	*1,233,000*	*$83,251,880,000*	*$149,612,375,000*	*$441,984,349,000*
Indirect Suppliers of Goods & Services				
Air Transportation	457,700	$26,711,470,000	$49,744,533,000	$93,874,615,000
Support Activities for Air Transportation	51,100	$2,674,087,000	$3,923,265,000	$6,370,341,000
State, Local and Federal Employment including TSA	16,900	$979,523,000	$1,590,756,000	$2,678,204,000
Non-Aeronautical Revenues	17,300	$997,537,000	$1,670,171,000	$2,893,725,000
On Airport Construction	60,200	$3,750,481,000	$6,012,475,000	$11,409,886,000
International Visitor Spending	79,200	$4,370,449,000	$7,276,746,000	$12,799,908,000
Air Cargo	1,739,500	$121,450,882,000	$196,185,306,000	$405,349,524,000
Subtotal Indirect Suppliers of Goods & Services	*2,421,900*	*$160,934,429,000*	*$266,403,252,000*	*$535,376,203,000*
Induced Impacts- Spending Workers' Wages				
Air Transportation	642,100	$30,385,013,000	$54,336,692,000	$91,350,165,000
Support Activities for Air Transportation	82,000	$3,879,341,000	$6,936,748,000	$11,662,653,000
State, Local and Federal Employment including TSA	116,900	$5,531,830,000	$9,892,118,000	$16,631,496,000
Non-Aeronautical Revenues	37,600	$1,778,801,000	$3,179,144,000	$5,345,239,000
On Airport Construction	81,600	$3,858,890,000	$6,897,526,000	$11,597,032,000
International Visitor Spending	125,200	$5,921,940,000	$10,587,534,000	$17,800,903,000
Air Cargo	1,949,300	$92,573,695,000	$162,745,236,000	$270,692,172,000
Subtotal Induced Impacts- Spending Workers' Wages	*3,034,600*	*$143,929,510,000*	*$254,574,998,000*	*$425,079,660,000*
TOTAL NATIONAL IMPACTS GENERATED OFF AIRPORT	**6,689,500**	**$388,115,819,000**	**$670,590,625,000**	**$1,402,440,212,000**

Note: Employment is rounded to the nearest 100, and dollars to the nearest $1,000. Dollars are in 2010 value

Sources: BEA, Office of Travel and Tourism Industries of the U.S. Department of Commerce, BLS-CES, U.S. Census Bureau, U.S. Budget, FAA Form 127 & NPIAS, ACI-NA, U.S. Department of Commerce data and other federal data assembled by IMPLAN. LLC. Calculations by EDR Group using 2012 National IMPLAN model.

Similarly, it is illustrative to separate the off-airport impacts generated by on-airport activities, visitor spending and international cargo. As shown in Table 34, activities that occur outside of the nation's airports are responsible for about one-third of the total national economic impacts generated by the airports. The contribution of air cargo represents about 60 percent of all impacts and international visitor spending contributes the balance. Note that hospitality industries are generally low-wage and labor intensive, so employment in visitor spending is about twice the proportion of output and value added. In contrast, many of the manufacturing sectors that export commodities pay high wages but also use significant automation processes, and therefore international exports generate larger shares of labor income, output and value added than employment.

Airports and International visitor spending facilitated by airports contribute approximately $274 billion to the national GDP and generate about $500 billion in output. In terms of economic contribution of U.S. airports, these two sources of economic impacts account for about 35 percent of GDP, 31 percent of output and 40 percent of jobs that comprise airports'' contribution to the national economy. The value of air cargo shipped to international customers, and subsequent indirect and induced multiplier effects generated from the production of air-shipped products, account for an additional one trillion dollars of output in total and almost $500 billion in value added.

Table 29. National Economic Contribution by Source of Impacts

Economic Impact Source	Employment	Labor Income	Value Added	Output
On-Airport Direct	939,200	$64,389,862,000	$97,811,688,000	$195,018,047,000
Airport Indirect and Induced Effects	1,563,400	$80,546,973,000	$144,183,429,000	$253,813,356,000
Total Airport Generated	2,502,600	$144,936,835,000	$241,995,117,000	$448,831,403,000
International Visitor Spending	518,400	$19,169,955,000	$31,585,111,000	$52,603,589,000
International Air Cargo	4,607,800	$288,398,892,000	$494,822,086,000	$1,096,023,267,000
Total	**7,628,800**	**$452,505,682,000**	**$768,402,314,000**	**$1,597,458,259,000**
Percent of Impacts				
Airport Facilities	33%	32%	31%	28%
International Visitor Spending	7%	4%	4%	3%
International Air Cargo	60%	64%	64%	69%

Note: Employment is rounded to the nearest 100, and dollars to the nearest $1,000. Dollars are in 2010 value

Sources: BEA, Office of Travel and Tourism Industries of the U.S. Department of Commerce, BLS-CES, U.S. Census Bureau, U.S. Budget, FAA Form 127 & NPIAS, ACI-NA, U.S. Department of Commerce data and other federal data assembled by IMPLAN. LLC. Calculations by EDR Group using 2012 National IMPLAN model.

4 REGRESSION ANALYSIS

To prepare to conduct regression analysis, the database was cleaned up to replace all zero values for the key dependent variables (airport direct revenue, airport direct employment, and airport direct income) and other key independent variables with missing values. Secondly, dummy variables were created to represent the different airport classes. Dummy variables were also created for the presence of a control tower, flight service station, or maintenance base. See Table 30.

A 95% level of confidence was used to assess significance of variables. For all regression models, the N (number of observations) and diagnostics have been reported to show overall findings, significance of each explanatory variable, reliance of variables (heteroskedasticity) and multicollinearity, which indicates when two or more variables are correlated and therefore explain the same occurrence.

We found that high correlations existed between variables of one type (e.g., domestic operations, passengers, departures, and destinations). Only variables with the best fit in the regression models were included from each type. Also, poverty and income variables were highly correlated, so only the best fit variables were used.

As expected, data compiled from different sources for many airports were conducted in similar but not exact methodologies. In some cases international and domestic activities are not separated. Also, studies vary in how air reliance of off-airport industries is addressed, or if these contributions are addressed at all. Similarly inclusions of impacts of airport construction are not consistent among studies, including the number of years included.[21] In varying reporting, some studies count full-time equivalent workers, while others report head-counts. In addition, studies treat multipliers differently – some studies separate direct, indirect and induced impacts, others separate direct but combine direct and induced, and yet others provide one number both direct and multiplier impacts or combine direct and indirect. Lastly, study years vary, so some findings are reported in 2011 dollars, while other studies are shown in 2010 dollars and in earlier years.

Very few observations on international passengers and operations, or the economic impacts of cargo were recorded to be meaningful in the regressions tested (see Table 30). The addition of any international variables reduces the number of observations (N) significantly such that the margin of error of the results at a 95% confidence level increases.

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[21] In many studies, multiple years of capital expenditures are averaged to avoid year to year fluctuations.

Table 30. Summary of Variables Used for Regressions, by Category, with Number of Observations

Total Number of records in database = 3,330 (very low number of observations (<100) highlighted in green)

Variable Block	Variable (name in Stata/SPSS files)	Description	No. of observations
Type	class	Airport NPIAS classification	3,330
	L	Commercial service large hub	3,330; 29 L=1
	M	Commercial service medium hub	3,330; 36 L=1
	S	Commercial service small hub	3,330; 74 L=1
	N	Commercial service non-hub	3,330; 239 L=1
	CS	Non-primary commercial service	3,330; 121 L=1
	R	Reliever	3,330; 268 L=1
	GA	General Aviation	3,330; 2,563 L=1
	L_and_M	Large and medium combined	3,330; 65 L_and_M =1
	S_and_N	Small and non-hub combined	3,330; 313 S_and_N=1
Facilities	ct	Presence of Control Tower	3,327; 556 ct=1
	fss	Presence of Flight Service Station	3,150; 20 fss=1
	mb	Presence of Maintenance Base	2,763; 2,059 mb=1
	runlength	Max Runway length (feet)	3,327
Passengers	enplane_dom	Domestic Enplanements (2011)	767
	enplane_intl	International Enplanements (2011)	283
	enplane_conn_dom	Domestic Connecting Enplanements	139
	enplane_conn_intl	International Connecting Enplanements	66
Aircraft operations	ops_domestic_pax	Commercial Passenger Airlines Domestic Ops.	817
	ops_intl_pax	Commercial Passenger Airlines International Ops.	324
	ops_cargo	All-Cargo Airline Operations	550
	ops_airtaxi	Air Taxi	1,904
	ops_itinerant	General Aviation Itinerant	3,150
	ops_local	General Aviation Local	3,010
	ops_military	Military	1,937
Commercial cargo	cargo_l	All-Cargo Aircraft Operations - Large	70
	cargo_m	All-Cargo Aircraft Operations - Medium	310

Variable Block	Variable (name in Stata/SPSS files)	Description	No. of observations
Commercial cargo	cargo_s	All-Cargo Aircraft Operations - Small	495
	belly_l	Belly Cargo Tons - Large	13
	belly_m	Belly Cargo Tons - Medium	205
	belly_s	Belly Cargo Tons - Small	287
	tons_l	All-Cargo Aircraft Tons - Large	70
	tons_m	All-Cargo Aircraft Tons - Medium	297
	tons_s	All-Cargo Aircraft Tons - Small	463
Schedule	dep_dom	Scheduled Daily Domestic Departures - August 2011	582
	dep_intl	Scheduled Daily International Departures - August 2011	237
	dest_dom	Number of Nonstop Domestic Destinations, Aug 2011	582
	dest_intl	Number of Nonstop Intl. Destinations, Aug 2011	237
Total Economic Impact Including Multiplier Effect	total_jobs	Jobs	1,015
	total_inc	Personal Income	1,015
	total_rev	Airport Revenues (Output or Business Sales)	1,015
Airport Impacts	airport_empl_total	Total employment generated	1,015
Breakdown of employment	airport_empl_direct	Direct (at airport)	708
Airport Personal Income (Wages) Generated	airport_inc_total	Total personal income generated	1,015
	airport_inc_direct	Direct (at airport)	687
Airport Revenues (Output or Business Sales)	airport_rev_total	Total revenues generated	1,015
	airport_rev_direct	Direct (at airport)	687
Airport capital investment	airport_investment	Direct construction and maintenance investment	914
Airport tax and fee contributions (federal, state, local)	airport_taxes	State and local taxes (income, sales, property tax)	216
	airport_fees	Federal aviation fees	2
	duration_dom	Average Visitor Duration of Stay, Domestic	1,033
	duration_intl	Average Visitor Duration of Stay, International	1,033
	visitor_dom_daily_spend	Average Domestic Visitor Spending Per Day	159

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Variable Block	Variable (name in Stata/SPSS files)	Description	No. of observations
Airport tax and fee contributions (federal, state, local)	visitor_intl_daily_spend	Average International Visitor Spending Per Day	3
	visitor_dom_visit_spend	Average Domestic Visitor Spending Per Visit	501
	visitor_intl_visit_spend	Average International Visitor Spending Per Visit	2
County variables	county_pop	POP_2010_county	1,033
	county_percapincome	Pers_Inc_PerCapita_2010_county	1,033
	county_income	Pers_Inc_2010_inthousands_county	1,033
	county_distress_index	Distress_Index_County_toUS_2010	1,029
Metro area variables	metro_pop	POP_2010_metro	449
	metro_percapincome	Pers_Inc_PerCapita_2010_metro	449
	metro_income	Pers_Inc_2010_inthousands_metro	449
	metro_empl	Total employment_2010_METRO	449
Economic variables	poverty_all	Poverty Estimate All Ages_2010	1,033
	poverty_percent	Poverty Percent All Ages_2010	1,033
	poverty_under18	Poverty Estimate Under Age 18_2010	1,033
	poverty_percent_under18	Poverty Percent Under Age 18_2010	1,033
	med_income	Median Household Income_2010	1,033
Industry Employment	Metro_empl_wage	Wage and salary employment_2010_METRO	449
	Metro_empl_prop	Proprietors employment_2010_METRO	449
	Metro_empl_farm_prop	Farm proprietors employment_2010_METRO	449
	Metro_empl_nonfarm_prop	Nonfarm proprietors employment _2010_METRO	449
	Metro_empl_farm_empl	Farm employment_2010_METRO	449
	Metro_empl_nonfarm_empl	Nonfarm employment_2010_METRO	449
	Metro_empl_nonfarm_pvt	Private nonfarm employment_2010_METRO	449
	Metro_empl_forestry	Forestry, fishing, and related activities_2010_METRO	132
	Metro_empl_mining	Mining_2010_METRO	151
	Metro_empl_utilities	Utilities_2010_METRO	184
	Metro_empl_constn	Construction_2010_METRO	358
	Metro_empl_manuf	Manufacturing_2010_METRO	356
	Metro_empl_wholesale	Wholesale trade_2010_METRO	302

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Variable Block	Variable (name in Stata/SPSS files)	Description	No. of observations
Industry Employment	Metro_empl_retail	Retail trade_2010_METRO	429
	Metro_empl_transport	Transportation and warehousing_2010_METRO	220
	Metro_empl_info	Information_2010_METRO	358
	Metro_empl_finance	Finance and insurance_2010_METRO	368
	Metro_empl_prof	Professional, scientific, and technical services_2010_METRO	292
	Metro_empl_realestate	Real estate and rental and leasing_2010_METRO	363
	Metro_empl_mgmt	Management of companies and enterprises_2010_METRO	236
	Metro_empl_admin	Administrative and waste management services_2010_METRO	282
	Metro_empl_edu	Educational services_2010_METRO	280
	Metro_empl_health	Health care and social assistance_2010_METRO	279
	Metro_empl_arts	Arts, entertainment, and recreation_2010_METRO	333
	Metro_empl_acco	Accommodation and food services_2010_METRO	333
	Metro_empl_other	Other services, except public administration_2010_METRO	393
	Metro_empl_govt	Government and government enterprises_2010_METRO	449
	Metro_empl_fed	Federal, civilian_2010_METRO	449
	Metro_empl_military	Military_2010_METRO	449
	Metro_empl_state&local	State and local_2010_METRO	449
	Metro_empl_state	State government_2010_METRO	371
	Metro_empl_local	Local government_2010_METRO	371

4.1 Stratified Regression Analysis

Making use of the database of 3,330 records detailing the complete list of NPIAS airports, two regressions were fit to try to predict individual airport employment and value added for the purpose of being able to conduct a bottom-up analysis of national airport impacts. Of the 1,013 airport economic impact studies added to the NPIAS database (Appendix 3A), the 675 airports that report revenue and 714 airports that report direct jobs formed the starting pools of observations for each regression out of the 3,330 airports. The remaining 299 - 338 airport economic impact studies in NPIAS database did not break out total effects of on-airport impacts (including multiplier effects) from direct impacts.

Depending on the completeness of the explanatory variables and the choice of variables, the functional observations available for each regression dropped accordingly. The 675 airports (observations) for the direct revenue estimation represented a total of 538 unique counties. One hundred five (105) of those counties have more than one airport within their geographical boundaries. Similarly, for the 714 airport dataset dealing with airport related jobs, a total of 106 unique counties housed more than one airport within the geographical boundaries.

Variable Selection

The selections of explanatory variable are focused on utilizing operations data to generate basic statistical relationships. Socioeconomic variables are then added to explain atypical/outlier behavior for intra-class variation. The availability of the data for a national aggregation is a complicating factor, because if a good predictor is missing too many records then it cannot be estimated (regardless of theoretical validity).[22]

Table 31 highlights the number of blank values/zero values present in the final database by airport classification type. The cells in green represent potentially useful explanatory variables which could be used for testing in the regression. They are useful because they involve behavior typical for that type of airport, and there are sufficient records to attempt a national estimation[23].

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[22] This is an issue for the subset of revenue data as well as the whole airport database.

[23] This means that less than 5% of the population records were missing, with increased strictness for higher value classes with smaller populations

Table 31. Missing Observations by Explanatory Variable, Class

	Domestic Enplanements (2011)	Domestic Connecting Enplanements	Domestic Commercial Operations	All Cargo Operations	Daily Domestic Departures
L	missing: 0; or 0%	missing: 0; or 0%	missing: 0; or 0%	missing: 0; or 0%	missing: 2; or 6.9%
M	missing: 0; or 0%	missing: 0; or 0%	missing: 0; or 0%	missing: 0; or 0%	missing: 0; or 0%
S	missing: 0; or 0%	missing: 0; or 0%	missing: 0; or 0%	missing: 6; or 8.11%	missing: 5; or 6.76%
N	missing: 4; or 1.67%	missing: 239; or 100%	missing: 3; or 1.26%	missing: 134; or 56.07%	missing: 72; or 30.13%
CS	missing: 21; or 17.36%	missing: 121; or 100%	missing: 21; or 17.36%	missing: 115; or 95.04%	missing: 62; or 51.24%
R	missing: 196; or 73.13%	missing: 268; or 100%	missing: 187; or 69.78%	missing: 230; or 85.82%	missing: 230; or 85.82%
GA	missing: 2,342; or 91.38%	missing: 2,563; or 100%	missing: 2,302; or 89.82%	missing: 2,521; or 98.36%	missing: 2,409; or 93.99%

Source: ACRP 03-28 Database

L: large hub, M: medium hub, S: small hub, N: non-hub, primary, CS: non-primary commercial services, R: reliever and GA: general aviation

For commercial airports, we would expect commercial operations to be relevant. However, information on connecting flights would likely be constrained among commercial services airports to mostly larger and medium hub airports. Similarly, for smaller airport classifications (small hub classification down to reliever and general aviation) we would expect an increasingly important relationship with total general aviation operations, which are not shown in larger hub airports). In defining these expectations, the specified regressions are based off of these premises but the process of selecting the most efficient set of predictors can lead some of these explanatory variables to drop in or out depending on which of them add the most explanation of the observed variance in direct revenue with the least redundancy in data.

While these basic operational characteristics are assumed to be important, it is the socio-economic characteristics which are believed to provide additional explanation. To this extent we added estimators dealing with population, wage, poverty, distress, and employment by industry as added variance explanations. Obviously we would not simply include the levels (i.e. tourism services employment count) as the correlation with performance/revenue could just as easily be due to the fact that larger counties had larger employment levels, as the fact that regions more geared towards tourism were likely to experience more revenue than those which were not destinations. To try to get around this, the percentage of the county level figures was used to remove the bias (because it is therefore scale/size independent).

The problem with the socio economic variables was that multiple airports resided within the same county and as a result, the relevant characteristics for different scale airports are

concealed when the regressions were estimated without finding a way to break out the relevant attributable populations influencing an airport. Otherwise a densely populated county could both be used to try to explain a vibrant airport, and a sub-optimally performing one, thus breaking down the statistical relationship. For the 675 airports where direct revenue is reported in economic impact studies, 105 counties are served by two or more airports (accounting for 137 of the 675 airports).

The sets of regressions conducted are broken out by NPIAS classification where possible[24], with the understanding that airports (depending on size and scope of services) would behave differently, and would be best estimated using different explanatory factors. Table 32 shows the differences in mean direct revenue by airport classification. Please note that the units for the direct revenue by airport class averages are in millions of 2010 dollars.

Table 32. Summary of Revenue by Airport Class (Millions $2010)

Airport Classification	Mean	Number of Airports (Observations)
Large hub	$5,636.27	6
Medium hub	$684.61	6
Small hub	$316.65	22
Non-hub, primary	$154.66	66
Non-primary commercial services	$18.55	23
Reliever	$544.79	48
General aviation	$5.37	491

*Source: ACRP 03-28 Database (developed in Tasks 4 and 5)*

If average revenue by airport classification by maximum runway length as a proxy variable for the scale and scope of operations is further broken down, a nonlinear pattern within the data is observed. While maximum runway length is not an individually useful (direct) predictor, it provides some insight into the behavior of the data and its underlying relationships. While runway length, when interacted with airport classification, is not an ideal measurement of direct output or direct value added (or that it particularly captures all the nuances at play); it is correlated with more appropriate variables.

The hypothesis being put forward is that the proxy is in fact correlated to the scale, frequency, and type of operations at an airport. It is expected that depending on the scale of operations, as captured and stratified via the NPIAS facility classifications, longer runways would accommodate larger planes which allow for reduced user costs and increased business utilization, which would be reflected in the premiums paid as revenues.

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[24] Meaning there were sufficient observations to do a regression, or the data behaved fundamentally different from other airport types that it merited separation.

Differing runway lengths within a NPIAS classification also serve to distinguish, albeit crudely, the differences in airport utilization because differing services require certain types of aircraft, and these different types of aircraft have varying runway needs in order for them to be able to operate at a given airport. This hypothesis depends on the assumption that airport sponsors behave in a rational manner and are pragmatic in their expansion plans such that they do not go about building un-utilized airport expansions when evidence of sufficient demand is not present. With this assumption holding, there is the basis for generating a simple linear relationship between airport scale/scope and revenue generation.

Figure 5. Average Revenue by Average Runway Length (as a function of FAA Airport Classification
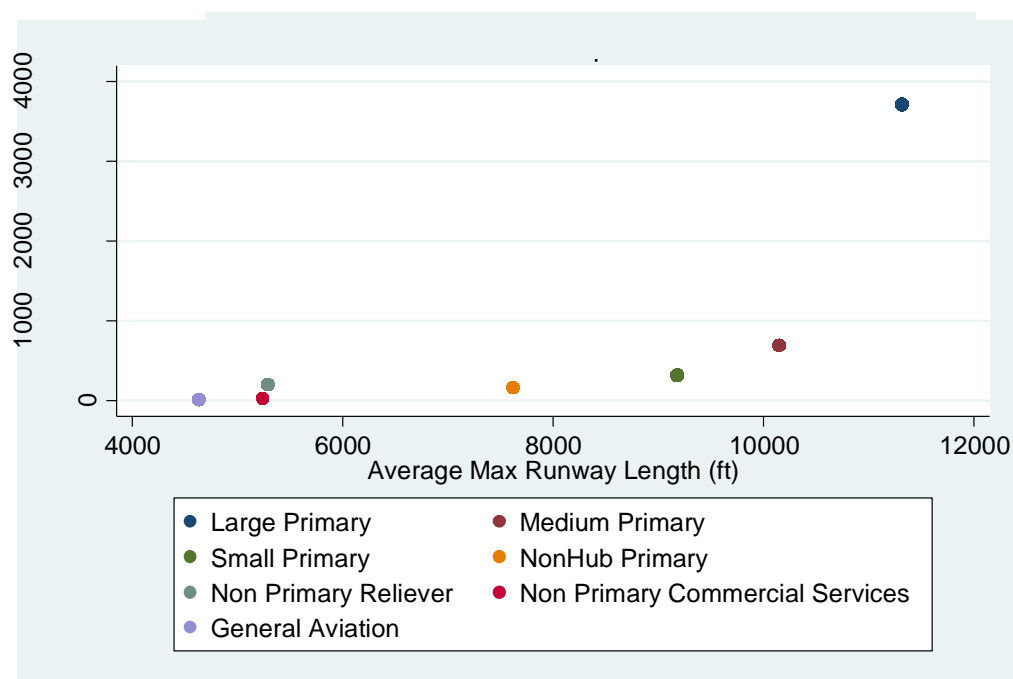
This quick analysis illustrated in Figure 5 provides a glimpse of non-linear behavior which needs to be taken into account when we begin the analysis. Understanding that there are different relationships in the predictors based on the type of airport means that when the regressions are estimated, the more stratified that the regressions can be specified, the better the resulting fit of the equation with the data. The next section gets into the technical specification of the regression.

Regression Analysis

In Table 34 to Table 37 below, four final regression models are presented, representing the seven classifications of NPIAS airports. The two groupings – (1) medium and small hub airports; and (2) non-primary commercial service airports, reliever airports & general

aviation airports – were created because these airports share common characteristics regarding commercial and GA operations. Secondly, in the case of medium and small hubs and non-primary commercial service airports and relievers, aggregation is necessary in order to approach or exceed statistically normal distributions. However, in the case of large hubs, there are only six airports in the data base, but as illustrated by Figure 5 , this class of airports is far outside the other levels of NPIAS airports and merging them into another category would greatly distort any subsequent findings. The airport-classification groupings for the final regressions (after deleting several outliers due to unexplainable revenue totals reported) are:

1. Large Hub Airports (Table 34)

2. Medium Hub Airports & Small Hub Airports (Table 35)

3. Non-hub Primary Airports (Table 36)

4. Non-primary Commercial Service Airports, Reliever Airports & General Aviation Airports (Table 37)

As seen in Table 33 and reported above, 675 airports in the ACRP 03-28 database report direct on-airport revenue—this is the cleanest common measure to use for the regression analysis. These airports represent about 20% of the NPIAS and by classification range from 17% (medium hubs) to 30% (small hubs). The other five classifications are clustered between 18% and 21% of NPIAS totals. After accounting for outliers, the total of 644 airports used in the regressions accounts for 19% of the total NPIAS, including: 21% of large hubs; 25% of medium and small hub airports; 27% of non-hub primary airports; and 18% of all non-primary facilities.

Regression analysis allows the interpretation of the statistical relationship, give us an idea about how strong they are, and how much variation in the data can be explained with the current choice of predictor variables. In the following regressions special care should be taken in observing the R-squared (% of variation explained[25]), coefficient estimate[26], P value[27], and the Number of observations[28].

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[25] Measures the overall fit of the regression, the larger the number the better

[26] Also referred to as the parameter estimate, which is listed under the 'Coef.' Column. Also, keep in mind that the _cons represents the 'constant', which is the 'b' value in the linear equation for y = mx + b

[27] This is a diagnostic test to see whether the parameter/predictor estimate is significantly greater than 0 (worth including). The smaller the number the better (below .05) and a variable is deemed to typically have a significant relationship with the variable being predicted (dependent variable).

[28] The number of observations is important – the more there are, the better the dataset. At a minimum it is preferable to have at least 30 airports (observations) in order to infer normality of a distribution for statistical testing, and greater than 100 to have a small margin of error

Table 33. Airports by classification in NPIAS, reporting direct on-airport economic output and used in the regression analysis

All Airports Reporting Direct on Airport Output	NPIAS	ACRP 03-28 Database	Percent of Total Class in Database
Large hub	29	6	21%
Medium hub	36	6	17%
Small hub	74	22	30%
Non-hub, primary	239	66	28%
Non-primary commercial services	121	23	19%
Reliever	268	48	18%
General aviation	2,563	491	19%
Totals	**3,330**	**662**	**20%**
Classifications Grouped for Regression Analysis	**NPIAS**	**Airports in Regression Analysis**	**Percent of Total Class in Database**
Large Hub Airports	29	6	21%
Medium Hub Airports & Small Hub Airports	110	24	22%
Non-hub Primary Airports	239	64	27%
Non-primary Commercial Service Airports, Reliever Airports & General Aviation Airports	2,952	547	19%
Totals	**3,330**	**641**	**19%**

There is also one further cautionary note relevant to regression output. In the fitted regressions not all variables were statistically relevant and log transformations had to be done in order to preserve a linear relationship between predictors and their dependent variable (direct on-airport revenue). Compounding such scale issues between variables makes it important to remember that not all units can be treated the same when comparing different classifications of airports (e.g., 1,000 connecting flights carry different implications than 1,000 domestic enplanements). Put simply, the order of magnitude of domestic enplanements occurring in the hundreds of thousands differs from the tens of thousands of connecting enplanements. As a result, the individual contribution of either variable cannot simply be directly compared.

Table 34. Model 1: Regression of Large Hub Total Enplanements on Airport Revenue

Linear Regression					Number of airports	6
					F(1, 4)	41.06
					Prob > F	0.0030
					R-squared	0.8108
					Root MSE	2328.6
Impact_rev~r	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf. Interval]	
tot_enpl	.000328	.0000512	6.41	0.003	.0001859	.0004702
_cons	-971.1102	1265.668	-0.77	0.486	-4485.167	2542.946

Notes: a) Where tot_enpl is the abbreviation for total enplanements (domestic + international) for large airports.
b) Because there were so few populated airports regarding direct revenue for large hub airports, no sophisticated modeling could be done.
c) All explanatory variables are highly significant, and showing the correct expected relationship

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Interpretation of this regression would go as follows: All else constant, a 10,000 additional total enplanements per year would be associated with an estimated 3.28 million dollars of direct airport revenue.

Table 35. Model 2: Medium and Small Hub Regression for Revenue based on Total Enplanements (Square Root)

Source	ss	df	MS		Number of airports	24
Model	1008.35493	1	1008.35493		F(2, 24)	26.58
Residual	834.451132	22	37.9295969		Prob > F	0.0000
Total	1842.80606	23	80.1220026		R-squared	0.5472
					Adj R-squared	0.5266
					Root MSE	6.1587
Sqrt_impac~r	Coef	Std. Err.	T	P>|t|	[95% Conf. Interval]	
Sqrt_tot_enpl	.0133673	.0025925	5.16	0.000	.0079907	.0187438
_cons	1.334365	3.121398	0.43	0.673	-5.139019	7.807749

Note: a) sqrt_tot_enpl is the abbreviation for the square root transformed total enplanements (domestic + international) for medium and small hub airports
b) All explanatory variables are highly significant, and showing the correct expected relationship

Interpretation of this regression would go as follows: All else constant, an additional 10,000 total enplanements would reasonably be expected to generate $1.8 million.

Table 36. Model 3: Non-Hub Primary Airport Regression for Revenue based on Domestic Enplanements and Max Runway Length (Square Root)

Linear Regression					Number of airports	61
					F(2, 62)	33.05
					Prob > F	0.0000
					R-squared	0.5751
					Root MSE	2.2043
sqrt_impact~r	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf. Interval]	
Maxrunwayl~t	.0003659	.0001677	2.18	0.033	0.0000301	.0007018
Sqrt_domes~n	.0128914	.0020539	6.28	0.000	0.0087786	.0170042
Military	.0002297	.0000489	4.70	0.000	0.0001318	.0003276
_cons	-.643154	1.167663	-1.55	0.584	-2.981358	1.69505

Note: a) maxrunwaylength is the maximum runway length (in feet) for the airport
b) sqrt_domestenplane is the abbreviation for the square root of the number of total enplanements in 2011 (domestic + international)

c) All explanatory variables are highly significant, and showing the correct expected relationship

The interpretation of this regression would be, all else equal, an additional 10,000 total enplanements at a non-hub primary airport would be associated with a $1.6 million increase in direct revenue. Additionally, a 1,000 foot runway increase would be associated with a $0.13 million increase in direct revenue.

Table 37. Model 4: Non- Primary Commercials Services, Reliever and General Aviation Airports Regression for Revenue based Runway Length Squared and Total General Aviation Operations (Square Root)

Linear Regression					Number of airports	547
					F(4, 541)	66.14
					Prob > F	0.0000
					R-squared	0.5089
					Root MSE	1.5887
sqrt_impact~r	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf. Interval]	
ga_rwy3	.0313795	.0049271	6.37	0.000	.0217009	.0410582
r_rwy3	.101516	.0145309	6.99	0.000	.0729721	.1300598
cs_rwy3	.044483	.0039706	11.20	0.000	.0366833	.0522827
ga_totalga	.0000297	9.48e-06	4.58	0.000	.000017	.0000425
_cons	.1348925	.1313813	1.03	0.305	-.1231864	.3929714

Note: a) ga_rwy3 is the squared max runway length (in thousands of feet) for general aviation airports
b) r_rwy3 is the squared max runway length (in thousands of feet) for reliever airports
c) cs_rwy3 is the is the squared max runway length (in thousands of feet) for commercial services airports
d) ga_totalga is the total GA Operations for general aviation airports
e) All explanatory variables are highly significant, and showing the correct expected relationship

For lack of better predictors, we had to rely on the interaction of airport class-specific binaries and max runway length as a proxy estimator of the type of activity enabled by different length runways, and the scale of operations. The maximum runway length adopted its squared form in order to account for the nonlinear behavior between airports, as discussed earlier. The simple interpretation for this regression would be that a reliever airport with a 1,000 foot increased runway length would, on average, tend to experience a $0.010 million increase in direct revenues. This interpretation can be followed when looking at the reliever and commercial services airports (by swapping out the parameter estimates). Additionally, general aviation airports experiencing an additional 1,000 general aviation (itinerant plus local) operations would see an additional $882. If we wanted to predict the direct revenue for a general aviation airport with a max airport runway length of 4,000 feet, and 10,000 general aviation operations, direct revenue of $0.93 million dollars is reasonably expected.

National Aggregation

Direct Revenue

Using the parameter estimates from the four regressions, the individual direct revenue values (value added) for each of the 3,300 airports in the compiled NPIAS database were estimated. Direct revenue in this case deals with on airport purchases for services which are broadly split into airport operations ranging from adiminstration/ management services, to fixed base operations, to air traffic control and ground handling. Much of the observations were already aggregated, so the exact breakout of the direct revenue into these principle components could not be done. As a comparison, the following chart shows a side by side point spread of all of the airports where the estimated direct revenue could be compared to reported values from prior studies (again, keeping in mind that all dollar values were adjusted to 2010 dollars).

Figure 6. Estimated versus Reported Direct Revenues (*Millions $2010*)
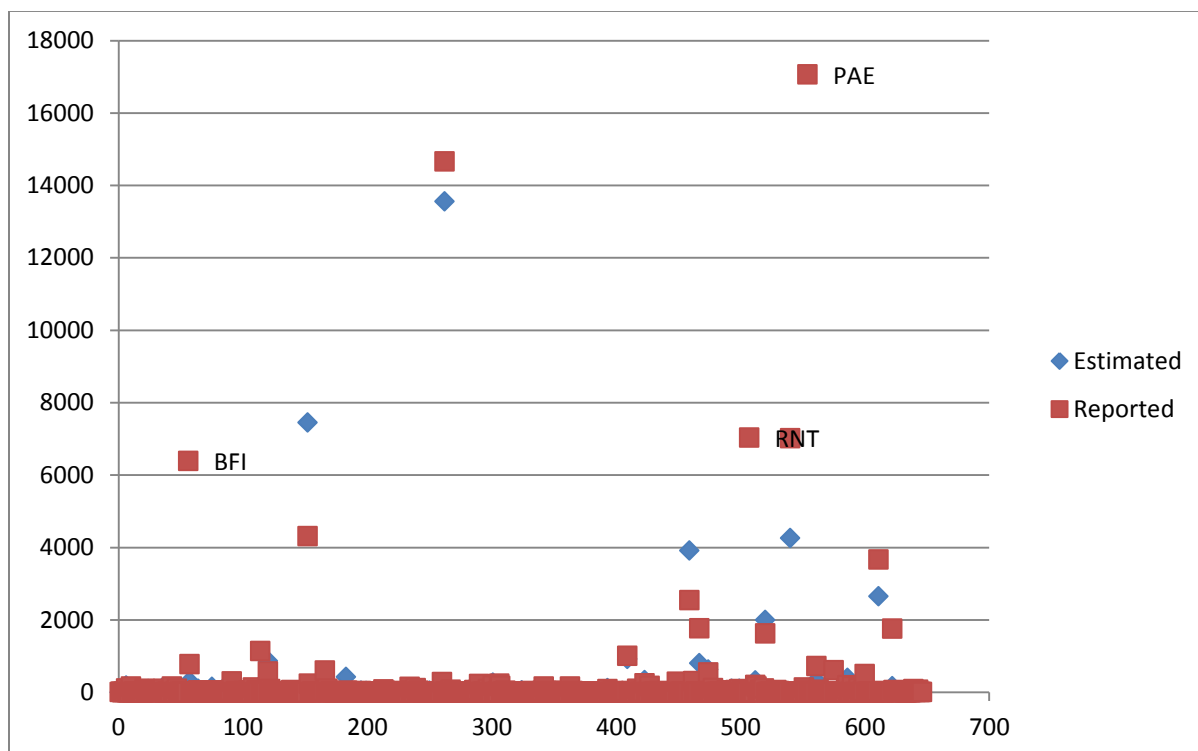
As can be seen, the approach of bifurcating the regressions by related class types does an overall decent job of explaining the variation and matching observed values. One cautionary note in interpreting this graphic is that there appears to be 2 observations suffering from some type of reporting/estimation error. This error creates an order of magnitude difference when we compare them to their estimated counterparts there is an order of magnitude difference. These problematic observations come from 2 reliever airports in Washington (Snohomish county –PAE, and Renton Municipal -RNT), which, if you were to

believe the reported numbers from these two airports, both outperform most large primary hub airports. To keep the national analysis simple, all airports outside of main-continental U.S. were removed during the aggregation process[29] to arrive at a revenue estimate of $199.2 billion (2010$).

Direct Employment

Employment is pivoted from the economic output numbers using naitonal ratios of output to revenue from IMPLAN, LLC. This approach is taken because it is difficult to fit a regression for employment with the available datapoints without confusing interpretation based on size correlation. A ratio of employment to economic output was estimated for each county for sectors 332 and 338 (Transport by Air, and Support Services for Transport). This approach arrives at a total direct employment estimate of 1,128,000 persons.

Visitor Spending

The database includes records of direct visitor spending for 501 airports. Only two airports provided visitor spending seperately for domestic and international travelers. As a result, spending represented in this database is a blend of (primarily) domestic and international visitors. Similarly, there are not enough observations to effectively split apart business and personal travel.

The 501 airports in the database represent 15% of all NPIAS facilities and 10%-16% of each airport type. As seen in Table 38, average visitor spending (per visit) ranges from $1,111 for large hubs to $93 for GA airports.

Overall, the classes of airports that report visitor spending are proportional to the size of airports in the NPIAS and reflect an expected gradation of vistor spending. Of all airports in the NPIAS, 78% are GA airports. Likewise, 391 of airports in the data base that report direct visitor spending are GA (77%). Primary airports and all commerical airports comprise 12% and 15% of airports in the "visitor spending" database and airports and 11% and 15% of NPIAS airports, respectively. That said, it should be pointed out that the database includes visitor spending for just three large hubs and four medium hubs. Although each class rounds to 1% in both the visitor spending databases and the NPIAS, they are slightly under represented. (Large and medium hub airports total 1.4% of the visitor spending database and 2.0% of the NPIAS).

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[29] Airports in Alaska, American Samoa, Guam, Hawaii, Northern Mariana Islands, Puerto Rico, and the Virgin Islands were not included.

Table 38. Visitor Spending by Airport Classification

Airport Classification	Number of Airports with Direct Visitor Spending in Database	Percent of NPIAS by Classification	Mean Spending per Visitor by Airport Classification
Large Hub	*3*	*10%*	*$1,111.33*
Medium Hub	*4*	*11%*	*$348.50*
Small Hub	*12*	*16%*	*$425.17*
Non-hub Primary	*39*	*16%*	*$525.46*
Non-primary Commercial	17	14%	$509.12
Reliever	35	13%	$111.71
General Aviation	391	15%	$92.95
TOTAL	**501**	**15%**	**NA**
Total Primary Airports	*58*	*15%*	*NA*
Total Commercial Airports	75	15%	NA

Source: ACRP 03-28 Database (developed in Tasks 4 and 5),

4.2 Diagnostics and Results of Regressions

This section tries to briefly explain the interpretation of some of the basic diagnostics which were used to assess the regressions estimated, followed by a summary for each estimation. Here we focus on testing for heteroscedasticity, collinearity, form specification and then look at the actual vs. fitted graphs as a gauge of overall success of estimation.

Heteroskedasticity

Heteroskedasticity tests are meant to determine whether or not the regression has homogenous variance in its residuals (no systematic/trend like behavior). There are many different tests for heteroskedasticity, but more commonly we see the Breush-Pagan and White tests for heteroskedasticity. Violation of this condition leads to a situation where the statistical significance of the individual explanatory variables can be difficult, but it does not influence the individual parameter estimates. To correct this we can regress using robust standard errors, or try various transformations. Generally the tests are specified such that large 'P' values implies that we fail to reject the null hypothesis of constant variance. (Note, large 'P' values are usually described as greater than the critical value –which is usually 0.05)

Collinearity/Multicollinearity

Here the term "multicollinearity" has to do with the type of situation where the predictors are linear combinations of one another. The larger the overlap in data explanation, the greater the inflating of the standard error to the point of potentially flipping the sign of the relationship from positive to negative. To test the degree of data redundancy, we use the variance inflation test. Interpretation of this test is on a scale from 1 (low presence) to 10 (potentially dangerous) and beyond. Treatment of this problem varies and, in some cases,

makes it more preferable to remove the variable in question; although, that opens up the regression to over/underspecification biases – something that is addressed in the model specification testing.

Model (Form) Specification (Over-/Under-Specification)

Model specification testing looks at if key variables are either omitted or if unimportant variables are potentially included. The presence of over or underspecified models can lead parameter estimates that are not truly measuring their statistical relationsihp and are under or over inflated. Specification testing will give you an approximate idea whether or not some certain minimum level of specification is appropriate. However, specification testing will not tell you whether or not it is over or under specified. One of the more common tests is the Ramsey Regresssion Equation Specification Error Test (RESET) Test, which tests the null hypothesis that the regression is not missing variables. P values large enough (again, greater than .05 in this case) are said to fail to reject the hypothesis (the model is properly specified to some minimum degree).

Fitted vs Actual

This is simply a dot plot and trendline of the regression estimated values plotted against the reported values. Ideally this plot should converge around a straight line along a 45-degree line (graph scaling permitted) if it is a good fit. Values which are above or below this theoretical line show instances of over/ under estimation.

Regression Output

Model 1: Large Hub Airports

Heteroskedasticity

```
. imtest

Cameron & Trivedi's decomposition of IM-test
```

Source	chi2	df	p
Heteroskedasticity	5.01	2	0.0817
Skewness	0.94	1	0.3332
Kurtosis	0.45	1	0.5018
Total	6.40	4	0.1715

The large p value means the equation does not suffer from severe heteroskedasticity

Collinearity

This test is only necessary if there are more than one predictors in the specified regression

Form Specification

```
. ovtest

Ramsey RESET test using powers of the fitted values of impact_rev_mdollar
      Ho:  model has no omitted variables
                F(3, 1) =       0.47
                Prob > F =       0.7589

. linktest
```

Source	SS	df	MS		Number of obs =	6
					F(2, 3) =	8.66
Model	97727781.6	2	48863890.8		Prob > F =	0.0567
Residual	16927735.4	3	5642578.47		R-squared =	0.8524
					Adj R-squared =	0.7539
Total	114655517	5	22931103.4		Root MSE =	2375.4

impact_rev~r	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
_hat	-.166925	1.293887	-0.13	0.906	-4.28465	3.9508
_hatsq	.0000739	.0000805	0.92	0.426	-.0001822	.00033
_cons	3082.957	3759.025	0.82	0.472	-8879.937	15045.85

Both tests show a basic appropriate level of specification in the regression

Fitted vs Actual
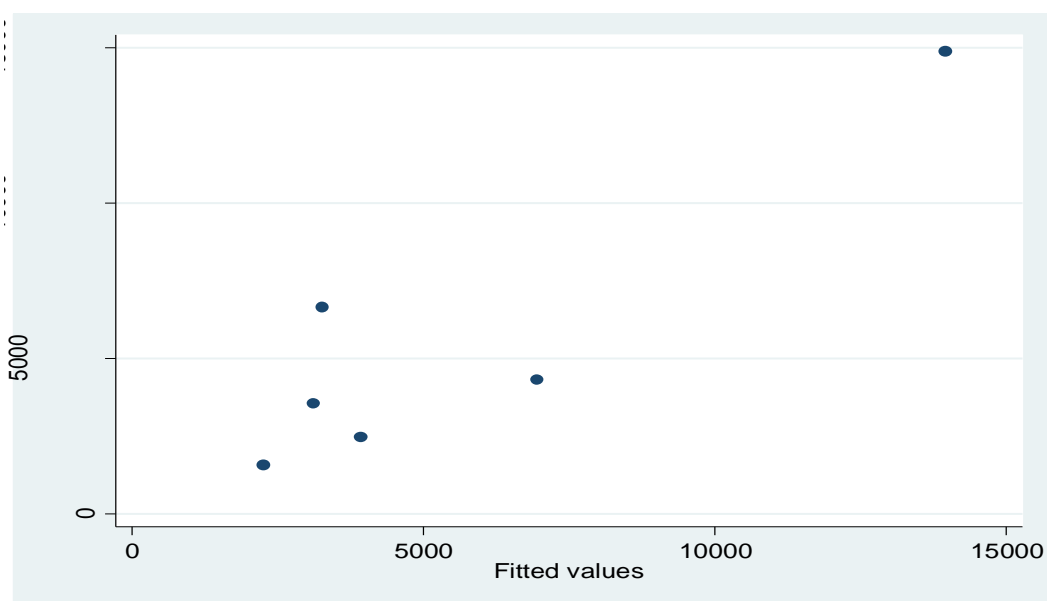
There is not much that can be done with this regression simply because there are too few observations to afford it the option of being tweaked. Because the behavior was also unique to other functional classifications, it could also not be merged with other classifications easily.

Model 2: Medium and Small Hub Airports

Heteroskedasticity

. imtest

Cameron & Trivedi's decomposition of IM-test

Source	chi2	df	p
Heteroskedasticity	5.00	2	0.0820
Skewness	1.54	1	0.2150
Kurtosis	1.51	1	0.2189
Total	8.05	4	0.0897

Collinearity

. vif

Variable	VIF	1/VIF
sqrt_tot_e~l	1.00	1.000000
Mean VIF	1.00	

Form Specification

. ovtest

Ramsey RESET test using powers of the fitted values of sqrt_impact_rev_mdollar
    Ho: model has no omitted variables
              F(3, 19) =   0.34
              Prob > F =   0.7967

. linktest

Source	SS	df	MS		
Model	1037.55755	2	518.778773	Number of obs =	24
Residual	805.248513	21	38.3451673	F(2, 21) =	13.53
				Prob > F =	0.0002
				R-squared =	0.5630
				Adj R-squared =	0.5214
Total	1842.80606	23	80.1220026	Root MSE =	6.1923

sqrt_impac~r	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
_hat	-.0238624	1.189333	-0.02	0.984	-2.497216	2.449491
_hatsq	.0270684	.0310175	0.87	0.393	-.0374361	.0915729
_cons	8.325214	10.1203	0.82	0.420	-12.72111	29.37154

Fitted Vs Actual
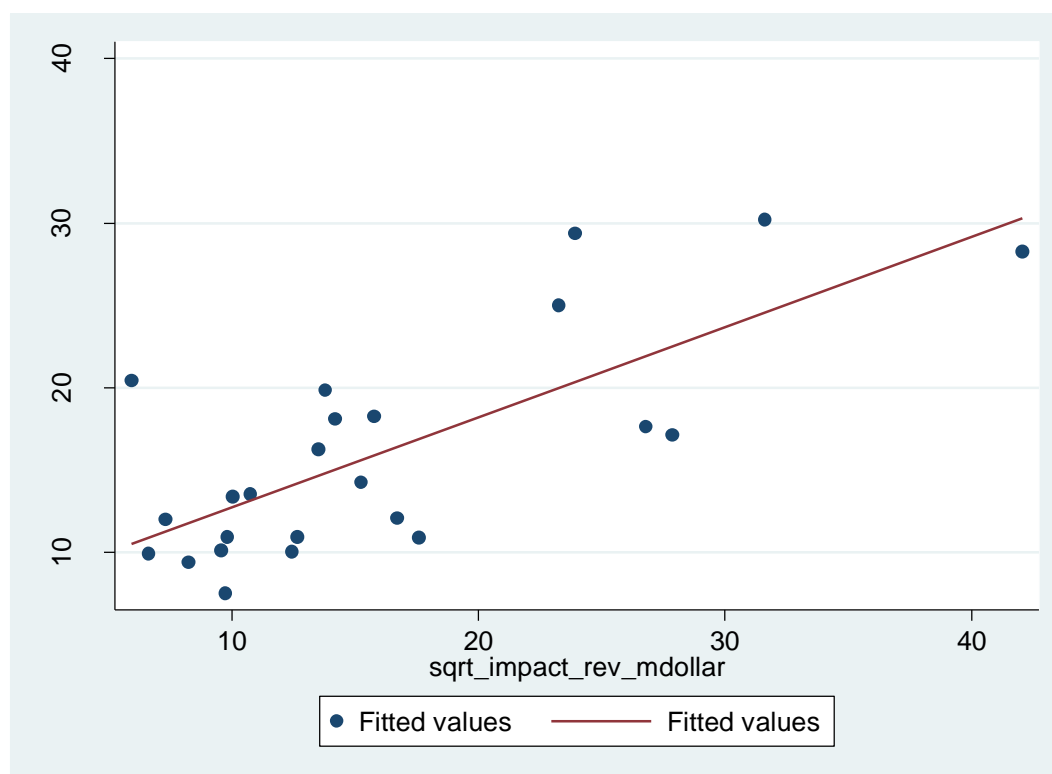
Model 3: Non-Hub Primary Airports

Heteroskedasticity

```
. imtest
```

Cameron & Trivedi's decomposition of IM-test

Source	chi2	df	p
Heteroskedasticity	5.86	9	0.7538
Skewness	4.58	3	0.2055
Kurtosis	1.56	1	0.2122
Total	11.99	13	0.5282

Collinearity

```
. vif
```

Variable	VIF	1/VIF
maxrunway1~t	1.67	0.597377
sqrt_domes~n	1.52	0.658733
military	1.14	0.880357
Mean VIF	1.44	

Form Specification

```
. ovtest

Ramsey RESET test using powers of the fitted values of sqrt_impact_rev_mdollar
       Ho:  model has no omitted variables
                    F(3, 54) =      0.46
                    Prob > F =      0.7105

. linktest
```

Source	SS	df	MS		
Model	375.858418	2	187.929209		
Residual	276.011514	58	4.7588192		
Total	651.869932	60	10.8644989		

				Number of obs =	61
				F(2, 58) =	39.49
				Prob > F =	0.0000
				R-squared =	0.5766
				Adj R-squared =	0.5620
				Root MSE =	2.1815

sqrt_impac~r	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
_hat	.7207986	.6318739	1.14	0.259	-.5440345	1.985632
_hatsq	.020797	.0463124	0.45	0.655	-.0719073	.1135013
_cons	.8078137	1.96009	0.41	0.682	-3.115732	4.73136

Fitted Vs Actual
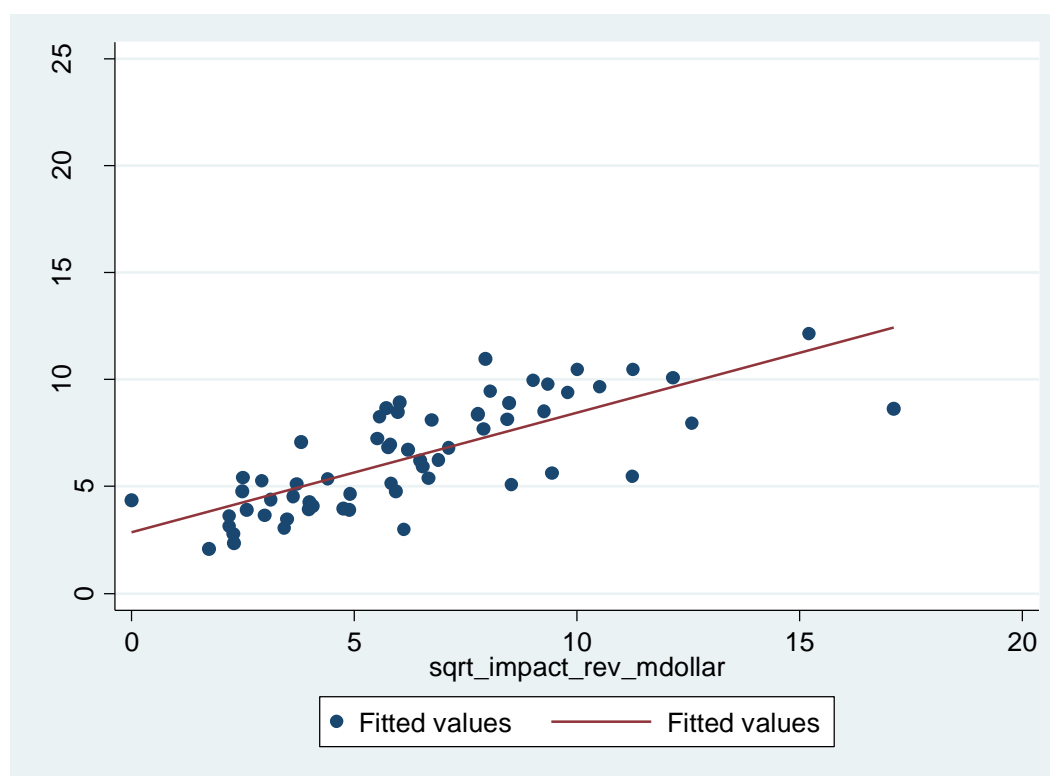
Model 4: Non Primary Commercial Services, Reliever, & General Aviation Airports

Heteroskedasticity

```
. imtest

Cameron & Trivedi's decomposition of IM-test
```

Source	chi2	df	p
Heteroskedasticity	11.03	11	0.4408
Skewness	1.91	4	0.7526
Kurtosis	1.09	1	0.2966
Total	14.03	16	0.5967

Collinearity

```
. vif
```

Variable	VIF	1/VIF
r_rwy3	1.33	0.754622
ga_totalga	1.26	0.796013
ga_rwy3	1.10	0.911023
cs_rwy3	1.03	0.970525
Mean VIF	1.18	

Form Specification

```
. ovtest
```

```
Ramsey RESET test using powers of the fitted values of sqrt_impact_rev_mdollar
      Ho:  model has no omitted variables
               F(3, 539) =      3.91
               Prob > F =      0.0089
```

```
. linktest
```

Source	SS	df	MS		Number of obs =	547
					F(2, 544) =	285.90
Model	1427.39575	2	713.697875		Prob > F =	0.0000
Residual	1357.98977	544	2.49630472		R-squared =	0.5125
					Adj R-squared =	0.5107
Total	2785.38552	546	5.10143867		Root MSE =	1.58

sqrt_impac~r	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
_hat	.8466141	.0875455	9.67	0.000	.6746454	1.018583
_hatsq	.0145634	.0072949	2.00	0.046	.0002339	.028893
_cons	.184237	.1355107	1.36	0.175	-.0819512	.4504253

Fitted Vs Actual
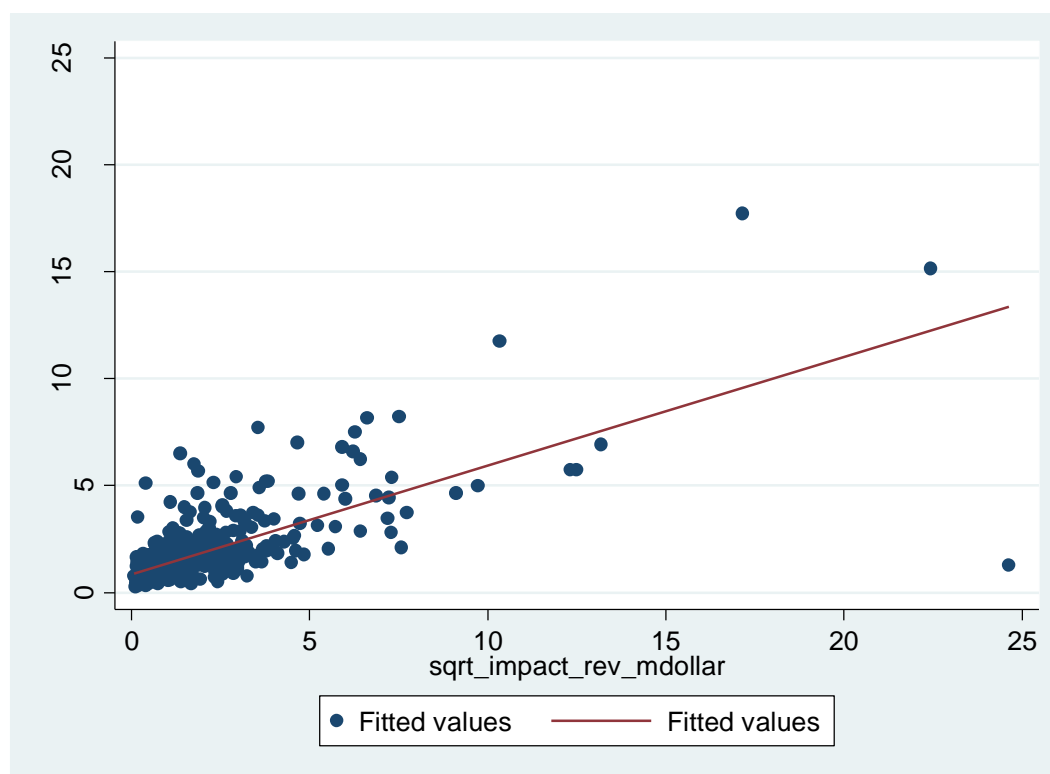
5 CONCLUSION

The regression analysis measured direct impact on airport in terms of revenue (output) generated by airport administration, public sector agencies[30], and airside and groundside tenants, including airlines and terminal concessions. The overall impact reported was $187 billion in revenue calculated from a series of regressions that encompassed 675 airports, as described in Chapter 4, above. It is important to remember that the studies of the 675 airports ranged in years from about 2005 through 2011. Although dollars were standardized to 2011, productivity measures of dollars of output to jobs reflect conditions in year of each study.

Comparing Regression Estimates to Analysis of National Datasets

The total on-airport direct economic output estimated at $198 billion from the four regression models is similar the $195 billion (2010 value) on-airport direct output that is calculated by aggregating national data bases (2010 value). As seen in Table 39, the total economic impacts (including direct, indirect and induced effects) derived from the regression analyses are slightly higher, but comparable to the total impacts based on the national level datasets. Note that this comparison does not include international visitor spending or international cargo.

Table 39. Total Impacts from Aggregated National Datasets and Regression Analysis by

Analysis	Jobs	Labor Income	Value added	Output
Aggregated Data Bases	2.5 million	$145 billion	$242 billion	$449 billion
Regression Analyses	2.9 million	$164 billion	$261 billion	$471 billion

Sources: Task 5 NPIAS Data Base, BEA, Office of Travel and Tourism Industries of the U.S. Department of Commerce, BLS-CES, U.S. Census Bureau, U.S. Budget, FAA Form 127 & NPIAS, ACI-NA, U.S. Department of Commerce data and other federal data assembled by IMPLAN. LLC. Calculations by EDR Group conducting using 2012 National IMPLAN model.

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[30] Federal agencies include the FAA, TSA and others. In addition, staff of state and local agencies are present on many airports.